

**Added Value**

**Of**

**Computer Aided  
Architectural Design**

**AVOCAAD**

## **Published by**

Hogeschool voor Wetenschap en Kunst  
Departement Architectuur  
Campus Sint-Lucas Brussel  
Paleizenstraat 65-67  
B-1030 Brussels  
Belgium

Tel. +32 (2) 242 00 00  
Fax + 32 (2) 245 14 04

wenkarch@innet.be

## **Copyright**

All rights reserved. No part of this book may be reproduced,  
copied or transmitted without the prior written permission of the  
Publisher.

## **Layout and typeset**

Tom Provoost

## **Printed**

Brussels, April 1997

**Depotnr. D/1997/8001/1**

**ISBN 90- 76101-01-9**

# Contents

|   |     |
|---|-----|
| Contents .....  | 3   |
| Preface .....   | 5   |
| AVOCAAD Statement .....   | 7   |
| Leandro Madrazo<br><i>The Added Value of CAAD for Education</i> .....   | 11  |
| Ranulph Glanville<br><i>The Value when Cybernetics is added to CAAD</i> .....   | 39  |
| Wolfgang Strauss and Monika Fleischmann<br><i>The House of Illusion: Extending the boundaries of Space</i> .....                    | 57  |
| T.W. Maver<br><i>Added Value for CAAD in Education, Highlights of an Exciting 25<br/>Years</i> .....                                | 67  |
| Jonas af Klercker<br><i>Implementation of IT and CAD - what can Architect Schools do ?</i> .....                                    | 83  |
| Alexander Asanowicz<br><i>Incompatible Pencil - Chance for Changing in Design Process</i> .....                                     | 93  |
| Malgorzatha Bartnicka<br><i>The Animal, Full Blood maybe, but Untamed</i> .....   | 103 |
| Jack Breen<br><i>Virtual Horizons</i> .....   | 109 |
| Vincent Brunetta<br><i>EXPLORER, a Procedural Modeler Based on Architectural<br/>Knowledge</i> .....                                | 125 |
| Mark Burry<br><i>The Cost and Value of Animation for Architectural Designers</i> .....  | 135 |
| Roel Daru and H.P.S. Snijder<br><i>GACAAD or AVOCAAD ?</i> .....  | 145 |
| Christian de Buhren<br><i>Expertise CAO et Conseil Organisationnel : diagnostic -<br/>precautions - gestion de changement</i> ..... | 163 |

|   |     |
|---|-----|
| Michael Hellgardt and Sourav Kundu<br><i>A Frame for Experimentation with Shape-grammars in Architectural Education</i> .....                               | 187 |
| Michael Hellgardt, Wouter Klinkenbijn and Sourav Kundu<br><i>Objective Casualty - an Experiment with Recognition and Emergence in Design Practice</i> ..... | 199 |
| Ann Hendricx and Ann Heylighen<br><i>From Literacy to Creativity in CAAD</i> .....  | 213 |
| Adam Jakimowicz<br><i>CAAD and Architecture - Fields of Transformation</i> .....  | 227 |
| Jen Kokosalakis<br><i>C AD VANTAGE for Communities, Professionals and Students</i> .....  | 235 |
| Kevin Mc Cartney and Andrew Jacobs<br><i>Testing the Benifits of Animation</i> .....  | 255 |
| Claudio Molinari and Cinzia Talamo<br><i>A Hypertextual Didactic Tool for a Maintenance Oriented Design</i> .....   | 263 |
| Gernot Pittioni<br><i>CAD as Interaction Instrument Between Planning Partners</i> .....   | 277 |
| Zenon Rychter<br><i>Objectware : from C++ towards CAD++</i> .....   | 287 |
| Sevil Sariyildiz, Sanja Durmisevic and Jasmina Ploco<br><i>Pattern Grammar within the Language of Architecture</i> .....                                    | 299 |
| Sevil Sariyildiz and Mathias Schwenck<br><i>Tools of an Integrated Software Environment for the Architectural Design Process</i> .....                      | 313 |
| Sevil Sariyildiz and Mathias Schwenck<br><i>The CIAD-System - Multimedia Teachware as a Driving Force for CAAD</i> .....                                    | 329 |
| Guido Stegen<br><i>Space Syntax, an Inspiring Design-Tool</i> .....   | 343 |
| Rob van Helvoort<br><i>Drawing with Pencil, Pen and Mouse</i> .....   | 363 |
| Harry Völker and Mathias Schwenck<br><i>Approaching a New Methodology : Integrated Architectural Design on the Basis of 3D Computer Models</i> .....        | 369 |

# Preface

Some five years ago, our Institute for Architecture Sint-Lucas started discussions with people from IBM. The topic on the agenda was the use of computers in Architecture. For more than a year we had regular meetings. From these discussions originated the underlying ideas of the Leonardo da Vinci pilot project AVOCAAD (Added Value of Computer Aided Architectural Design). The project summary is given on one of the following pages.

The Institute decided to concentrate on these aspects on which it has good knowledge and experience: the creation of ideas and the design process. The consequence was we wanted to concentrate on the early design stages and wanted to stimulate the use of computers in these early phases, we called this 'upstream' comparing the design process with a river, the source is the initial ideas, the see the realisation of the project. So, the research group is not interested in the drawing or production of plans, but is mainly interested in the creative and experimental possibilities offered by the new media.

As such we invited all participants to this first international AVOCAAD conference to give there view on the added value the computer is offering to Architecture. During the discussion, we hope to concentrate on the experiences with and possibilities offered by computers to the designer during his design process.

The pilot project AVOCAAD aims to develop several new course modules stimulating the creative and experimental use of computers during the design process. A first step will be to make an overview of existing course contents. We invite every participant of the conference to sent us the course contents and if possible, the course materials used in the actual courses. As a follow up, we will sent him/her a copy of the first (giving a 'state of the art' in actual courses) and following reports of the project.

This conference also aims to be a start in an ongoing discussion on what computers can and should offer for architects.

Organising a conference is a lot of work. I thank all members of the organising committee and everyone who has participated in the preparations of the conference for their work and help. On the other hand, if we see the materials sent in, we have to thank all contributors and look forward to all discussions during the conference.

Johan Verbeke



# AVOCAAD Statement

Normally, a long and tedious design process precedes the realisation of an architectural object. During this design process, the initial ideas and concepts of the architect crystallise out in a realisable form.

The recent new technologies, the availability of computers and software which become cheaper and more user friendly, imply that (even small and medium) design offices start using CAAD (Computer Aided Architectural Design). This has an important impact on the design process which is currently under major change. CAAD offers a lot of new possibilities and there is an increasing number of examples showing us this new technologies support and change the design process in a positive way. Nevertheless, we see an important part of the design offices is not using these new possibilities. They are using CAAD only for producing plans. Acting in this way, these offices do not gain any added value of CAAD. Although the new technologies offer a lot of new techniques and can have a positive impact on the design process, we see a lot of architects who get confronted with these new media, react in a negative way. So, it is clear new impulses are needed in order to develop the added value of CAAD to the design process and to make this positive impact clear to the architects.

In order to realise the previous goal and to react to the rapid changes in the field, it is necessary to develop new training methods, new course contents and new training material. This material has to underline the added value of CAAD to the design process. This will augment training quality and the meaning and position of CAAD in the curriculum. It will also give maximal chances to CAAD in the future. In a second phase we see a positive impact of the designing offices and the architectural Institutes on the further development of CAAD. The new training methods, new course contents and new training materials will make the anticipation to future developments and faster innovations possible.

This can be realised in the following way. The project will benefit from the practical training program AVOCAAD-stage. The experiences will be brought together in order to develop a new vision on the creative use of CAAD. New course material will be the concrete result. This will be the start of new training and in-service training oriented towards the added value of CAAD. As a final period we see training periods in design offices during which the new developed vision and training material will be confronted with the design practice.

By incorporating this new material in the curriculum and by making it available as a short intensive course (as part of the continuous education as young architects who finished their studies in the near past have not yet gained this knowledge), we hope to reach a maximal effect. Moreover we will experiment with training-on-the-job and video-courses.

Because of the complexity and the fast evolution, it is clear this project can only be realised by a co-operation of different partners all over Europe: design offices, software specialists and universities. We want to bring together the variety of experiences and ideas in Europe in order to incorporate the added value of CAAD as well as possible.







# The Added Value of CAAD for Education

**Leandro Madrazo**

ETH Zürich  
Switzerland

*This paper summarizes a teaching project carried out at the Chair of Architecture and CAAD, ETH Zurich; its aim has been to integrate computers into architectural design education. Here the theoretical bases of the different courses are outlined and the exercises described. Some reflections based on the experience of teaching these courses are also presented. In all, this pedagogic work demonstrates the need to create an appropriate conceptual framework so that computers can be used in a meaningful way throughout architectural design education.*



## The Added Value of Caad for Education

It was not so long ago that educators in the field of CAAD claimed that in the near future, sophisticated computers would replace the drawing board and the model shop in Schools of Architecture. They contended that intelligent systems would guide the designer through the intricate maze of design decisions, and would formulate design proposals and decide by themselves the best 'design solution'. These speculations have tended to set the debate on the role of computers in architectural education off on the wrong track. Moreover, they have diverted the discussion away from the issues that are crucial for architectural education onto other issues that, in the best of cases, might be a matter for research. Because, while on the one hand the imminent computer revolution in architecture was being postulated, on the other hand, computers were being used in the Schools mainly to draw and model what had been previously represented by traditional media. Thus a wide gap existed between what computers were expected to do and what they were actually being used for. To bridge this gap, what was needed was not more sophisticated tools, but rather an intellectual framework within which to make meaningful use of the existing technology in academic education.

Today, it might be more appropriate to speak about the **integration** of computers in architectural education than to keep postulating the advent of a computer technology that would automatically bring, in itself, a revolution in the way we understand and teach architecture. It seems more reasonable for us to see the computer tools as instruments that impel us to rethink and reframe our knowledge on such fundamental issues in the education of architecture, as the relation between conception and representation, space and perception, form generation and design process. This could be, in fact, the value that computers add to the education of architecture: by forcing us to confront the established body of the architectural tradition with a new conceptual framework, computers can contribute to a better understanding of some fundamental questions in architecture.

The teaching project that was initiated at the Chair of Architecture and CAAD, Zurich, in 1990, has pursued this type of integration of computers into architectural education (Madrazo 1992a). In the course of the past six years, we have striven to develop and implement a conceptual framework within which the use of computers can bring a new value to architectural education. This paper summarizes a part of the pedagogic work carried out in this six year period.

## A teaching project to integrate computers in architectural education (1990-1996)

This teaching project was first conceived in the years 1990-91 and was later developed and implemented in the course of the five following years (Madrazo 1993). According to this project, a sequence of three courses would take place during one academic year, in the following order: 1. an introductory course, focused on the generation of abstract forms; 2. a second course, focused on the aesthetics of form, followed by 3. a design studio dedicated to the design of concrete projects.

### 1. Introductory course: Form and Structure

This introductory course was first implemented in the Winter semester of 1990 and was offered during each Winter semester until the academic year 1995/1996. The spirit of this course is somewhat similar to the one that inspired the work done in the celebrated introductory courses of the Bauhaus. Like in the *Vorkurs* of Johannes Itten, the purpose of this course is to make students aware that form creation with a computer is a process that combines subjective experience and objective knowledge<sup>1</sup>. Unlike the Bauhaus courses, however, in a *gestaltung* course with computers the material component in the form generation process plays no role. The form generation process with computers involves mainly conceptual structures, such as instantiation, hierarchical structuring or substitution. Thus the course focuses on the understanding and application of these conceptual structures in the generation of form.

The distinction between **form** and **structure** is a fundamental part of the theoretical background of this course. A basic premise is that form and structure represent two distinctive aspects of design: while the conception and perception of form is an exclusive faculty of the mind, structure, on the other hand, is amenable to computer representation. By structure we understand the explicit representation of a relationship of the parts within the whole. This explicit relation can be captured by means of a variety of techniques provided by most computer graphic programs. The assumption is, that by reproducing the inner structure of form on a computer, a designer can gain new insights in the form making process.

---





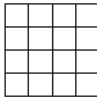
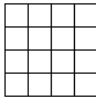
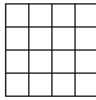
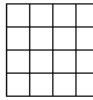








<sup>1</sup> One of the basic goals of Itten's *Vorkurs* was to make students aware of the subjective and objective dimensions of form creation. The subjective side had to do with the inner creative power of the individual, while the objective had to do with the material and the methods used in the production of industrial objects. As Itten explained it later (Itten 1975), this was one of the three fundamental tasks of his *Vorkurs*: "*Für ihre zukünftigen künstlerische Berufe sollten den Studierenden die Grundgesetze bildnerischen Gestaltens vermittelt werden. Die Gesetze der Form und der Farbe eröffneten den Studierenden die Welt des Objektiven. Im Verlaufe der Arbeit konnten sich die subjektiven und die objektiven Form- und Farbprobleme in vielfältiger Weise durchdringen*". (p. 7)

## 1.1. The exercises

The exercises have been conceived to allow students to do creative work from the very beginning of the course. After one week's introduction to the basic notions to the Unix operating system and to the basics of a general purpose modelling program, students begin with the first design exercise: a composition of two-dimensional shapes. In the following exercises they continue creating objects in three-dimensional space. These objects and shapes are not meant to have any architectural significance; they do not have to respond to any function or program, nor they need to have a particular scale. They are purely formal compositions in space.

A fundamental component of the course is the computer tool we have designed to enable the students to do the exercises. The tool was conceived with the intention of giving support to the concepts formulated in the exercises. This tool is built upon the paradigm of types and instances. Basically, it consists of a hierarchically structured library of types and a graphic user-interface. A type can be selected on an icon menu, and inserted in the model. Attributes of the instances can be edited interactively or by entering values in a dialogue box. Instances of a particular type can be replaced by instances of a different type in a direct and intuitive way, using the graphic interface. Individual instances can be grouped to create compound objects which also become part of the library of types.

The course work consists of four exercises dedicated to the creation of abstract objects (composition on the plane, objects on the plane, hierarchical structures and level of detail), followed by a final exercise in which the concepts previously learned are applied to the design of an architectural object. The format of the first four exercises responds to a basic idea: the paradigm of theme and variations. The layout of every

|             | THEME   | VARIATION1  | VARIATION2  | VARIATION3  |
|-------------|---|---|---|---|
| GRID        |  |  |  |  |
| SYMMETRY    |  |  |  |  |
| FOCAL POINT |  |  |  |  |
| COLOR       |  |  |  |  |

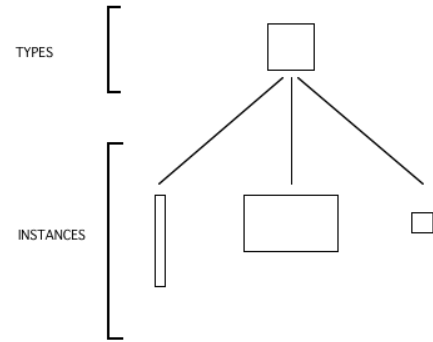
exercise consists of a grid where the first column corresponds to the theme and the next three columns to the variations.

The format and description of the exercises was reviewed after each academic year to make them more suitable to the students' needs,

incorporating the feed-back obtained from previous years<sup>1</sup>. This was the description of the exercises, as it was formulated in the Winter semester 1995/96:

*first exercise: composition on the plane*

The notion of instantiation (the *types and instances* paradigm) is introduced in a simple manner. A library of two-dimensional shapes provides the design vocabulary, e.g. a collection of types that are then instantiated to make a composition. The themes to which the students are asked to give a formal expression are: grid, symmetry, focal point and color.

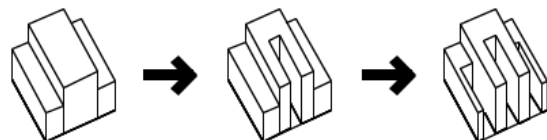


*Fig. 2. Kim Riese, Winter semester 1994/95.*

*Fig. 3. Alexandre Zumbrunnen, Winter semester 1995/96.*

*Fig. 1. Yves Racine, Winter semester 1992/93.*

*second exercise: objects on the plane*



<sup>1</sup> A detailed description of the exercises can be found in <http://caad.arch.ethz.ch/~madrazo/teaching>



The purpose of the second exercise is the composition of extruded shapes on a plane. Objects are created according to two different formal languages: the language of prismatic shapes and the language of parallel planes. The concept of substitution is introduced in this exercise: the variations of an object are created by replacing the individual components by instances of another type.

Fig. 4. Extruded shapes. Leo Bietry, Winter semester 1995/96.

Fig. 5. Parallel planes. Gerd Grohe, Winter semester 1991/92.

Fig. 6. Parallel Planes. Zbigniew Wiklacz, Winter semester 1993/94.

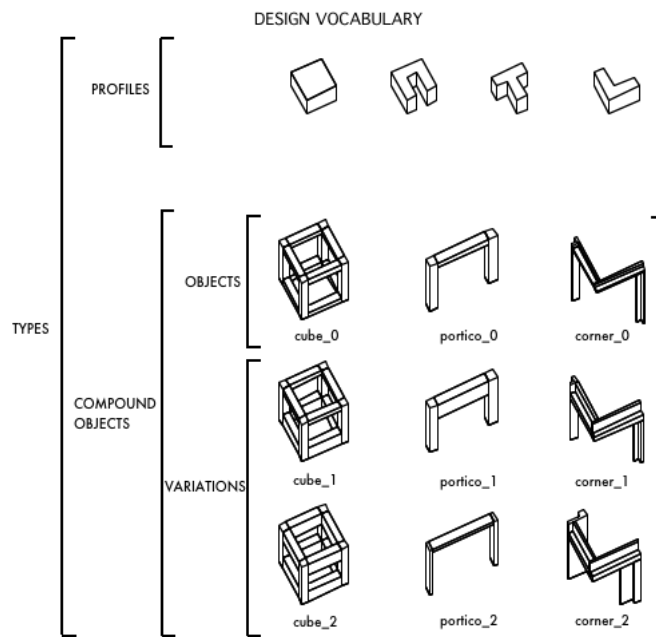
Fig. 7. Parallel planes. Thomas Caro, Winter semester 1994/95.

Fig. 8. Parallel planes. Kim Riese, Winter semester 1994/95.

Fig. 9. Substitution. Yves Milani, Winter semester 1993/94.

*third exercise:  
objects in space*

The third exercise focuses on the notion of hierarchical structures. The inner structure of an object is represented on the computer by means of compound objects and layers. The exercise consists of two themes: 1. frame and volume: creation of an object composed of a frame structure and a volume. 2. path in space: creation of an object by connecting points in three-dimensional space.



*Fig. 10. Frame and Volume.  
Moreno Maconi, Winter semester  
1993/94.*

*Fig. 11. Frame and Volume.  
Zbigniew Wiklacz, Winter  
semester 1993/94.*

*Fig. 12. Frame and Volume.  
Thomas Caro, Winter semester  
1994/95.*

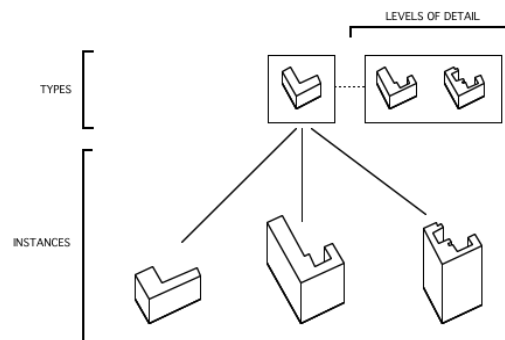
*Fig. 13. Path. Leo Bietry, Winter  
semester 1995/96.*

*Fig. 14. Path. Yves Milani, Winter  
semester 1993/94.*

*Fig. 15. Path. Christoph Huber,  
Winter semester 1994/95.*

*fourth exercise: level of detail*

The fourth exercise deals with the notion of levels of detail, according to which the appearance of an object would change according to the distance between object and viewer. The notion of level of detail can be thought of as a corollary of the idea of substitution: in the computer model, instances of an object can be replaced by other instances with a different level of detail.



*Fig. 16-18. Level of detail. Daniel Overhoff, Winter semester 1995/96.*

*fifth exercise: the architectural object*

At the end of the series of short exercises, every academic year there has been a special final exercise. Some of the topics proposed have been: the

design of a tower, a pavilion in the Parc de la Villette, and a facade. In the design of each one of these themes, students were asked to apply the concepts of instantiation and design vocabulary, hierarchical structures, and level of detail.

Issues of architectural representation, which were not relevant in the previous exercises, now become important in the design of an architectural object. For example, axonometric and perspective views might not suffice and plans and sections are needed to represent the object.

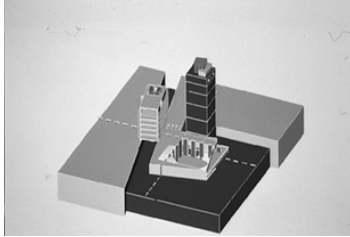


Fig. 19-21. Tower. Gerd Grohe, Winter semester 1991/92.

Fig. 22. Tower. Gerd Grohe, Winter semester 1991/92.

Fig. 23, 24. Pavilion in La Villette. Nicklaus Liechti, Winter semester 1992/93.

## 1.2. Some reflections derived from teaching the course.

The following are some reflections derived from the experience of teaching this course during six consecutive years:<sup>1</sup>

*The course becomes a theme in itself.* We realize that, after repeating the course for a number of years, this became a theme in itself, as if every new course were a variation of the previous ones. The exercises made by students in the previous years became the theme upon which new students create new variations. This can represent a risk of self-repetition, since some students tend to create in a rather mechanical way variations of themes that had been ‘discovered’ by previous students. In spite of this, the fact is that many students, year after year, have succeeded in creating their own personal interpretation of the themes we have proposed.

*Generative modelling versus visual thinking.* Although a quick look at some student work might suggest that they are exercises in generative

---

<sup>1</sup> A comprehensive collection of the most relevant student work created between 1991 and 1995 can be found in <http://caad.arch.ethz.ch/teaching/archive/archive.html>. The final presentation of the Winter semester 1995/96 can be found in <http://caad.arch.ethz.ch/teaching/caad/ws95/fp/>

modelling, the fact is that they are not. Both the theme and the variations have been created without the support of algorithmic representations. This warrants some explanation. Typically, an exercise in parametric design involves, in this order: 1. devising the algorithmic representation of a shape/object 2. generating the graphic representation of the shape/object after assigning values to parameters and 3. selecting the most appealing or promising shapes/objects from the point of view of the designer. To be sure, this is the most efficient way to create shapes (**shape**, not to be confused with **form**) in computer graphics. The problem is that the procedure followed to create those shapes is at odds with the way a designer creates form. In other words, while generative modelling has to do with generating *shape*, design has to do with creating *form*.<sup>1</sup> Design, as Rudolf Arnheim and Paul Laseau had maintained, is basically ‘visual thinking’. It encompasses the understanding of **form** through visual representations. Then, the reason why we ask students to make variations on a theme without the mediation of an algorithmic representation is because we want them to develop their visual thinking skills, that is, their design skills. We are not ‘teaching the computer’ to make variations of a theme, as some authors have sought to do,<sup>2</sup> but teaching architectural design to architectural students with the help of a computer.

---

<sup>1</sup> Douglas Hofstadter has associated creativity with the creation of variations on a theme. In *Metamagical Themas* (Hofstadter, 1982) he contended for example that “Making variations on a theme is really the crux of creativity”. But Hofstadter has refrained himself from identifying creativity with parametric variation. In *Gödel, Escher, Bach: an Eternal Golden Braid*, (Hofstadter, 1979) he related his frustration when after having written a computer program to create sentences, he realized that after a while the sentences fell within a given conceptual space and could not go beyond it. He writes: “At first it seemed very funny and had a certain charm, but soon it became rather stale. After reading a few pages of output one could sense the limits of the space in which the program was operating; and after that, seeing random points inside that space - even though each one was ‘new’- was nothing new. This is, it seems to me, a general principle: you get bored with something not when you have exhausted its repertoire of behavior, but when you have mapped out the limits of the space that contains its behavior.” (op.cit., p. 621)

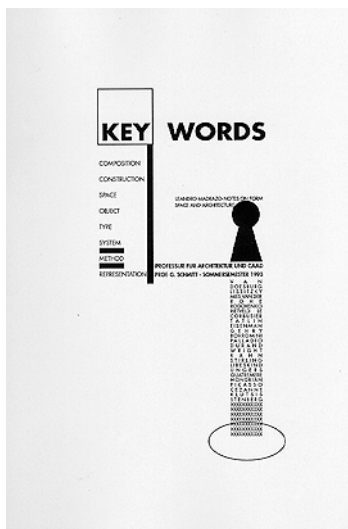
<sup>2</sup> George Hersey and Richard Freedman in *Possible Palladian Villas (Plus a Few Instructively Impossible Ones)*, 1992, present a program that creates variations of Palladian villas according to the principles of parametric variation. The authors declare that “We have decided to teach a computer to design Palladian villas rather than doing it ourselves with pencil and paper.” (op.cit., p.10). Robert Mc Kim, *Experiences in Visual Thinking*, 1972, wrote on the other hand: “Computers cannot see or dream, nor can they create: computers are language-bound. Similarly, thinkers who cannot escape the structure of language, who are unaware that thinking can occur in ways having little to do with language, are often utilizing only a small part of their brain that is indeed like a computer”. We believe that this statement is still basically true.

*The typological and non-typological modes of designing.* From the different approaches adopted by students in the exercises, it is possible to distinguish two main approaches to form creation. First there is what we call the typological approach, according to which a designer would have in mind a strong *image, idea* or *type*, that serves as a guide during the design process. Only by being aware of this image, can a designer decide which formal transformations are appropriate for a given stage of the design process. In the second approach, which we call non-typological, the designer frees himself or herself from that strong image in an attempt to remain open to any sort of emerging form.<sup>1</sup> In reality, such a clear division between the two modes of creating form probably does not occur. In many of the examples, a form is the result of a mixed-process that combines both approaches, typological and non-typological.

*The personal interaction.* It is often taken for granted, that in a course with computers the most important issues are the computer tools and, eventually, the pedagogic method. By the same token, some basic aspects of education such as the capacity of the educator to motivate the students or the exchanges between students and teacher, are often ignored. However, at the risk of repeating the obvious, it must also be said that in a design course with computers the personal interaction is fundamental, and is as important, or even more important, than the method and the tools.

## 2. Keywords: The Aesthetics of Form

While the introductory course of the Winter semester is mostly concerned with the conceptual structures operating in the generation of abstract forms, the next course in the Summer semester advances towards more architectural issues. Now, aesthetic issues regarding form come to the fore. A basic premise of this course is that there exists a strong link between some fundamental principles of Modern Art and Architecture and the intrinsic representational capacities of the computer tools.<sup>2</sup>



typological and non-typological, has been formulated in philosophy (the relation between the whole and the parts) and in psychology (the different definitions of beauty from Vitruvius to Arnheim's reference to 'organization from top-down'), and in the field of design and computing ('top-down').

Manfred Mohr (Bruegmann, 1989) has referred to a possible connection between the work of Russian constructivist artists and computer graphics. He contends that the work of the Russian constructivists, "in which simple geometric 'primitives' are formed by fairly simple operations, formed the basis of most computer graphics programs designed for mechanical engineers -which in turn became the basis for many of the first programs for architects. Likewise Chernikov's use of brightly-coloured lines, frequently arrayed in dense parallel configurations or grids, is relatively easy to achieve on the computer". (op.cit., p. 142).

The course content is structured into eight *keywords*, namely, COMPOSITION, CONSTRUCTION, SPACE, OBJECT, TYPE, SYSTEM, METHOD and REPRESENTATION. The theoretical background for the course is contained in a script given to the students at the outset (Madrazo, 1992b). The following is a summary of the ideas developed in this text:

1. *Geometry as formal language.* The compositions of Theo van Doesburg and Piet Mondrian are pure combinations of lines and rectangles in an abstract space. Every formal configuration is presented as one among many others. Combinations are endless. A vocabulary of geometric figures and the possibility to combine them in endless ways is what characterizes any computer graphics tool.

2. *The concept of space.* A similar concept of space lies behind paintings, sculptures and buildings made by some of the leading artists at the beginning of the century. The *Counter-Constructions* of Theo van Doesburg, Gerrit Rietveld's *Red and Blue* chair and Mies van der Rohe's *Brick House*, are the expression of the same spatial concept: an abstract, Cartesian space that exists prior to the forms that are placed in it. Precisely, the sort of spatial concept which is built into any computer graphics program.

3. *Abstraction takes over reality.* In the early works of *avant-garde* painters, the traditional relationship between representation and reality began to change. The link that had kept them together since the Renaissance was broken. Representation no longer needed reality. Moreover, representation took over the place of reality. This was most clear in the work of Russian constructivists as, for example, in the early work of Tatlin or

Rodchenko. In Tatlin's *Selection of materials*, the objects are projected out from the canvas to become part of the real world. Similarly, the '*prouns*' of Lissitzky also reveal an exchange of roles between the abstract and the real. This exchangeability of the real and abstract worlds is intrinsic to computers.

4. *The abstract nature of modern architecture.* With a formal language based on simple geometric elements, came the retreat of architecture to the realm of abstraction. A building such as the Barcelona pavilion seems to belong more to the realm of abstraction than to reality: walls become abstract planes floating in an abstract space; reflections and transparencies contribute to give the impression that the building is not real. In the Barcelona pavilion, abstraction became an end in itself; the building itself being a 'materialized abstraction'. Other buildings of the same period started to look like enlarged models, for instance the Villa Savoye or the building of the Bauhaus. A transformation of architectural works into abstract objects is exactly what takes place as a result of modelling a building in the computer. In the realm of computers, architectural works are transformed into objects; architectural objects.

5. *The self-transforming objects.* Conceptually, some of the buildings of Le Corbusier can be understood as organisms made up of systems and subsystems. The Villa Savoye, for example, can be understood as a system made up of subsystems: a subsystem-*ramp*, a subsystem-*structural grid*, a subsystem-*circulation*. Considering it as an abstraction, the Villa Savoye can be compared to a living system in the process of continuous transformation. As in a living organism, an equilibrium between the different systems is never reached: there are tensions between the subsystem-*ramp* and the subsystem-*structural grid*. In principle, computers are bound to capture and to reproduce the sort of transformational process implicit in the Villa Savoye.

In the work of the artistic *avant-gardes*, the boundaries that separate painting, sculpture and architecture were consciously removed. What emerged instead was a new concern with the idea of representation. As a matter of fact, the biggest achievement of modern art was to make us aware that representation is the key question before any artistic creation, whether this is painting, sculpture or architecture. This awareness of the mediating role of representation in the process of creation is still a characteristic of contemporary art. Furthermore, the question of representation is the key issue underlying any creative work done with computers.

### **The course work**

The course KEYWORDS took place in the Summer semesters of 1992 and 1993. The course work was structured in two distinct parts: one, limited to the first three *keywords* (COMPOSITION-CONSTRUCTION-SPACE) consisting of three short exercises; a second one, in which an architectural project was developed following the sequence of the remaining *keywords* (OBJECT-TYPE-SYSTEM-METHOD-REPRESENTATION).

*Fig. 25. Composition. Balaji Bal, Summer semester 1992.*

*Fig. 26. Composition. Antonio Torres, Summer semester 1992.*

In the first three exercises, original works created by artistic movements like De Stijl, or Russian constructivism provided the aesthetic for the students to create new works. In the first exercise (COMPOSITION) students recreated the pavement design made by van Doesburg for the house De Vonk. The original design of van Doesburg consists of a vocabulary of color rectangles hierarchically organized. After making an interpretation of the rules of composition of the original design, students came up with their own set of rules which they used to create a new design. In the second exercise (CONSTRUCTION) the assignment was to create an object which could be both a sculpture and a piece of furniture. Rietveld's furniture and some of the constructions of Klutisjs were given as examples. In the third exercise (SPACE) the task was to create a three-dimensional space using a formal vocabulary of planes, as van Doesburg did in his counter-constructions.



*Fig. 27. Construction. Miklos Gyarfas, Summer semester 1992.*

*Fig. 28. Construction. Herman Verkerk, Summer semester 1993.*

*Fig. 29, 30. Space. Miklos Gyarfas, Summer semester 1992.*

### **Some reflections derived from teaching the course.**

*The provision of a conceptual space to create form.* Modern art works provided a conceptual space within which students were able to create their exercises. These works have a enormous didactic value since they contain certain compositional rules that are easily apprehended by students. This was particularly important for students in the earlier semesters of the program who took part in the course. After grasping the compositional rules of the original work, these students could quickly invent their own work, often with remarkable results. On the other hand, students in the later semesters, who had already gained experience in design, were encouraged to create their own conceptual space, e.g. to develop their own aesthetic, and to forge a more conceptual relation between the works they created and the works of the artistic *avant-gardes*.

*The aesthetic of the representation.* One of the characteristics common to most of the work created by the pioneers of modern art is the conscious use of simple representational techniques (elementary shapes, elementary colors) to convey a strong conceptual content. Students were encouraged to apply a similar economy of representation with the computer tools they used. For most of the exercises, flat shading was the only representation technique. Properly used, this technique sufficed to achieve convincing results.

*Art work and art work images.* It is necessary to keep in mind the distinction between an original work of art and a digital image created after it. A composition based on a painting of Mondrian made with a computer graphics application, for example, is not necessarily

comparable to the original Mondrian. They are indeed two different things. In one case we have electronic image displayed on the monitor; in the other is an original work of art materialized on a particular medium with pictorial techniques.<sup>1</sup>

*Artistic principles and computer tools.* Students responded favourably to the attempt to create a unified conceptual framework encompassing both the principles of modern art and computer tools. The discussion of ideas in the classroom proved to be inspiring for the students. The educator is fundamental for the success of this sort of courses. He or she needs to have a background in architecture and in computing, and be able to bring both worlds together.

### **3. Designing with Computers: The relation between conception and representation**

The logical conclusion of this step-by-step strategy to introduce computers into architectural design is to apply them to the design of concrete architectural projects. The assignments have consisted of small projects: a tower, a private library. The sequence of *keywords* (OBJECT-TYPE-SYSTEM-METHOD-REPRESENTATION) provides the methodology for the design process. Students were asked to present a first scheme or idea at the volumetric level (OBJECT), and then explore variations of that scheme (TYPE) before committing themselves to a formal solution. At an advanced stage of the design, they were asked to consider this as a SYSTEM composed of different subsystems. Towards the end of the semester, the students were asked to trace back the design process they had followed and represent it in an schematic way (METHOD). In the whole design process, from the first sketch to the

---

<sup>1</sup> Regarding the relation between original works of modern art and works elaborated after them on the computer, it is necessary to keep in mind that the alleged mathematical character of certain pictorial compositions is not always true. This commentary on the work of Mondrian reminds us about this fact: "From 1920 on, Mondrian had struggled to correct the misconception that his art could be characterized as geometric. He insisted again and again that he did not work according to a system, but rather than intuition served as his sole creative guide. Neither friend nor foe seemed able to accept this entirely, and countless attempts have been made to decode the supposedly fixed and mathematically proportional relationships within his work. All such efforts have been fruitless, since it is demonstrably clear that Mondrian's compositional method was anything but systematic nor mathematical. The surfaces of his canvases are rich in subtle variations of texture and brushwork. Nothing was predetermined. Reworking, rethinking, and refining characterized his resolution of every problem". (Joosten, Rudenstine, 1994, p. 295).

final presentation, students were encouraged to seek a consistency between the design and its REPRESENTATION.

*Fig. 31, 32. Kiosk in Paradeplatz. Christian Lauterburg, Summer semester 1993.*

*Fig. 33, 34. Kiosk in Paradeplatz. Herman Verkerk, Summer semester 1993.*

*Fig. 35. Kiosk in Paradeplatz. Herman Verkerk, Summer semester 1993.*

*Fig. 36. Private library. Zoran Zladoljev. Summer semester 1992.*

Using computers for the purposes of architectural design raises the question of the relation between conception and representation. There is a strong tendency to use the computer to reproduce what has been previously created with other media (a sketch on paper, a line drawing, a mass model). In this event, the influence of the computer in the design is reduced to a minimum. At the other extreme, there have been attempts to carry out all the conceptual part of the design on the computer. Only in this way, it is claimed, is it possible to create really innovative forms that justify the application of computers in architectural design. In our courses, we have encouraged students to find a mid-way between both extremes: making extensive use of sketches and physical models while taking advantage of the capacities of the computer to model complex

forms, to perceive the inner spaces, to understand the inner structure of the design, and to make representations of the final results.

## **Structures: Text, Shape, Object, Space, Light**

This seminar has been carried out for the first time in the Winter semester 1996/97 in the postgraduate program, at the ETH Zurich. The purpose of the seminar is the understanding of what -almost paraphrasing Giedion- we might refer to as *fundamental facts*<sup>1</sup> of architecture, those that have to do with the conception and perception of form, space and light. The purpose of the course is to integrate *gestaltung*, architectural theory and computers in a unified theoretical discourse.

The central theme of the course is the notion of STRUCTURE, which is analyzed from the five different points of view: *text, shape, object, space* and *light*. Each one of these keywords is in fact a model of thought through which some fundamental facts of architecture can be revealed.

*Fig. 37. STRUCTURES: on-line script and entry page of the Nachdiplomstudium of the Winter semester*

---

<sup>1</sup> In *Space, Time and Architecture*, Sigfried Giedion distinguished between constituent and transitory facts in architecture. Constituent facts in architecture were for Giedion those “tendencies which, when they are suppressed, inevitably reappear” (Giedion, 1954, p. 18). He mentioned the undulating wall or the open ground plan as examples of such constituent facts. Transitory facts, on the other hand, were those that could only be valid for a particular period of time. We are using the expression ‘fundamental fact’ to refer to a series of issues that are common to the architecture of all times: the incidence of the light in the interior space, the inner structure of the form of a building, the opposition between object and space.

1996/97.L.Madrado. (<http://caad.arch.ethz.ch/teaching/nds/ws96>)

It is common to refer to the structure of a text, or to the structure of a shape, of an object, of a space or even to the structure of light. In all of these cases we mean an inner order that can be intellectually apprehended, that is, a structure. Structure is then what all of these models of thought (text, shape, object, space, light) have in common. However, to define structure itself is a more difficult task, since structure, like other synonyms of form, is a tautological notion that eludes definition.

The course consisted of lectures followed by a two-week exercise. The script with the course content was published both in paper (Madrado 1996) and electronically in the Internet (<http://caad.arch.ethz.ch/teaching/nds/ws96>). The exercises were presented by each of the students to the rest of the class with an Internet browser projected on a large screen.

The following is a short summary of some of the topics discussed in each one of the five parts of the course and the description of the corresponding exercises:

TEXT. *Topics:* the evolution of hypertext and hypermedia; the relation between the structure of a text and hypertext and mental structures; Hume's notion of association of ideas; the relation between language and reality in James Joyce's *Finnegans Wake*.

*Exercise:* the exercise consisted on the analysis of three manifestos by Mies van der Rohe, Theo van Doesburg and Le Corbusier. The task was to unfold the critical vocabulary in these texts, to confront the use of similar terms by different writers; to associate images or/and texts to the critical terms; to make a personal reflection about the content of the text, and its relation to today's architectural problematic. Tools: Internet browser.

*Fig. 38. Text.  
Cross-reading of  
three manifestos.  
Cristina Besomi,  
Winter semester  
1996/97.*

SHAPE. *Topics:* the process of figuration to abstraction in Modern painting; the notion of formal language in Mondrian's compositions; synesthesia of pictorial and musical compositions in Mondrian's *Broadway Boogie-Woogie*; the iconic and symbolic character of the pictorial sign in the works of Klee and Mondrian.

*Exercise:* analysis of Mondrian's *Broadway Boogie-Woogie* reproducing it with vector images and raster images; implementation of the inner structure of the composition by means of layers and blocks; application of the same formal language to create a different composition, in another context. Tools: vector based and pixel based programs.

*Fig. 39. Shape.  
Analysis of  
Mondrian's  
Broadway  
Boogie-Woogie.  
Malgorzata  
Miskiewicz,  
Winter semester  
1996/97.*

OBJECT. *Topics:* three different formal languages of form generation: the language of the solid, the language of the plane, the language of the frame; the relevance of structural form in architectural theory: the theories of Vitruvius, Laugier, Viollet-le-Duc; the influence of structural form in the invention of a new art form: Russian constructivism; the role of the different formal languages in the invention of Modern architecture as well as in contemporary architectural creations.

*Exercise:* to create an architectural object, based on one of the three formal languages (solid, plane, frame); to experiment different translations between formal languages, for example, from frame to plane, from plane to solid. Tools: a general purpose three-dimensional computer program, sketches, physical models.

*Fig. 40. Object.  
Translation from  
planes to solid.  
Cristina Besomi,  
Winter semester  
1996/97.*

SPACE. *Topics:* distinction between two notions of space: space as the abstract relation between objects, and space as the inner cavity or void; relationships between notions of space in architecture and other notions of space developed in other fields; distinction between space representation, and existential space in Renaissance painting; architecture as composition of spaces: *la promenade architecturale* from Le Corbusier; the concept of space in Kevin Lynch's *The Image of the City*.

*Exercise:* to create a composition of spaces, concentrating in the relation between space and motion. Tools: animation programs, slide shows, VRML.

*Fig. 41 Space.  
Multiple spatial  
representations.  
Malgorzata  
Miskiewicz,  
Winter semester  
1996/97.*

LIGHT. *Topics:* concepts of light as formulated in fields like philosophy, optics and physics; distinction between representation of light and light as a natural phenomenon: Renaissance painting versus the Flemish school of painting; the relation between scientific theories of vision and impressionist painting in nineteenth century; architecture as inner space and light; distinction between the conceptual and phenomenological dimensions of architecture: the work of James Turrell and Toyo Yto.

*Exercise:* to create an inner space, using light as *gestaltung* element. Tools: a radiosity rendering program, image editors.

*Fig. 42, 43. Light. Shadows shaping space. Bettina Müller, Winter semester 1996/97*



*Fig. 44. Spiritual vs. hectic spaces. Albina Grzesik, Winter semester 1996/97.*

*Fig. 45. Three spatial ambiences: andante, allegro, vivace. Malgorzata Miskiewicz, Winter semester 1996/97.*

## Conclusions

The integration of computers in architectural education represents a big challenge for architectural educators. It is necessary to devise appropriate strategies, to create adequate conceptual frameworks within which the application of computers becomes meaningful for architectural education. Those educators willing to meet this intellectual challenge must not only be knowledgeable in computer technology but, also, be able to confront the whole complexity of issues that affect architectural education. This means being able to transcend artificial boundaries that separate the field of computer architectural design from other fields, like *gestaltung*, architectural design and architectural theory. Indeed, the most relevant contribution that computers can bring to architectural education today is the possibility of integrating in a unified discourse, different subject-matters that traditionally have been kept separate in the architectural curriculum.

## Acknowledgements

The courses described have taken place in the course of the teaching activity of the author at the Professur für Architektur und CAAD-Prof. Gerhard Schmitt, ETH Zürich. I would like to thank Prof. Schmitt for his support in the development and implementation of this pedagogic project. My special thanks go also to the students who have made this teaching project possible, year after year, with their enthusiasm and good work.

## References

Arnheim, Rudolf (1977). *The Dynamics of Architectural Form*. University of California Press. Berkeley and Los Angeles.

Bruegmann, Robert (1989). 'The Pencil and the Electronic Sketchboard: Architectural Representation and the Computer'. Published in *Architecture and its Image*. Eve Blau and Edward Kaufman, editors. Canadian Center for Architecture, Montreal.

Giedion, Sigfried (1954). *Space, Time and Architecture*. Harvard University Press, Cambridge. First published in 1941.

Itten, Johannes (1975). *Gestaltungs- und Formenlehre*. Otto Maier Verlag Ravensburg.

Hersey, George and Richard Freedman (1992). Possible Palladian Villas (Plus a Few Instructively Impossible Ones). The MIT Press, Cambridge and London.

Hofstadter, Douglas R. (1979). Gödel, Escher, Bach: an Eternal Golden Brain. Penguin Books.

Hofstadter, Douglas R. (1982). 'Metamagical Themas. Variations on a theme as the essence of imagination'. Scientific American, October.

Joosten, Joop and Angelica Zander Rudenstine (1994), Catalogue of the exhibition Piet Mondrian 1872-1944, Leonardo Arte.

McKim, Robert (1972). Experiences in Visual Thinking. Monterrey, California. Brooks/Cole.

Madrazo, Leandro (1992a). Design Education with Computers. Proceedings of CAAD Futures '91. Gerhard Schmitt, editor. Vieweg & Sohn. Wiesbaden.

Madrazo, Leandro (1992b). Keywords: Notes on Form, Space and Architecture. Publication of the Professur für Architektur und CAAD, ETH Zürich.

Madrazo, Leandro (1993). Entwurfsunterricht mit dem Computer: eine Methode. In New Realities-Neue Wirklichkeiten. Entwerfen im Zeichen des Computers. Museum für Gestaltung Zürich.

Madrazo, Leandro (1996). Structures: Text, Shape, Object, Space, Light. Publication of the Professur für Architektur und CAAD, ETH Zürich.

# The Value when Cybernetics is added to CAAD

**Ranulph Glanville**

CybernEthics Research TM  
United Kingdom

*In this paper it is argued that cybernetics gives added value to design in general and to CAAD in particular. Essential cybernetic concepts are introduced, and are then shown to reflect design. These reflections are shown to be potentially amplifiable by the use of computers through CAAD, if we will and dare it.*



# The Value when Cybernetics is Added to CAAD

## Foreword

The theme of this conference is added value. In general, the idea is to explore how CAAD gives added value when it is applied. In contrast, in this paper (in some respects more of a tutorial) I explore how another subject (in this case, Cybernetics) adds to the value of CAAD.

In order to do this, I firstly talk about the relationship of theory to those subjects in which it is applied. It has become common for theory to be imported from one area into another, and it is interesting to consider why. What is theory about and why do we like to have it? This is a question of particular interest, I believe, in architecture. But it also leads to the need for examining aspects of theory, in itself.

There then follows what is, in effect, a tutorial section, in which I introduce a number of cybernetic concepts which I believe to be of great value to architecture, both from the point of view of the application of theory, and also in their own right. (I assume, as has been indicated by many including me, that architecture, or, more generally, design and Cybernetics have a great deal in common.) This forms the main section of this paper. I explain these Cybernetic concepts and their extensions, and I also introduce certain concepts concerning computation, some of which are clearly tied up in the Cybernetic concept-world.

Finally, I indicate how these concepts shed light on design and outline their particular relevance in CAAD, improving performance and, thus, adding value.

This is an ambitious undertaking. Inevitably, it is underexplained. There is much to be argued, and this is not possible within the scope of a single, short paper. Much of this I have argued elsewhere (see, eg, Glanville 1995, 1997). But not all. Much is also new.

## Theory

Scientists have some clearly thought out concepts concerning theory.

For instance, theory is what is proposed to explain the phenomena that science concerns itself with. This approach to theory concerns itself with the notion of description, abstraction (pattern finding) and testing, for instance: it is looking to exactly describe patterns in the phenomena of observation such that the description is always in accordance with the patterns in the phenomena. Thus, this sort of theory is attempting to attain the unattainable: it is constituted of a number of concepts, several of which even seem to be in contradiction: for instance, that the description is made of observations, yet that there may be a "truth" waiting to be revealed. In its peculiar and sceptical approach it espouses

falsification: the job of science is to test these descriptions to destruction.<sup>1</sup> (Popper 1963)

The benefits of this approach and of the development of this sort of theory (especially, I believe, the avowal of rigour and argument) are always with us as part of our everyday lives.

I would like to suggest that our use of, even need for, theory may be considered in another way. Theory lets us believe we are alright. If what we say is in accord with a theory, we have reason to believe it is strong and viable. (This assumes the theory is “right”. But for many, merely having a theory makes it right.) Thus, theory satisfies a psychological need, the need to feel that there is justification and that opinions are not alone. It provides security in an insecure, unmanageable world. It helps us . It gives cohesion and an overview: and it simplifies the world so that we do not have, personally, to take responsibility for everything we find. It is a prop. And it lends authority.<sup>2</sup>

This view is in accord with the general view of theory and, in particular, science. This view holds that humankind starts to face the complexity of the world it finds itself in (or it constructs for itself) by the construction of myth, the first theory. The role of myth is to explain the universe, to handle the incomprehensible, and to give rites and routines that allow both a belief in control and the ability to pass on some responsibilities. In this (constructed, historical) view, theory helps us believe there is sense and that we have a place. This belief remains behind all developments and applications of theory. My proposal of the psychological basis for the acquisition and application of theory is in broad accord with this view.

## **Cybernetics as the Theory of/for Design**

It is my view that Cybernetics is the theory that matches the activity of design. It shares the form and preoccupations of design, and its way of working, unlike so many other theories that design has borrowed, pasting them on top of the practice of design. The connection is integral and natural.

I am not alone in this view. As early as 1969, my teacher Gordon Pask indicated he saw a relevance of Cybernetics for Architecture both in providing a sensitive and appropriate theory and in his characterisation of design as a conversation with yourself via paper and pencil, about which more later (Pask 1969).

In order to demonstrate the viability of this assertion, we can look to the sort of appreciation of theory that the scientist has. We have to ask not only about the theory’s ability to support our insecurities, but also its ability to shed light on the subject. In particular, we look to see if the theory not only helps us understand a subject area better (with more

---

<sup>1</sup> I do not wish to debate the social correctness of the position assumed here, as many have done, although I do not believe scientists really behave in this manner: it is a (hopeless) ideal.

<sup>2</sup> On another occasion I shall hope to argue this point more fully: I include it here because I believe it will have an immediate resonance with thinking architects.

clarity, greater coherence, etc), but also whether it can extend our understanding and appreciation of the area the theory operates on. Usually this is taken to be successful prediction. Good theories predict what we had not yet experienced/known. But they also account for more with less: this is Occam's Razor, the origin of Philip Johnson's Miesian aphorism "Less is More".

If Cybernetics does this for design, and particularly for Computer Aided Architectural Design, then my assertion can be taken to have more than psychological value (although I am certainly not belittling the importance of this). If it does not, we can dismiss the parallel, or pursue modification possibilities: but we will not need to do either of these!

## Cybernetics

In its modern incarnation, Cybernetics can be said to stem from Norbert Wiener's book (Wiener, 1948) entitled "Cybernetics: or Control and Communication in the Animal and the Machine". However, it is Ross Ashby's 1956 book "An Introduction to Cybernetics" (Ashby 1956) that is the main source for (aspects of) the characterisation of Cybernetics given in the following sections, for it takes the work of Wiener and his colleagues and distils it into one, unified, coherent and highly abstracted body.<sup>1</sup> I use this book as a general reference for Cybernetics in general and for most of Ashby's concepts (except where otherwise referenced).

In this paper I briefly introduce certain aspects of Cybernetics that do, I believe, add value to CAAD.

## Feedback

Cybernetic systems are often characterised through feedback. Feedback is necessary wherever there is (potential) error: Feedback lets the actor in a situation know whether the result of his action is what he desired (ie, did it achieve the goal). If not, it is possible to try again, having modified the action according to the error (the result), to compensate for (take account of) it.

## Control

Feedback is, therefore, central to the working of control. If one system is to control another, it needs to know what that other is doing and, if it is not doing as required, to be able to control the other (use it to modify its behaviour) so that it performs more as required.

However, the controlling system must also modify its behaviour, itself, according to how the other system is doing. Ie, it is controlled by the other system. Thus control, through the action of the feedback loop, is circular. The controlling system is itself controlled by the controlled

---

<sup>1</sup> Heinz von Foerster tells a lovely story about Ashby. When in the late 1960s he was visiting the Biological Computer Laboratory in Urbana Illinois, Heinz asked Ashby's students how he was getting on. The students said it was all rather simple. With some trepidation, Heinz told Ashby this. Ashby burst into enormous guffaws of laughter. He said "It's taken me 20 years to make it that simple".

system: which is controlling and which is controlled is a matter of a naming convention. Control exists within the circularity (between the systems), and not in one, the other, or even both of them.

Think of a thermostat. The wall switch turns the heating system on and off. What turns the switch on and off?

## Communication

In order for control to be possible and to be effective, information must pass between the systems in the control loop indicating the states the systems are in. In this respect, communication is simple and trivial. But the moment communication is studied in its own right it is no longer trivial. For instance, just how are the (results of) actions encoded into information, and just how is that information transmitted and unencoded? And how do we know that this leads to the meaning being transmitted? What about the characteristics of the means of transmission (eg noise)? Communication is raised as a significant question.

## The Observer

Until recently it has been customary to talk of that which we observe as if the observer<sup>1</sup> did not impinge upon it. Observations happened, and thus, not being the responsibility of anyone in particular, could be assumed to emanate from a postulated reality. This reality has the property of continuing immutable, and following some laws (of nature) which it was our task to discover, thus becoming revealed to us without our involvement.

In a circular system this is not a tenable position. The observer is in the system (or, as the Americans say, in the loop). In observing, the observer interacts with that which is observed and, so doing, changes it. The observer is not without effect, just as the controller in a (circular) control system interacts with that which was thought of as the controlled.

Cybernetics is concerned with systems in which the observer also makes judgements and initiates actions, and accepts that, in observing a system using the Cybernetic perspective, the observation of that system affects that system (ie, that “scientific” observation is not viable within the cybernetic model—except, perhaps, as a special case, according to Occam’s Razor).

## Second Order Cybernetics

The explicit inclusion of the observer in the system that changes the system so that it becomes a proper part of second order Cybernetics.<sup>2</sup> Second order Cybernetics is the Cybernetics that is aware of itself, that

---

<sup>1</sup> Observe is used here as an abstraction, not meaning “see”, but meaning to sense in any manner.

<sup>2</sup> I would prefer no longer to differentiate first from second order cybernetics. To me, one of the lessons of second order cybernetics is that the first order is properly part of the second order, and that when we treated it as first order it was because we didn’t know how to move on!



examines itself as (part of) its subject area (the Cybernetics of Cybernetics). It is the Cybernetics of observing (as opposed to observed) systems (von Foerster 1974).

Second order systems are becoming well enough known nowadays, but they create problems in theory. Second order Cybernetics has set out to deal with these problems. It has examined the nature of systems in which the observer is an actor, and in which observing is seen as active, ie the observer's observations do not come about by magic but involve an active and participant connection with the system.

## **Difference**

In including the observer in the system, the individual difference between the particular observer (you, me, the others) becomes very important. When the observer is not part of the system, and observations magically come to him, somehow preformed to be just what is required, the observer may be without impact. When the observer is part of the system the particularity of the observer counts. There are devices to minimise this difference (they are very useful, and they do allow us a "science": indeed, the conventional scientific observer is one such). But Cybernetics accepts that these differences are present, and does neither deny them nor attempt to dismiss them or rule them out, any more than it denies the existence of error, or attempts to dismiss that.

Thus, the significance of being you, or me, is recognised in Cybernetics.

## **The Black Box**

A characterising cybernetic device is the Black Box.<sup>1</sup> This is a conceptual device that creates transformations between signals understood as entering and leaving the device. The observer observes both in and output. Indeed, the observer modifies the input (feedback). The arrangement is circular. The observer builds descriptions of the behaviour of the Black Box: these are used to predict outputs from the inputs the observer applies. The description is not what is in the Black Box (which we can never see inside). It is a proposal which we test. Because we have no idea what is in the Black Box, the description cannot have that sort of truth value (but what description can?): and this means that the Black Box embodies Wittgenstein's assertion that because something has gone on does not mean that it must continue to go on.

The Black Box is the device that embodies our ability to continue and to act in spite of not knowing what is there: the world as constructed

---

<sup>1</sup> Ashby, who writes extensively about the Black Box, claims that the Black Box is a universal model for the mechanism of our ability to understand. He asserts that James Clerk Maxwell invented the concept, although I have never been able to trace this. There are many who state that the Black Box is a first order cybernetic device. I disagree. In the circularity of its description and in its accepted and inherent uncertainty, it is truly second order. I had a long and difficult disagreement with Geoffrey Vickers over this: he assumed the Black Box was entirely reductionist and mechanical; I assume it is non-reductionist and deeply human! In the end I persuaded him of my point.

hypothesis and description. It conquers the ignorance that is the basis of human existence. (Glanville 1979, 1982)

## **Conversation (not Code)**

When you don't know what others are thinking (and who, in all honesty, ever knows this?), you might use the Black Box model to describe their behaviours.<sup>1</sup>

Conversation is the mechanism that allows us to communicate even when we don't know what it is we are talking about<sup>2</sup>, and even when we cannot know what our conversational partner is thinking. In a conversation, each of us builds our own understandings and our own meanings.<sup>3</sup> We express what we wish through the medium of some "language", which our conversational partner hears as they will, and then re-iterates to us through the medium of language in their own words. If we can build an understanding from the partner's reiteration that matches our original intention, then we can assume we have communicated and that our partner has a meaning that, for them, works more or less as ours works for us. We own the development of this mechanism, and the concepts that go with it, to Pask (who worked extensively with architects).

Notice that there is no communication or meeting of meanings. And, since each of us makes our own meanings (different as we are), there is always "mismatch". This can lead to novelty: that you see things differently to me and communicate some of this can lead, should I keep an open mind, to new ideas that you, my conversational partner, give me.

This is in sharp contrast to the notion of coding, in which accuracy of communication is taken to be determinable and is all-important. In coding, there is no difference in understanding between the partners (whereas in conversation there is no alternative), and messages are transmitted from the source to the reception, whereas in conversation communication is between participants. Coding, in this sense, is a very limited version of conversation. (Glanville 1995)

## **Complexity and the Possible**

---

<sup>1</sup> In both senses. The Black Box might be the device chosen as the description type, and the working of the Black Box might be used to build the precise description.

<sup>2</sup> In the sense of the Black Box, rather than in the sense of the being loudly ignorant and assertive!

<sup>3</sup> I would argue that this is the general case. But not here. This takes a whole paper of its own! See Glanville (1996).

Another aspect of Cybernetics is its concern for complexity and for what is and is not, in principle, computable. Hans Bremmerman (1962) carried out a calculation on the theoretical computational capacity of matter (bits per gram per second). From this, Ashby (1964) calculated how much the earth, as computer, might have computed in its lifetime, as well as how much the universe might calculate. These rather arcane calculations should not be taken as accurate. They give a sense of scale and indicate that there are limits. Looking at the structure of these limits and combinatorics, one can very easily see that the possible answers to well-defined questions rapidly become beyond what could be computed even if the earth, or for that matter the universe, was a computer. Thus they are transcomputable.<sup>1</sup>

One example is in the choice of possible combinations of chemical elements. Apparently, according to Christopher Alexander (I cannot find the reference), there are  $10^{20}$  possible combinations of chemical elements. Based on best estimates of the size of the universe and assuming the universe is a perfect computer, the universe, in its entire life, would not have been able to compute which combination of 5 elements would provide the ideal collection of materials for some purpose (eg, building a room: how many rooms only use 5 materials).

### **Variety (and the Law of Requisite Variety)**

A measure of complexity is Variety. Variety is a measure of the number of states a system can have (repeated states are considered only to be one state). It is closely analogous to Shannon and Weaver's concept of information. There is a very important law that concerns the behaviour of systems that are to control other systems, the Law of Requisite Variety (due to Ashby). The Law of Requisite Variety is a law from first order Cybernetics . It states that the variety of the system that is controlling must at least equal the variety of the system to be controlled. If it is not, then it is not possible for the controlling system to "take into account" all the possibilities of the controlled system: in which case the so-called control would not be control but restriction.<sup>2</sup>

The second order corollary is that the variety in the controlling system must exactly equal that in the controlled system, since either could be named to the role controlled, and either the name controlling. Since both must have variety at least equal to the other, the only possibility is that both have variety exactly equal to each other. This is, of course, an enormous difficulty even in the relatively undemanding situation where the controlled system goes transcomputable.

---

<sup>1</sup> Of course, there are different ways of describing the contexts within which questions are formed. It is perfectly possible to answer a question by immediate association: the next thing that happens is taken to be the answer: this requires very little computational power.

<sup>2</sup> The cybernetic concept of control is technical and devoid of the unpleasant notions that we often include with control, such as the type of so-called control Hitler exerted. Hitler, in the cybernetic sense, did not control: he destroyed variety and restricted the system. The cybernetic notion of control is closely allied to that of regulation.

## Computing

I have argued at length concerning the nature of the computer and its application in design (eg Glanville 1994b, 1995).

I summarise here.

Computers make vast numbers of perfect copies almost instantly, and can send them virtually (!) anywhere in the world. This destroys uniqueness and hence that value of owning the original. Origination remains important. Owning the original does not.

Computers can carry out calculations that are vastly more complex than those we can manage, even working as a team for a long period. This was apparent right from the start, in Bletchley Park.<sup>1</sup> Thus, the scale of iteration that may be considered is changed (this makes slow acting genetic algorithms such as used by John Frazer (Frazer 1995) viable), and the shapes resulting from the intersection of complex shapes can be determined.

Computers can carry out transformations that are also beyond our powers. That is to say, computers can transform things in ways that are, at worst, only vaguely imaginable, and at best, completely beyond what we can imagine. Betweening and morphing are capable of suggesting new forms that we could not ourselves envisage.

Computer programs also have characteristics of their own. Often these go unnoticed. One way to reveal them is to encourage their abuse: ie, to use the software in ways beyond those intended. Inevitably, this way of using software in unexpected and unintended ways leads to surprises.

Finally, computers go wrong. What do we mean by “go wrong”? One characterisation is that they behave in ways we did not anticipate. Sometimes this is thoroughly destructive (hard disc crash). In others, it can be enlightening. This is serendipity. Any machine is liable to go wrong: finding ways of benefiting from this is a constructive and potentially regarding challenge.

## Cybernetics, CAAD and Architecture

From my point of view, the purpose of CAAD is to help us increase our creativity. Of course, creativity is a difficult area. It is in the nature of creativity that it cannot be either predicted or measured. When I talk of increasing creativity I talk in the manner of Ashby’s (Cybernetic) amplification of intelligence (Ashby 1956). Ashby suggested that, to transcend the fixedness of the brain’s variety, we could increase our effective intelligence through narrowing the areas we worked in. I believe we can enhance creativity in a manner similar in approach but the reverse in application: that is, we can increase the range of resources (ie

---

<sup>1</sup> The home of the original computers built under the direction of Alan Turing during the Second World War and used to check possible combinations in decoding the German Enigma Code.

the variety) available to us. And I am interested in the use of computers to aid this, in the belief that this enhances at least our potential creativity.

This is not without problems. Increasing range can, for instance, lead to overload. Nor is this the only way computers can aid architectural design: improved visualisation, clash checking and other co-ordinative activities and rule based form generation are all areas in which computers are taken to aid architectural design. I do not, here, wish to question this. But neither do I want to discuss these ways of helping or their effectiveness. I shall stick to the potential enhancement of creativity.

## **Design as Reflected in Cybernetic Theory**

As early as 1968, and in sharp contrast to the prevailing approach in design research and methods, the cybernetician Gordon Pask had seen the connection between design (and specifically architecture) and Cybernetics. Pask spent much of his working life associating with architects (for instance, he worked with Cedric Price on Joan Littlewood's Fun Palace), and, to the end of his life, taught at the Architectural Association School in London (where his memorial was celebrated). He argued (although for different reasons than those I give here) that Cybernetics was able to provide the theory that was appropriate to architecture. And he argued that design was akin to holding a conversation with yourself via paper and pencil. On the base line, design is a circular process, and so is Cybernetics.

Thus, one would expect Cybernetics to be able to inform design at all levels and as practised through whatever form, including the use of computation. And perhaps one would expect even more since cybernetics is so often identified with computation and the future.

## **The Observer is a Designer**

Many studies of designers at work are made by (pseudo) classical observers who like not to participate. And many accounts of how designers do their work make designers look like classical observers.

This is rather like the peculiar trick that biologists have traditionally played: killing what is alive in order to study life.

Cybernetics offers a paradigm in which the observer is within the system, that is, the observer behaves in the same manner as the designer. In effect, in Cybernetics we are concerned with activities as verbs, not nouns. The involvement of the observer parallels the involvement of the designer. It is circular, and it partakes in forming the outcome.

In addition, since each observer is different, each point of view is different, too. Thus, individual difference is preserved (and, with it, personality, individuality and style).

## **Design, Surprise and the Unknowable**

Any theory that is to account for design, at least in the sense in which I mean it, must integrally support the notion of surprise. The experience of

design is, I believe, rich in surprise, in finding the unknown and the unpredictable. The process of design typically involves finding that the design act itself leads the designer: you start with one idea and this develops to another, often while you are quite unaware of it. Equally, you make some doodle or sketch and, looking at it, are surprised to find in it ideas and images you have no awareness of having put there (hence Pask's styling of design as a conversation with yourself via paper and pencil). Designers handle the unknown and the unpredictable. This property is not one that comes about from poverty of description, but is structural.

For example, this is not a matter of emergence. I have argued (Glanville 1994a) that emergence is a property that derives from the description after the event. In contrast, this is a matter of being surprised and of not quite knowing what will happen, ie involving novelty: which, after the event, may appear describable as emergence.

The Black Box model is a model in which the unknown is accepted and welcomed. Indeed it is the *raison-d'être*. It is integral. Of all models, this is the simplest to permit the unknown. And it involves interaction with the observer to make whatever will become known known. (In this it is radically different from such models as chaos, etc, which develop in and of themselves, autogenetically.) The Black Box models the development of some believed in description or statement of what is, through interaction with the observer. Substitute designer and medium (eg paper and pencil), and you have a description of designing which recognises and develops the element of surprise and dealing with the unknown.

This raises a challenge for the computer. Can CAAD act in the manner of paper and pencil, ie as a Black Box, to participate in and encourage the creation of novelty and surprise that so characterise design? (I believe it can, and cover this briefly below.) The cybernetic model of the Black Box not only describes the activity of design, it also challenges us in using CAAD in designing.

## **Variety, Sharing and Copying**

The Law of Requisite Variety tells us, for instance, that the so-called controlling system must have at least as much variety as the controlled system. Very often, this seems not to be possible. For instance, the variety in a teacher's brain is very unlikely to be able to even begin to approach the variety available in a classroom full of scholars (see Robinson 1979).

There are three ways to deal with this (retaining the classroom example). The first, the traditional (military/fascist) way, is to reduce the variety in the classroom. This is familiar from the conventions of the old-fashioned classroom.

The second is to allow some form of mutual control, such as has been practised quite generally in more recent educational strategies in which students form groups and the teacher is a facilitator, observer, friend.

The third is to increase the variety in the teacher's brain.

This latter is the strategy of interest here.

How can this be done?

The architectural studio is an example. You can increase the variety in your brain if you can borrow the brains of others. And this is precisely what happens, at least to some extent, in the architectural studio.<sup>1</sup> The studio is a place where theft is legalised, or, rather, where the notion of ownership of ideas is rejected—as it should be—and replaced with the notions of respect for origination and free access. It is an arrangement where we borrow each other's creativity. The question is how, with computers, we might arrange something similar.

## Conversation

To increase the range of what we can experience, we share. We do this through the form of conversation. Conversation is a circular feedback mutual control mechanism in which all is assumed to be intelligent (Turing teaches us that intelligence is an attribute, not a property). Conversation admits that it will wander (while not becoming unstable). Conversation allows that we will find novelty, that ideas will move from one to another, developing, bifurcating and contradicting. Conversation is a medium in which we treat other participants as partners (that is, we attribute to them the properties we attribute to ourselves). Conversation is open, full of “misunderstanding“ and consequent revelation. Conversation is an activity that exactly reflects the process of design, as we experience it.

In a conversation, we need to give to our partners: we have to be open-minded and generous, treating each as a worthwhile and distinct individual, otherwise we cannot hear what they have to offer. In acting this way, we affirm that we have these qualities. Conversation is a mirror: what we see into others is a reflection of ourselves. Thus, conversation affirms our distinction and generosity. It allows—it requires—us to exist as actors who play differently. It is the only model we know to permit communication, that respects the individuals involved.

## Design, Cybernetics and CAAD

In the previous sections, a number of observations have been made about how Cybernetics can act as the theory of design, including some that suggest extensions to our understanding of design.

In this final section, I will indicate how some of these findings can drive computing so that CAAD can become much richer, and more capable of generating an improvement in quality of design through positive interaction. I could have told the story the other way round, but it seems

---

<sup>1</sup> As noted earlier, Ashby argued that you could increase the intelligence of a person by restricting what he was working on: constant variety applied to a smaller problem space. Others have followed this notion of intelligence amplification. In handling creativity, in contrast, I propose that the problem space be kept as large as is wished: and we borrow the creativity of others.

to me, at the moment, to be potentially more productive to retain CAAD as an extension of design as we see it.

Can we, for instance, use the computer to build an equivalent of the studio: that is, to handle the problem of requisite variety/creativity amplification? Certainly. And we can use it to enhance the studio-like idea, too. If we draw on computers (for instance) and arrange so we can copy (computers are excellent at copying and distributing files), we can vastly widen the range of potential sharing by sending our drawing files to a vast number of other (human) designers/users. At the same time, by examining how users borrow, and what of what's offered them they accept, we can predict—that is, eventually learn to tune the material sent on. Finally, by tracing borrowing, we can return modified work (eg drawings) to original and earlier contributing authors (also learning about whether there are designers whose work seems to be drawn together in the (later) work of others). This also allows us to benefit from being “out of control”: that is, from letting ideas come to us through our openness to receive them, rather than through our insistence that we force them from ourselves. We use the computer to make for better communication between (more) human designers, whose creativity thus becomes available to us, while also sending them feedback, enriching them, too. Thus, we benefit from incalculable complexity: and yet we are not lost. We have a way to interact—a model<sup>1</sup>.

What about surprise, novelty, and the Black Box? The answer here is yes, too. We can treat the computer as a Black Box (not as a literal electronic Black Box, which probably no one would truly claim to understand, but as something that we develop understandings through interacting with and which we allow to surprise us). One way of putting this is that we stop insisting the computer “goes wrong” and, instead, see if these “errors” are not blessings. Another way is to use the computer in ways other than those apparently intended, usually by software manufacturer. I call this “abuse”: using equipment in manners other than those the manuals tell us about, letting them surprise us.

This relates to the idea of the conversation, and the medium/partner. Can we treat CAAD as a medium? To treat it as a medium means to accept it has qualities of its own, that we cannot just say what we want for the medium will form it somehow. In much CAAD computer software the concept of a medium is already inherent, although the descriptive language is that of the tool (a medium is a tool that “kicks back”). We then work with a (human) partner through the medium of computing. But to really accept that CAAD is a medium will involve us in accepting that it changes what we do rather than attempting to command it to do our will. A medium is not a slave: it is already a partner.

At another level, too, we can hope to treat the computer as the literal (and non-human) partner in a conversation: to attribute to it the intelligence to join in developing the conversation itself. This may be a matter of putting

---

<sup>1</sup> There are associated problems. For instance, the enormous increase in material we face, and the need to order and filter it, is immediately apparent



the “AI” in CAAD: CAAIAD. However, work such as that of Frazer (Frazer 1995) may already be seen as doing this.

To participate in a conversation with the computer means either treating it as the medium of conversation (in which case it will change what we do), or as our conversational partner (in which case it will change what we do), or both (in which case...). It means we stop commanding, and set to listening, to see what’s on offer.

There are other possibilities that computation offers through CAAD. We can surprise ourselves with calculations of great complexity that allow us to transform and visualise in ways never previously possible. We can fly through spaces, and one day we may really be able to mould them to our whim, on the fly. We can do things that are beyond us.

The argument given here, and the examples, tie in with the cybernetic understandings I have indicated and are enriched by them. They are imbued by the ideas of surprise, of being out of control (or at least not being fully in control), of openness and gratitude and watching how and where things take us, which I take to be the major attributes of design that differentiate it from other activities (and which make it so centrally human, so much the basis of how we understand ourselves to think, and therefore of our world).

## Afterword

I describe just a beginning. I am limited by my imagination and to my imaginings. As I treat the computer more as a partner, it will tell me more of what it can do. More will be on offer, if I am willing to see it. I believe Cybernetics will help here, for Cybernetics and design are opposite sides of the same coin, and Cybernetics does, indeed, illuminate design. And computing.

## References

- Ashby, R (1956) “An Introduction to Cybernetics” London, Chapman and Hall
- Ashby, R (1964) “Introductory Remarks at a Panel Discussion” in Mesarovic, M (ed) “Views in General Systems Theory” Chichester, John Wileys and Sons
- Bremmermann, H (1962) “Optimisation Through Evolution and Re-Combination” in Yovits, M, Sawbi, G and Goldstein, G (eds) “Self-Organising Systems” Washington DC, Spartan Books
- Foerster, H von (1974) “The Cybernetics of Cybernetics” Champaign-Urbana, BCL-University of Illinois
- Frazer, J (1995) “An Evolutionary Architecture” London, Architectural Association

- Glanville, R (1979) "The Form of Cybernetics: Whitening the Black Box" in Miller, J (ed), "Proceedings of 24 Society for General Systems Research/American Association for the Advancement of Science Meeting, Houston, 1979" Louisville, Society for General Systems Research
- Glanville, R (1980) "The Architecture of the Computable" Design Studies vol 1 no 4
- Glanville, R (1982) "Inside Every White Box there are two Black Boxes trying to get out" Behavioural Science vol 12 no 1
- Glanville, R (1994a) contribution to workshop on Emergence, 7th Congress of the International Institute for Advanced Studies in Systems Research and Cybernetics, Baden-Baden
- Glanville, R (1994b) "Variety in Design" Systems Research vol 11 no 3
- Glanville, R (1995) "Architecture and Computing: a Medium Approach" in Kalisperis, L and Kolarevic, B (eds) "Computing in Design: enabling, Capturing and Sharing Ideas—ACADIA '95" Seattle, University of Washington
- Glanville, R (1996) "Communication without Coding: Cybernetics, Meaning and Language (How Language, Becoming a System, Betrays Itself)" Modern Language Notes vol 111 no 3
- Glanville, R (1997) "MIXIT" grant application to the European Community Training and Mobility of Researchers Panel.
- Pask, G (1969) "The Architectural Relevance of Cybernetics" Architectural Design 9/1969
- Pask, G (1975) "Conversation, Cognition and Learning" London, Hutchinson
- Popper, K (1963) "Conjectures and Refutations" London, Routledge and Kegan Paul
- Robinson, M (1979) "Classroom Control: Some Cybernetic Comments on the Possible and the Impossible" Instructional Science vol 8
- Wiener, N (1948) "Cybernetics" Cambridge Mass, MIT Press

# The House of Illusion : Extending the Boundaries of Space

**Wolfgang Strauss**  
**Monika Fleischmann**  
School of Fine Arts Saarbruecken  
Germany

*The article presents projects on spatial research and Interface Design. The interdisciplinary work was done at ART+COM and the German National Research Center for Information Technology GMD. The work focuses on new notions of space as they emerge from the use of information and communication technologies. As new forms of perception and experience of time and space emerge, new fields of architecture appear. By using the computer as a media our architects office has changed into a Media Space Lab.*

**Keywords:** *man-machine communication, unsharp/intuitive interfaces , Interactive storytelling*



## **THE HOUSE OF ILLUSION: EXTENDING THE BOUNDARIES OF SPACE**

The article presents projects on spatial research and Interface Design. The interdisciplinary work was done at ART+COM and the German National Research Center for Information Technology GMD. The work focuses on new notions of space as they emerge from the use of information and communication technologies. As new forms of perception and experience of time and space emerge, new fields of architecture appear. By using the computer as a media our architects office has changed into a Media Space Lab.

### **The digital crash or what happens if... ... the musicians change their instruments?**

Working with digital media challenges our preconceptions of things. We stand to lose nothing less than our identity in doing so. In the digital design process, in a stream of calculations, miscalculations occur. Imagine a cube with eight corner points and six sides. Most of us can picture this in our mind's eye. But computers cannot. They do not have the same cultural conditioning as we do. If we enter cubes, cubes and even more cubes into the computer it will eventually respond with a digital crash. Technology only becomes reality through the drama of the crash. Only then does the actual involvement with the machine really begin. The crash calculates cubes in innumerable manifestations as constellations of 8 points and 6 sides in space. This gives rise to a whole series of possibilities, possible manifestations and virtual realities. As in the domain of living things, a form only becomes reality because it undergoes constant change.

"Between 0 + 1" is the name we give to the artistic method we discover following our first crash - the method of decoding and recoding image space. "Between 0 + 1" describes the virtual space that is generated by computing and recomputing. It symbolises a flexible intermediate value, an intermediate space that represents the unknown and the unfocussed between the two fixed values 0 + 1. "Between 0 + 1" plays with the displacement, distortion, stretching and folding of geometry, topology and perspective. Just as if virtual space were fitted with controls and knobs that could be used for the infinitely variable generation of any form that triggers a continuous space metamorphosis. The transformation of the data record transforms virtual cities into planets, gardens or other organisms. Mental images are created in the computer! Images that we turn on their heads and re-interpret from different angles. We find clues to decode the light and sound spaces created using digital-genetic processes. We find them in the distorted images of the anamorphosis and the collage, in high-speed futurism, fragmented cubism and the

crystalline light architecture of Bruno Taut, but also in the analysis of sight.

The speed at which information is conveyed and the quantities involved can be overwhelming for the individual. Can the arts work with science and technology to counteract this feeling of disorientation? To combat disorientation and the omnipresence of technological power we resolve to design "artificial worlds (...) in which we can 'navigate' as if in a game. New metaphors for action time and action space for net travellers" must be devised. Stories should be told that do not pursue narrow narrative forms, but rather incorporate hypermedia, virtual reality and spatial environments.

### **"Cyber City" - a place of communication**

"Berlin - Cyber City" or How do I step into the virtual city? This study is the first of its kind to examine audience anticipation and the use of interactive systems in public spaces. The fall of the Berlin Wall provided the impetus in 1989 for us to take a closer look at our city. The reconstruction of the former capital now reinstated presents a major challenge in urban planning and one for which no-one is prepared. We are interested in making the various plans accessible to the public as a virtual reality game. But how can we convey the complexity of urban planning to a large audience?

The entrance to the "Cyber City" is an aerial shot of Berlin which is secured to a table and forms the reference level of the real city. We play the "let you finger do the walking" game and use an electronic thimble (Polhemus) to move around, show and visualise. The thimble is a sensory mechanism that conveys its positional data on an ongoing basis to the position detector secured underneath the table. The real location on the aerial photograph can thus be coordinated precisely in the computer with the 3-D simulation of the city architecture. The visitor gains both an overview and an insight into the situation. The wall-high projection screen behind the table allows the visitors to follow their virtual trip through the "Tiergarten", past the Congress Hall (now the House of Culture) and the Reichstag. "And this is where we ought to be able to take a stroll through the Brandenburg Gate," calls out an enthusiastic East Berliner and is amazed when he finds he really can "drive through it, turn around and can then even fly back over it".

The table is a metaphor for language and encounter which actually functions. At the international radio and television exhibition in Berlin in 1991 visitors are not discussing the new VR technology but rather what had happened in 1989 when the Wall fell. The virtual table turns urban planning into a discussion of the city that incorporates both past and future. The "Cyber City" can be compared in form with a video sculpture. Set up in a public space it consists of the two elements - a table and a video wall. There are only two main perceptual surfaces: the horizontal (the table with the overview plan that corresponds to the lie of the city) and the vertical (the large video wall which embodies the city facade). The observer becomes a stroller through a virtual film set.

## **"Home of the Brain" - the computer's memory**

While the observer is only the onlooker, this "looking" is a kind of movement. It embodies "active observation". From a certain moment when the observer becomes immersed in the action, his "passive onlooking" is replaced by "active observation". The observer discovers that he - and not the artist - is the one creating the situation. When the situation changes and the observer becomes a player, he suddenly begins to identify himself with the situation. Observation becomes more than merely consumption. In this moment consumption ceases. This is all the more true in interactive scenarios when the observer participates in the game and can intervene in it. In 1990 we endeavour to construct Alice's Wonderland. With virtual reality goggles and gloves, the body is exposed to new spatial experiences. The body is the interface between the interior and the exterior, between reality and virtual reality. "Home of the Brain" - depicted as a metaphor for the computer's memory - is awarded the Golden Nica of Ars Electronica in 1992. The work is a vision of the future of telecommunications. Four year later it will be possible to work with a similar version on the Internet. The Internet is already being used as a public forum, as a venue for the virtual representation of masks, avatares and agents (intelligent advisers). This vision was still Utopia back in 1992.

"Home of the Brain" is a three-dimensional mandala. Every visitor can move around in this virtual environment using the virtual reality glove and finger gestures. He can fly backwards and forwards. He can penetrate into the depths and move through walls. He can make himself extremely large or extremely small by changing the scale of his environment. He can fly through tunnels and even come face to face with himself. He can view things from the perspective of an ant, a mouse or a bird. He will be constantly surprised by what his new body can now do. The performer's gestures will become immediately visible to himself and his audience through the representation of his hand. The entire production can be observed on monitors or a large video screen. The performer functions like a kind of shadow artist in the virtual space behind the screen. "The virtual hand discloses its true soul to us," explains neurologist Hinderk Emrich commenting on the virtual flight and lively movements of a physically handicapped participant in Geneva whom we are watching via ISDN lines from Berlin. Below the head mounted display he cannot see anything of the outside world and instead sees himself as an integral part of the new virtual world which surrounds him. For a short time he feels himself free of his real body. During the virtual flight he sets his own agenda and develops his own personal perspective of sound, since the objects are interactively associated with sounds, noises and fragments of text.

The "Home of the Brain" is inhabited in virtual terms by pioneers in media development. The thoughts of Vilèm Flusser, Paul Virilio, Joseph Weizenbaum and Marvin Minsky are implemented in the computer's memory. "Do we need that? Why do we need it?". Weizenbaum's warnings against the power of the computer and the impotence of reason wrap themselves around his "House of Hope" on Moebius-like chains of

thought. In Virilio's "House of Disaster", the "racing standstill" is tested under trees falling as if in slow motion. Flusser's "House of Adventure" shows his vision of flowing space: "I dream of a house with walls that can be changed at any time, of a world whose structure is no more than an expression of my ideas". In Minsky's "House of Utopia", a crystalline transformation object, future computer generations are discussed "which are so intelligent that we can be pleased if they keep us as pets". The "Home of the Brain" has anticipated paradigms that today are at the very heart of discussions relating to media communication. They include the organisation of information in virtual space, telepresence, information linking and interaction with objects in virtual space.

### **"The Responsive Workbench" - thinking with the hand**

Man is a mover. If man does not move, he is dead. We have learnt to move our "head" alone. The rest has to remain still. Our society has long since run up against a brick wall, since everything in our head is also turning. Be that as it may, we do not want to remain stuck in old systems. Do we really have to sit still at our work? We want to use our hands. We want to draw, build models and not just be keyboard operators. We want to see these models through the virtual camera. We want to let our eye take flight and spring across the wall of reality. Instead of drafting plans we want to produce 25 frames per second. Film language is exerting an influence on architecture. We are developing a photographic pattern of thinking.

In 1994 we design the "Responsive Workbench" as a virtual work desk. The rigid arrangement of computer monitor and keyboard is to be replaced by a real training situation in which architects, engineers, medical staff and scientists can check and change their work in a simulated environment. The "Responsive Workbench" is a further development of the "table" metaphor used in the "Cyber City" project. Real-life situations and activities have been examined as to whether they can be transferred to virtual reality. The haptic checks with activities such as sketching, drawing, writing and painting are performed intuitively when we work with our hands. Kant calls the hand "man's external brain". The gestures of the hands and the gestures of speech control events on this reactive workbench. The person's own sight and body movements are connected to sensors that open up a dynamic perspective. The machine understands and reads our wishes for every possible observer standpoint and does so immediately from the eyes.

Sensor-controlled stereo goggles makes the objects under the interactive glass projection table appear as transparent holographs. Visual houses can be designed and changed with a virtual reality glove. Every angle of vision, each one of my body movements is recalculated in real time as a function of the virtual object. In medical simulations, the beating heart of a virtual patient can be lifted out, removed and examined from every angle. A self-learning voice recognition system reacts to specific commands in order to keep the hands free for other operations. The user interacts with the virtual scenario, displacing, changing and manipulating



it in order to test it for realism. He can also retrieve information from the computer which works invisibly in the background. The objects and activities themselves become the inputs and outputs for this environment. There is no longer a clearly perceivable interface between the user and the system.

### **"The Virtual Balance" - looking with the feet**

We want to be able to move freely in space while we are thinking. We want to be able to think aloud and want to be able to describe the space we are designing. These descriptions give rise to new moving images in our heads. We generate and develop an idea in discussions with others using our bodies.

Like Hermes the celestial messenger, the observer navigates as a "Skywriter" using "virtual balance" and the metamorphosis of digital landscapes. To do this, he uses neither mouse, joystick or virtual reality glove. He simply has to move his body's centre of gravity accordingly to allow him to fly upwards or downwards, to the right or to the left. Unlike a joystick or mouse which reduces man to minimal reflex actions, "Virtual Balance" requires the coordinated use of the entire body and its perception. Neither time optimisation nor disjointed gestures are required, but rather an interplay of the senses. Apparently without effort, the "Skywriter" is able to fly through virtual landscapes. Linear storytelling is translated into interactive action and transformed into virtual space-time. The dramatic effect of the action is governed by the person's relationship to his own body. Here, too, we observe physically handicapped persons who are motivated in their movements. The ground below their feet becomes an interactive surface and the body's perceptual sensitivity coupled with body balance become a control instrument.

"Virtual Balance" is a navigational system for controlling images through the use of the body. It is also a platform for observing the effect of images on the body. In the "Telepolis" 1995 exhibition in Luxembourg, Luxembourg's Grand Duchess accompanies her tour through the virtual city of Xanten with real-life jumps and reinforced body movements. During the presentation at CeBit '96 in Hanover, neurologist Hinderk Emrich finds himself repeatedly in dance situations and discovers there an "enthraling" perspective of the virtual world.

"Virtual Balance" was developed in 1995. It consists of a platform with 3 weight sensors and is controlled solely by the changes in the position of the human body's centre of gravity. Movements and gestures, the body and the entire perceptual apparatus become the interface. The observer's positional information is passed to the graphical system for the purpose of calculating the current image and the required information. Depending on the level of detail of the virtual model, which is calculated from the distance to the virtual objects, different information content is made available to the observer. For example, the visitor can take a virtual trip into the Xanten of the past. The "Skywriter" recognises a certain amount of detail as he approaches specific houses or temples. With the freely designed elements, the objective when working with the simulation is to

convey a feeling of poetry and to motivate the observer in the learning process and, in doing so, to make him curious about reality. Colonia Ulpia Traiana was a Roman settlement that existed around 100 A.D. and which has been partially reconstructed in the archaeological park in Xanten and is still being excavated. In cooperation with architects, construction engineers, archaeologists and computer scientists a spatial computer model is being constructed on the basis of the archaeologists' current understanding of the structure of this ancient settlement.

This first application in part of a global navigational concept that can be accessed via the Internet or as a permanent installation on site. The "Skywriter" will then fly through virtual continents, eavesdrop on the sounds of the various cultures, or discover the symbol sets of the different peoples. The "Global Passage" around the virtual world is intended to visualise cultural identity and convey this between different cultures. In the longer term, it will be possible to control this virtual world tour using two synchronous interfaces. The navigator will then be accompanied by a second "Skywriter". The coordinated movement of the two navigators is then used to control a shared virtual trip. The multimedia navigational environment is ideally suited for public spaces, banks, department stores and museums in order to be able to make contact with other cultures when travelling to another world or a different location. "Virtual Balance" is envisaged as an interface for navigating in the three dimensional net space, for surfing the Internet, for children, players and performers.

### **Virtual reality and interactivity as medium - the dissolution of space**

Painting, photography and television traditionally assume a static observer who, since the development of the frontal perspective in the Renaissance, has symbolised a distanced, quasi-objective approach. The technologies of virtual reality, on the other hand, anticipates a moving observer who himself is IN the image. Dynamism and constant change are the key features of interactive media, the illusion also encompassing the observer. His movement and location in space determine perspectives and the way of seeing things. He is IN the illusion. Linear spaces with static perspectives and fixed observer standpoints are thus history. Images are becoming virtual spaces unhindered by boundaries. The space is no longer a place, but rather a means.

In physical terms, the observer was always an outsider in the fictive worlds of cinema and television. His involvement in the course of events, in the fiction, called for emotional intelligence, identification and catharsis on the part of the fixed observer who was firmly planted in his seat. With interactive simulation techniques, on the other hand, it is not the mobility of the eye alone that is demanded but of the whole body. From these aspects, the technologies of virtual reality can be linked with other illusion technologies such as panoramas, relief cinema and stereoscopic photography which also enable the eye to move around at will. As with panoramas from the 19th century, interactive media allow

us to develop new dramatic forms of storytelling. The dynamic approach of VR systems is replacing the static perspective of the Renaissance.

In the interactive VR environment, the image space is losing its fixed boundaries. At the same time, while the body's sensation is reinforced, a new feeling for spatial orientation needs to be developed. Identifying the position of the eyes, head and body - like the identification of gestures and speech - has the purpose of harnessing the human senses for directly controlling communication. Man must not be asked to change his body and senses to match the machine. Instead, the machine must be tuned to man's needs. To a far greater extent than with traditional media, the VR media interface serves as a key to the media work and thus determines both the dimension of interaction and the dimension of perception.

We have to bridge the computer with our life experience. The connections between the viewer and the work presented in public is part of the experience we need to develop new man-machine interfaces. Exploring the difference between real space and virtual space, the difference between real time and virtual time, leads us from architecture to cybertecture. Like Jean Cocteau's 'Orphee', we step into the other side of the mirror into a world of images and experience the phenomenon of timeless space.

### **Short-Bio**

Wolfgang Strauss (1951) is architect and visiting professor in interactive media studies at the School of Fine Arts Saarbrücken, Germany. Strauss studied Architecture at the Academie of Fine Arts Berlin and has held teaching positions in Visual Communication at the HDK Berlin and at the KHM Media Art School Cologne. He was co-founder of ART+COM, Berlin in 1988. Strauss and his partners' - Media Artist Monika Fleischmann and Computer-Scientist Christian A. Bohn - work has been included in exhibitions and festivals of new media art worldwide, awarded in 1992 at Ars Electronica with the Golden Nica. Developing design methods for space-related installations and intermedia forms of representation, his recent work as a guest researcher at the GMD Institute for Media Communication in Sankt Augustin deals with the relationship between the human body and the digital image space.

email: [strauss@gmd.de](mailto:strauss@gmd.de), <http://viswiz.gmd.de/projects/art/art.html>



# **Added Value for CAAD in Education**

Highlights of an Exciting 25 years

**T.W. Maver**

University of Strathclyde  
United Kingdom

*The history of CAAD is just 25 years. In that short span of time the subject has advanced from the minority time hobby of a very few academics to a multi-billion ECU industry. This presentation highlights four areas of application of Information Technology to the education of architects and anticipates how these applications will impact on practice.*



# ADDED VALUE FOR CAAD IN EDUCATION

## Highlights of an Exciting 25 Years

### History

Three of the origins of CAAD can be found in the work of Souder and Souder, Whitehead and El'dars and ABACUS.

Souder et al made clever use of the first graphics technology. They were able to construct, using a light pen and a circular CRT Screen, flickering images of floor plans of proposed hospital designs. Accessing a database of the typical journeys made by medical and nursing staff on a typical day, the programme evaluated each layout proposed, in terms of total travel time. This pioneering work is an outstanding example of **users** (i.e. designers) determined to try to use the best possible tools (i.e. CAAD) to improve the quality of design.

Whitehead and El'dars attempted to take the application of the technology a step further; they developed an algorithm to **generate** floor plans which sought to minimise travel distance. This was the forerunner of many algorithmic methods/programs which paradoxically discredited design methodology and CAAD technology, in the early 1970's.

The Architecture and Building Aids Computer Unit, Strathclyde (ABACUS) came into existence in 1968 and drew inspiration from both Souder and Souder and Whitehead and El'dars. Despite their initial implementation in a primitive hardware/software environment (Tectronix Direct View Storage Tubes/Fortran) the only programs developed by ABACUS still represent the primary poles of CAAD: to generate or to evaluate.

Of course, there are many other aspects of design to which the information technologies can contribute; one of these - **computer aided drafting** - blossomed in the 1980s and wholly overshadowed **computer aided design**. The importance of **computer aided drafting**, to the

Maver

fig 1 - 2



efficiency of architectural practices is well established; we can look forward, hopefully now, to the application of **computer aided design** to a built environment which is fit for purpose, cost-effective, environmentally friendly and formally pleasing.

The following sections of this paper describe current developments of significance in CAAD.

They are:

- i) developments in computer aided appraisal of design
- ii) developments in CAL and CBT.
- iii) the use of high-bandwidth communication networks.
- iv) the concept of virtual heritage.

## Computer Aided Appraisal

This section gives a detailed account of a 12 week student project to design a Primary School relying very heavily on computer aided design support. It was a requirement of the brief that the design produced by the student should come within the (severe) cost, area and energy consumption constraints set out in the brief. The process of design search was so complex and so closely related to the computer output that it was difficult to convey the process and product of the design activity using conventional drawings in a conventional crit. For this reason, students were encouraged to make their presentation in a multi-media environment.

The multi-media presentation of one of the students, Lindsay Johnston, is in six sections. The **Introduction** explains the intentions and requirements of the project; the section on **GOAL Analysis** explains how she used the CAD software to investigate issues of geometry, construction and orientation; the section on School Analysis is concerned with modelling an existing school; **Conceptual Design** explains how she generated the original idea; **Design Process** explains how the CAD software guided her search for a good solution; and the last section presents her **Final Design**. Initially, Lindsay used the CAD software known as GOAL (which was first devised in 1972 and is constantly being updated and improved) to investigate, in abstract, the impact of **Geometry, Materials** and **Orientation** on building cost and performance.

Maver

Fig 3 - 4

The 'benchmark' against which students were required to test their design ideas was Eastfield, an existing Primary School designed to exactly the same brief. Lindsay and the 15 other students in the CAD Design Units input the geometry and construction of Eastfield into GOAL to assess its cost and performance. This level of cost and performance then became the "target" or "benchmark" which the students were encouraged to match or to beat. The students visited Eastfield School in order to assess, by observation and interview with teachers, the qualitative aspects of the design which were not predictable using GOAL. An architect and an administrator from the client organisation - Strathclyde Regional Council - contributed to the briefing process and took part in all subsequent crits.

The concept was developed and a single storey plan form, Design A, produced (Figure 1). She also generated Design B and Design C which are on two storeys. Figure 2 shows the cost-performance profile generated by GOAL of Eastfield against Designs A, B and C.

Although Design A is the most economical, Lindsay develops two further variants of Design C which she identifies as C1 and C2.

She also develops a family of designs identified as Designs D and D1 which again she compares, using GOAL, with Eastfield and with Design A. The detailed cost output from GOAL suggests that the more economical schemes are those with a lower volume. Lindsay then compares the sections of D and D-1 and goes on to develop Design D-1.

Design D-2 compares very favourably with Eastfield (£60,000 lower in capital cost) so she then explores alternative constructions for D-2, arriving finally at a complete specification, in terms of geometry and materials for her final design D-3 (which is £91,000 lower in capital cost).

Figure 3 compares all designs. The buttons on the left side of the Frame allow the user to access plans and elevations of any scheme.

Figures 4 and 5 are part of an animated sequence in which Lindsay shows the detail of her final design for the Primary School - a design judged by her tutors to be superior in form, function and cost-effectiveness that the existing school, Eastfield, which formed the benchmark.

It is clear from her presentation that her search for a good design was informed and guided by the cost-performance predictions of the program GOAL; without the CAD support it would not have been possible to find, and evidence the quality of, such a good design.

## Fig 5 - 6

## Computer Aided Learning

The concept of environmentally friendly buildings is encapsulated in a multi-media document commissioned by GA Design and Build.

GA Construction had a declared commitment to 'quality' in design and build, with a particular concern for energy conscious design. The TCS presented the opportunity to work with ABACUS over a two year period in an effort to establish "what are the life-cycle costs/benefit from energy conscious design and construction and how can improved quality be marketed".

The project was carried out in five overlapping phases:

- i) establishment of the basic physical principles which determine the energy behaviour of buildings.
- ii) analyses of case material drawn from EDAS.
- iii) establishment from the case material of the main design parameters of form and fabric which are likely to impact on energy consumption.
- iv) simulation, using the ESP computer model, of the predicted impact of these design parameters in two main building types.
- v) evaluation of the life-cycle costs, energy consumption and production of pollutants relating to each design variant.

The core activity of the project was the application of the ESP programme to a wide range of parametric variations on two main building types and the subsequent costs-in-use analyses of each case. The incontrovertible conclusion - which matched perfectly with the prime concerns of responsible building client organisations - was the paradigm that:

"good (computer-aided) design, without costing any more over the life-cycle of the building, can reduce energy consumption and, therefore, the associated harmful levels of atmospheric and stratospheric pollution, by a full 50%".

This whole research project was reported in a specially commissioned multi-media document which includes 6 main sections (Figure 6) and over 100 case studies. It also includes CAL modules which explain the principles of energy efficient buildings (Figure 7).

Fig 7 - 8

This application demonstrates the power of multi-media to communicate, to students, to practising architects and to their clients the complexity, importance and attainability of energy conscious, environmentally friendly building design.

## High Bandwidth Communication

The University of Strathclyde and Glasgow School of Art are currently involved in a collaborative project which is primarily aimed at exploring the potential of video conferencing over broad bandwidth communications networks using Glasgow's Metropolitan Area Network, commonly known as the MAN. CREDIT (Collaborative Research in Education for Designers using IT), funded by SHEFC, has been initiated by the Schools of Architecture in both institutes, under the premise that resources may be shared by broadcasting lectures, hosting joint design reviews, seminars, and expert tutorials.

To date video conferencing has yet to prove its potential in this field of application. This is mainly due to the constraints of current network technology. Even *Narrowband ISDN Communication* which represents the highest quality of video conferencing technology in general use today is fraught with difficulties caused by lack of network bandwidth, resulting in degradation of image and audio quality to the extent that communication is often disrupted.

The Glasgow Schools of Architecture, were hopeful that by using the MAN and ATM (Asynchronous Transfer Mode) communications, most of the reported problems connected with video conferencing could be solved, and at the same time guidelines established for future users.

In application five types of session were run, in order to explore various forms of communication relating to the teaching of architecture. These were :

- Lecture - traditional presentation format using traditional media with a participating audience at both sites.
- Lecture - computer oriented presentation format using video media, where the audience were at the remote site.
- Design review - traditional presentation using traditional media, with jurors and participating audience at both sites.
- Design review - computer oriented presentation using interactive, multimedia presentation tools, with jurors at both sites.
- Exhibition tour - where the participating audience was remote.

At the design stage it was envisaged that the most problematic experiment would be the design review. Traditionally, this comprises a student presenting a design hypothesis using a number of different physical media. It was expected that the introduction of an additional remote jury/audience into this situation which was rich in information types and communication paradigms would push both the technology and the managerial aspects of conferencing to its limits. In practice it emerged to be perhaps the most successful of the sessions, with the biggest surprise being the ease at which drawings and models could be read with clarity from the remote site.

To date the quality of the pictures and sound achieved over the MAN has been exceptional, with full screen, full resolution, s-vhs quality visuals and CD quality sound experienced (Figure 8). The system even supported the use of projected 35mm slides used during the traditional lecture. Feedback from these sessions, has been in general very favourable. The quality of communication having attracted much interest and also the participants' experience of feeling 'involved' with events at the remote site.

The quality of this communications infrastructure undoubtedly liberates the users from the problems incumbent in previous video conferencing hardware. In the past it has been suggested that the negative aspects of struggling with a limited technology base may outweigh the cognitive benefits of having visual communication. The experience of this project would suggest that the technology now exists to support high quality communication.

## **Virtual Heritage**

The emerging technologies of QTVR and VRM offer an unparalleled opportunity to explore and to communicate our historical and contemporary architectural heritage. An important example of this is the current collaboration between ABACUS and Historic Scotland - custodians of around 2000 magnificent examples of Scotland's architectural heritage - and a virtual reality experience of Skara Brae, Northern Europe's most complete Neolithic settlement.

- The objective of the project is the development and preparation of computer based presentational material which can be used to enhance the users understanding of the Skara Brae settlement. Due to a growing concern about the conservation of our heritage and an increasing focus on the need to manage the physical impact of tourism on heritage sites it is not possible to allow public access to all areas of the settlement. The presentation is designed to take full advantage of the introduction of Interactive Media and especially the role of Virtual Reality in mitigating these constraints.

- The presentation sought to place Skara Brae in the context of Orkney's pre-history as well as dealing with the site's more recent history in terms of its discovery and subsequent excavation. Users will be able to explore the village in the company of an expert "interpreter" as well as in an interactive mode. A choice of "interpreter" will allow users to gain an overview of the site from different perspectives such as that of an archaeologist, historian or perhaps an original villager.
- Features of special interest are highlighted and explained. These features can be approached on two levels, differentiating between what experts think is unquestionably true of the village and the life of its people and secondly offering a best guess as to what was thought most probable. The interactive nature of the presentation should seek to encourage the users curiosity and help answer the questions that this remarkable village may have provoked.
- Parts of the village that have succumbed to the ravages of time will be reconstructed. This aspect will explore the methods of construction and materials used. It should be possible to experience a recreation of a part of the village as it would have looked 5000 years ago. A rich collection of objects have been recovered from the site, these will be reintroduced to their original locations and a mechanism should be provided to encourage users to "virtually" touch and handle artefacts.

Because of the perceived need for an experiential approach to interpreting the site it was decided to investigate the potential of QuickTime Virtual Reality, a recent addition to the multimedia developers tool kit from Apple. QTVR is a means of creating virtual environments from photographic source. A typical virtual reality environment is comprised of three elements:

- *An object* is an interactive item that the user can pick up, turn and view from all angles. Objects can be embedded in *panoramas*.
- *A panorama* is a 360 degree image that allows the user to pan and zoom within the confines of the space. A single panoramic scene is termed a *node*. Hot spots can be defined within each node to provide hypertext links that index associated information or provide access to other nodes within a *scene*
- *A scene* is a collection of panoramas linked together by hypertext hot spots. In a multi node scene a user can navigate between nodes to move throughout the scene (Figure 9).



This technology was well suited to the project for a number of reasons.

- The high level of interactivity that is expected by today's more technologically literate audience (the SEGA generation) is well catered for as is the requirement for an experiential virtual reality interface.
- The quasi organic nature of ruined structures is not conducive to traditional 3-D modelling CAD tools, which function best in a more rectilinear environment, so the photographic approach combines a high level of realism with a relatively quick and easy mode of construction
- The hardware requirements are at the low end of the technological scale, far below those required by VR in its conventional guise.
- The use of a VR interface simplifies many of the navigational problems encountered in mainstream interactive media. In the traditional format interactive media is structured as a series of hyperlinked pages each containing interactive elements. With a VR interface the context is always apparent, thus reducing the structural depth of the media while interpretative media area always presented at the top level.
- As with many sites, recovered artefacts tend to have redistributed to national museums, virtual media enables the reinstatement of items into their original context.

## Conclusion

This paper has summarised four different but effective approaches to the use of information technology - notably computer aided design and multi-media - in architectural education. It is clear that as our young graduates enter the profession we can anticipate a massive increase in the use of the technologies in architectural practice

figuur 9



**Implementation of IT and  
CAD - what can Architect  
schools do?**

**Jonas af Klercker**

Lund University  
Sweden



## **Implementation of IT and CAD - what can Architect schools do?**

### **Summary**

In Sweden representatives from the Construction industry have put forward a research and development program called: "IT-Bygg 2002 - Implementation". It aims at making IT the vehicle for decreasing the building costs and at the same time getting better quality and efficiency out of the industry.

A seminar was held with some of the most experienced researchers, developers and practitioners of CAD in construction in Sweden. The activities were recorded and annotated, analysed and put together afterwards; then presented to the participants to agree on.

Co-operation is the key to get to the goals - IT and CAD are just the means to improve it. Co-operation in a phase of implementation is enough problematic without the technical difficulties in using computer programs created by the computer industry primarily for commercial reasons. The suggestion is that co-operation between software companies within Sweden will make a greater market to share than the sum of all individual efforts.

In the short term, 2 - 5 years, implementation of CAD and IT will demand a large amount of educational efforts from all actors in the construction process. In the process of today the architect is looked upon as a natural co-ordinator of the design phase. In the integrated process the architect's methods and knowledge are central and must be spread to other categories of actors - what a challenge !

At least in Sweden the number of researchers and educators in CAAD is easily counted. How do we make the most of it ?

### **Background**

The Construction industry in Sweden has for a long time been used by governments as an economical tool for getting more money into the market in bad times. Also the right to a high private housing standard has been a political goal. According to the argumentation in the daily press and TV the construction industry in trouble therefore always seems to start acting by looking for governmental subsidies.

On the initiative of some enthusiastic researchers, developers and practitioners within this industry, a national research and development

program, IT-Bygg, was started in 1990 - then with 2/3 governmental money and 1/3 from the Swedish Construction industry development fund. The goal of the program was to create joint environments for research and development for the construction industry at the three Technical Universities of Sweden with schools of architecture and engineering in Göteborg, Lund and Stockholm. This was also achieved at the end of the program in 1996 but a continuation is needed to make use of these efforts.

A group of representatives from the different partners of the construction industry has put forward a document "IT-Bygg - 2002 - Implementation". Five areas of interest are indicated, each to be acted upon within the fields of research, development and implementation. The areas are:

1. Communication and provision of knowledge
2. Human - machine interface
3. Product, process and computer models
4. Classification and standards
5. Implementation and changed forms for action

The document<sup>1</sup> is primarily aimed to be used when promoting the companies of the industry to participate and contribute economically to the program - 40% government and 60% industry. It is therefore quite brief. To analyse the impact of the program on design and modelling the author of this paper was asked to host a seminar with some of the most experienced researchers, developers and practitioners of CAD in construction in Sweden.

Some 30 persons were contacted personally by phone and almost everyone took part in the seminar. By way of introduction each participant personally declared his special concern, then a group discussion took place which finally was summarised and made the base for a final discussion. The activities were recorded and annotated, analysed and put together afterwards; then presented to the participants to agree on. Some of the problems are put forward and discussed in this paper.

## **Co-operation - the key to renewal of the construction industry**

Analyses have pointed out that the construction industry is characterised by its fragmentation into a lot of actors usually representing different knowledges and even separate companies; working in ad hoc project groups in a sequence of separate phases.

It was stated at the seminar that the total knowledge needed for a construction task long ago passed the limit of what is possible to keep in the head of one person. Yet architects and the bosses of building sites are doing their best to do just that. The advantage for the information keeper

---

<sup>1</sup> "IT-Bygg - 2002 - Implementation", draft

is that he has to be present personally when the information is needed. The serious disadvantage is what happens if he cannot.

If we cannot rely on the "one person model" we have to co-operate. Sharing information is essential to co-operation. Information Technology can be a fantastic tool for those who have to share information. But is it yet ?

One of the real difficulties is how to convince holders and creators of information to let go of their privileged access to it. This is to a great extent a matter to be dealt with by social scientists. As most of the industry with cautiousness looks at behaviourists, making a link to interdisciplinary work might be a way for the Architect schools to support the development of attitudes. At least within Lund University there are good contacts between the CAAD lab and for example the department of Applied Psychology.

### **Commercial competition versus co-operative development**

For some reasons the frustrations of early users of CAD and IT has not been a popular issues to be studied neither by researchers nor the market. One severe reason for user frustration is the use of computer "formats" and grade of user friendliness as tools in the commercial competition. It would be interesting to get an evaluation of what has been actually gained by these rather crude measures. A natural hypothesis was stated by some of the participants of the seminar - that the total market to be shared by the competitors would have been much larger with for instance more generous attitude towards formats. However, this is almost impossible to prove so it can only be used as an "academic" argument.

From an academic point of view it is easy to find the weaknesses of the CAD market, but what can actually be done to improve co-operation between rivals? Being neutral or support those you think might win? Being short of funding and therefore seriously tempted by anyone who offers you soft- or hardware free of charge - it is not easy to be neutral. From another point of view, the MIT Media lab, Nicholas Negroponte<sup>1</sup> sketches a promising future for the development of the digital media's. More efforts are being put into user friendliness. Even persons who want to stay computer amateurs facing computers feel will at home interfacing the machines. Format troubles are going to be solved whether the computer industry wants it or not. There is already promising progress being made with for example Java and TCP/IP on the Internet.

In the seminar there was a concern about how to be oriented in the international environment. Writing almost any academic paper demands

---

<sup>1</sup> Negroponte, N. P. "Being Digital", First Vintage Books edition, New York 1996, ISBN 0-679-76837-8

that issues are related to what is being done at other universities. It is therefore a natural task for the universities to take responsibility for keeping updated information on the state of the art in the world. Building networks such as AVOCAAD is a good example of what an Architect school can do to create a forum where especially those belonging to small firms or organisations have a chance to keep in touch with what happens.

The seminar suggests an inventory of softwares already in use in the country, analysing it and describing it to be published as IT environment tools. It was also suggested that efforts should be put into a “de facto standard“ to be used until a better one, internationally agreed upon, is available.

### **The “slavery“ of drawings**

An architect, who is in charge of the implementation of IT in one of the biggest consultant firms of architecture and constructions in Sweden, stated at the seminar that “architects must be relieved from the slavery of drawings“. And he got support for that opinion !

The reasons are in short that using CAD for production of drawings is not taking advantage of CAD. The production of drawings would still rule the process keeping intelligent humans occupied by doing work which to a great extent easily could be automated. The time could be used to put more efforts into the design work.

*“The problem with a set of architectural drawings, for example, as a symbolic picture or model of a building is that they present an inadequate means for the rigorous testing of the form against the requirements of the programme or context; they are a model of what the proposed building will look like, how it will be disposed three dimensionally in space, but not how it will behave.....“<sup>1</sup>*

The quotation from Philip Steadman is another argument against overestimating the role of drawings, but it also states a warning! If we use the CAAD modelling tools the same way as we would use drawings we are not very much better off ! When educating architects at the CAAD lab in Lund, we have found that there has to be a change of mentality. Students are taught to present there projects in the form of drawings for everyone to make his own opinion. They have to be taught more about communication and how to create messages and tell stories.

### **Information Technology in the design process.**

The concept of Computer Aided Design might to the advanced IT user feel a bit ancient but to the majority of the construction industry it still

---

<sup>1</sup> Stedman, P. The evolution of Designs, Cambridge University press 1979, ISBN 0 521 22303 4.



means something - mostly 2D computer drawing, but never mind... At the seminar there was a lot of discussion about different aspects of Information handling etc. It has to be stressed, though, that object-(product-) modelling is the narrow key part of IT in the design process which is the basis for the following phases. The need for a certain amount of communication tools for exchange of information etc. within the design work could be incorporated into the concept of CAD. It also seems a waste of manpower to state a new concept when CAD has finally been established.

Co-operation in the design phase must mean that more actors are being involved in the design work - evaluating consequences, suggesting new solutions, negotiating to create compromises etc. There is a misunderstanding among architects as well as engineers that architects are the only actors who are expected to be creative. There is a difference in methods of problem solving. Engineers want to have a fixed framework and rules within which to solve the problem. Architects often start when everything is uncertain and nothing is decided trying to stretch the limits to be able to use the solution in his imagination. Architects often summarise their method in the concept of "sketching".

If the design process is going to make use of co-operation and more integrated work more actors will have to learn how to sketch. As architects in general disagree whether to use computers for sketching or not, it might have to be both ways.

### **Implementation of IT is a huge challenge to the educators of architects and engineers.**

There was a time when CAD was just another drawing board which did not at all affect architects aged traditions of work methods. Now, having more experience, we imagine that the new technic offers possibilities which will change many of our ingrained options.

So far education of CAD for practitioners has been something between two days and a week. It has been offered by the dealer of the software and as such naturally focused on the most urgent commands. In a study made by some doctorate students at the CAAD lab in Lund some years ago, it was obvious that this was disastrous in at least two ways. The operators of the CAD system at the office were anxiously limited in what to do with the system. To a large extent they were occupied by making plan drawings as they had been taught to do when the system was installed. This also meant that the operator was very keen on making just that but had begun to loose their identity as a qualified architect or engineer, which is an embarrassing wastefulness.

To make the full use of IT in the construction process will mean using a lot of different software for different tasks. There will be plenty of opportunities to teach "key pressing and mouse clicking" for a long

period of time. But taking experience so far seriously we have to perceive that this still has to be the smaller part.

The real challenge is to make a lot of sceptical professionals convinced and willing to develop skills in reigning a powerful medium into a personal assistant. It will have the same need for support by theoretical clarifications and methodology as other subjects already taught in architect and engineering schools.

### **Educating the reflective practitioner - architect as well as any other professional.**

Donald Schön<sup>1</sup> has described how the traditional way of teaching design also can be used for education of any other practitioner. Every architect reading his examples will smile with recognition of how this actually worked - at least once or twice. Briefly it means that students are being coached through the design task by an experienced teacher who brings problems to the surface for reflection and discussion. Within the Architect schools there ought to be a knowledge of this educational method which could be used for a broader group of students.

At CIFE at Stanford University<sup>2</sup>, among other places, education has been given to practitioners from different disciplines. Offering an educational platform for consultants from different professions to try each others tasks and methods could definitely be of interest for the construction industry.

In Sweden we are discussing a co-operation between the CAAD labs of Göteborg, Lund and Stockholm to develop a joint course package for a collaborative educational project to meet the predicted needs. It would certainly be interesting to discuss making an even broader base for it on Scandinavian or even European levels.

### **International joint ventures for Architect schools.**

At the seminar it was stated that Swedish industry has an advantage before many other countries - we talk with each others over the phase and professional boundaries. In Sweden the number of researchers and educators in CAAD and CAD in the construction industry are easily counted. So we will have to start talking with our colleagues outside the country.

---

<sup>1</sup> Schön, D.A., (1987). Educating the reflective practitioner. San Francisco, ISBN 1.55542-220-9

<sup>2</sup> <http://www-leland.stanford.edu/group/CIFE/index.html>

Beside some exchange of students within European programs so far there is not very much contact between Swedish and other architect schools generally. However, the educational conditions for CAAD has been strikingly similar.

This paper is a kind of test to see if conditions in other countries are similar enough for us to share experiences and use each others good examples.

## **What can Architect schools do?**

Finally a summary of the proposed answers. Architect schools could support implementation by:

- Making a link to departments of social sciences for interdisciplinary work
- Building networks, such as AVOCAAD, to create a forum where especially those belonging to small firms or organisations have a chance to keep in touch with what happens
- Taking responsibility for keeping information updated on the state of the art of CAD.
- Getting away from the slavery of drawings, students have to be taught more about communication and how to create messages and tell stories
- Teaching other actors of the design process how to sketch.
- Teaching object- (product-) modelling to students of architecture as well as engineering
- Making a lot of sceptical professionals convinced and willing to develop skills in reigning a powerful media into a personal assistant
- Creating support for CAAD education developing theoretical clarifications and methodology
- Making use of the traditional learning method - That students are being coached through the design task by an experienced teacher who brings problems to the surface for reflection, discussion and action.



# **Incompatible Pencil - Chance for Changing in Design Process**

**Alexander Asanowicz**  
Technical University of Bialystok  
Poland

*The existing CAAD systems limit designers creativity by constraining them to work with prototypes provided by the system's knowledge base. Most think of computers as drafting machines and consider CAAD models as merely proposals for future buildings. But this kind of thinking (computers as simple drafting machines) seems to be a way without future. New media demands new process and new process demands new media. We have to give some thought to impact of CAAD on the design process and in which part of it CAAD can add new value. In this paper there will be considered two ways of using of computers. First - creation of architectural form in an architect's mind and projects visualisation with using renderings, animation and virtual reality. In the second part - computer techniques are investigated as a medium of creation. Unlike a conventional drawing the design object within computer has a life of its own. In computer space design and the final product are one. Computer creates environments for new kind of design activities. In fact, many dimensions of meaning in cyberspace have led to a cyberreal architecture that is sure to have dramatic consequences for the profession.*



## Incompatible Pencil - Chance for Changing in Design Process

„... how fast can the design process go?  
As one architect recently put it, we can draw faster with CAD, but it can't help us think faster.”

Thomas Fisher

Progressive architecture 4/95

### Designing

The primary goal of design is to give shape to an artefact - the product of design. This artefact is the result of a complex of activities - the design process. But the artefact is a concrete form that does not manifest this process of creation. It does not give evidence for motivations that initiated its creation. „What is creation ?” Architectural creation included three connected with oneself areas:

- intellect (intuition and mind),
- emotions (intuition and imagination),
- logic (mind and imagination) (Araujo I., 1976).

The search of idea and its materialisation, links together imagining, concentration, evaluation and choice of variants, later on several times checked. In that process possible are contradictions, doubts and unexpected solutions. In the first stage of the creative act the subjective factors become visible, and only later on tendency for objectivisation arrives.

Creativity is a not linear deterministic process. It is activity in which the sequence of particular functional components is of no crucial importance. The creation activity is multiplanar. (Asanowicz A., 1996) One of the most important aspects of this activity is that it is usually conducted with incomplete information. It means that either the specification are not completely defined when the designing starts. In this respect design can be viewed as an exploration action, which has two elements: **the activity** and **the state** (Murdi L., 1994) The state is the sketch itself . All type of activity, there may be in architectural design, the result of the activity is generally a sketch described the form.

### Traditional Design Tools

The sketch is usually perceived as the most important element of the process of creation. Sketches best correspond to the specifics of the future object search form, due to quick materialisation of the idea

invented. Sketching could be considered to be the creative search. During it, the creator gradually fulfils picture of a form. Defused, unprecise object image, expressed by pictograms transforms into more and more defined drawing of a form. The whole process is individual, it evolves differently at each architect's mind. Even same architect designs each next project a different way. Each time an eye and a hand materialise the designer's concept differently. Also differently carried out is a process of visual evaluations of drawings and its transformation. The history of architecture provide evidence that graphics technics used in creative process of design, were inseparable component of the whole process itself. A drawing has always been a very important communication tool.

An idea practically does not exist unless it is communicated. It needs to be expressed through some medium for it to be of any use. A design solution is the communication of an idea. The act of communication, its nature, its style, are deeply linked with design. The art of communication is inseparable from visual thinking, which is an attribute of creative thinkers. The natural and obvious medium for expressing visual thinking is graphic communication.

With people inclined to concrete visual thinking a drawing plays role of catalyser. With its help a visual pictures formed within architect's mind change and become more precise. Simultaneously as a feedback, drawings reflect our memory, complementing spatial pictures already conceived in it.

On the other side, designers inclined to abstractional thinking prefer to present their ideas through scale models. Such method of design influences character of a form in more degree that using of a drawing. The image of the designed object (formed within our memory as a sequence of visual pictures) is immediately preserved as a scale model. That influences character of a form and shapes it out.

## **Computer as a design tool**

In our consideration we would concentrate on graphic means of communication in view of computer use in creation of spatial forms. Although its worth to admit, that the scale models method linked with computer technics could open a new perspectives.

The architectural drawing has always been considered to be the best in presentation of a project. That is why implementation of computers in architecture began from elaborating of automatic drafting procedures. Computers were introduced to the architecture profession as „automated drafting machines”. However, architects can reinterpret the computer as a tool for processing and communicating information about buildings. Architect can use computer to simulate building itself and produce better and more complete information, including animation, virtual reality scenes, interactive facilities management models, sum studies, real time cost analyses, as well as working drawings.

Traditionally, CAD software development has mimicked the hardware tools (pencil, paper, paint brushes) used in the practice of architecture.



Many designers think, that a computer is a tool, just a piece of charcoal is. Using computer as traditional tools would be used, they feel disappointed. If they are doing conceptual work, it is more difficult to make just a hint or suggestion of something with computer than to do it by hand. A computer wants to render real things. It is extremely difficult to create a drawing that hints at a basic form or idea. A computer drawings is too finished to use at this stage. Though respecting use of a computer in design (they think of design office) they have a hope that some of the work being done by hand now will be done on computer by architects in software that emulates charcoal. Compatible CAD software and rendering techniques will make possible to merge the architectural quality of hand-made drawings with computer generated images and photographs.

Such point of view is very naive. Comparing computer to a pencil or technical pen is a mistake. Of course, that when we make a drawing of a project, we use a computer as technical pen. We draw lines, arches, curves ... . Thanks to that we are able to produce technical documentation a lot faster than before. Without any doubt it is an Added Value - created by computer in a design process. But it is not enough that one could expect from such an advanced technology.

### **Digression 1**

Most of designers known to me use computer as a technical pen. They use AutoCAD software, and resist very much using of complementary software permitting to produce technical flat drawings as well as 3D computer models. Such designers claim that drawings created by those programs are resistant to further modifications. AutoCAD used as an intelligent technical pen allows to change cross sections or faces drawing while still elaborating of the technical documentation. What I write about is by no means an AutoCAD complement, but only a statement that it is a good technical pen.

On the other side, produced using computers photo-realistic renderings of objects are nothing less than colour pictures, just like in the XIX century were washed drawings, or later the hyper-realistic paintings. The washed drawings from the beginning of the century are as much communicative, and for sure at least as much beautiful.

### **Comparison**

If we consider use of computer the traditional means of visualisation point of view it would be appropriate to say, that such comparison not always has a sense. Allegations appear, that a computer is incompatible - it can not be used as a pencil for sketching. The computer can only produce technical drawings, or renderings similar to washed drawings. So it is capable of doing, what very well could be done without it. In the chart below an attempt of computer and traditional tools comparison was undertaken.

| Traditional tools   | New tools   |
|---|---|
| Pencil, technical pen, brush, scale model   | Computer  |
| <p><b>Description:</b></p> <p>There are many traditional tools of design. Each one of them is different, and their good point is that they can be used at any stage of design. Efficiency of those tools is different, and varies from the individual skills of designer.</p> | <p><b>Description:</b></p> <p>The computer is being treated as it was a pencil, a technical pen and a brush simultaneously. Attempts to use it in all stages of design usually end up with failure. The efficiency of a computer is related to an operator skills only in a small degree.</p> |
| <p><b>Difference:</b></p> <p>We shall not claim from a pencil to display renderings.</p>  | <p><b>Difference:</b></p> <p>We complain that a computer can not be used as a pencil</p>  |

**Conclusion:**

A pencil is a pencil.  
 A computer is a computer.  
 A computer isn't a pencil.  
 A pencil isn't a computer.



*This is just an example of what you can do with a new program that adds life to computer drawings (?)*

## AVOCAAD

According to the above a question about AVOCAAD arises. Could use of a computer create the Added Value in a design process? What sort of conditions must be created for an effective use of computer technics in a design process as a whole? A design process consists of three phases: 1) the drawing on the back of envelope, 2) production of documentation, 3) presentation. Changes in faze 2-nd and 3-rd have created a new quality, but faze 1-st poses a lot of problems. It requires revolutionary changes both in the process of creation, as well as in computer technics.

The computer could start a new art form, which would create a new way of doing things. Computers, originally intended as fast calculators, are now recognised as the primary tool to access, understand, and

communicate the main design ideas through images, text, and sound, through the media of television, telephone, compact disc, and the Internet.

The time for a synthesis has come. The time for a formation of the new art in which traditional disciplines - painting, graphics, sculpture, architecture would join with the latest achievements in CAAD, VR and cybernetics. Use of computer technics and its specific ability to dynamic creation of design idea should permit the increase of intellectual capacity of a designer. The insufficient flexibility of the contemporary software and hardware in space modelling requires implementation of new technics - not only the computer ones. CAAD systems should be transformed into CAAC (Computer Aided Architectural Creativity) environment, which could assure the possibility of dynamic transformation of conceptual space and visualisation of creation processes. Such the activity should be based upon two principles: 1) Dynamic development of idea - creation of abstractional visual models and their transformation. The transformation procedures come to use when a model does not conform to architect's concept. 2) The dynamic perception of creation process - memorising of the consecutive stages of transformation and creation of a topological sequences of idea.

The process of creation begins with the preliminary composition of an object's form within architect's imagination. Ideas are born in the intellectual space of our mind. In such a composing a designer uses different tools: genetics algorithms.

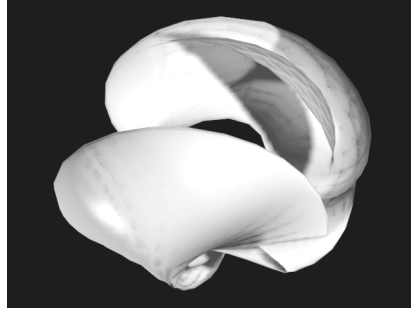
Produced forms are than subjected to further transformation in virtual space. The architect as a cybersculptor defines direction of changes and interactively transfers the primal forms.

Such an application of a computer determines a necessity of new forms arrival in the process of creation. Lets forget about a pencil. A pencil is incompatible. That will be the Added Value created thanks to computer use in a design process.

## Digression 2

The visual, clearly spectacular character of changes, which found it place in visualisation technics of architectural form could be explained only by the analysis of change in perception process itself. Considering specific type of perceptual consciousness, we would also get a specific type of visual art. Each type of a perceptual consciousness requires matching it means of expression. Each perceptual phenomenon expresses itself only through some, being able to express it components of a form. Each new set of means of expression is simultaneously a new set of formal means. Transformation within processes of architectural visualisation derive form transformation of perceptual consciousness. In order to see a new meaning of a new subject we ought to change a method of observation.





*Evolution of drawing from neolithic age to age of informatics*

## References

1. Araujo I., La forma arquitectonica, Ediciones Universidad de Navarra (EUNSA), 1976
2. Asanowicz A., The new output of traditional design methods, EAAE Conference - „Doctorates in Design and Architecture”, Delft, 1996
3. Frazer J.H., Frazer J.M., The evolutionary model of design, in Asanowicz A. and Jakimowicz A. (Des) - Approaches to computer Aided Architectural Composition, Technical University of Bialystok, 1996
4. Glanville R., Creativity and Media in Architecture, 2nd European Architectural Endoscopy Association Conference in Vienna, 1995
5. Jakimowicz A., Towards affective architectural computing: an additional element in CAAD, IV Conference Computer in Architectural Design - „CAD Creativeness”, Bialystok (PL), 1996
6. Murdi P., Perny P., Chauvel P., An approach to design support using fuzzy models of architectural objects, in Gero J.S. and Sudweeks F. (eds.) - Artificial Intelligence in Design 1994, Kluwer Academic Publishers, Dordrecht, Boston, London, 1994
7. Rychter Z., Mathematical Architectural Synthesis, III Conference Computer in Architectural Design - „CAD Space”, Bialystok (PL), 1995
8. Streich B., Computer Aided Architectural Composition by media experimental design work, in Asanowicz A. and Jakimowicz A. (eds.) - Approaches to computer Aided Architectural Composition, Technical University of Bialystok, 1996

**The Animal,  
Full Blood maybe,  
but Untamed**

**Malgorzata Bartnicka**  
Technical University of Bialystok  
Poland



## **The Animal, Full Blood maybe, but Untamed**

*Special thanks to Brava.*

So far yet, even the most advanced technology has not been able to substitute a human, his thoughts, feelings, dreams, longings, visions. It can though, removing need for all kind of effort from our everyday life, surrounding a human with unprecedented comfort, create feeling of peace and security. Task of a computer is to provide assistance, helping in calculations, forming of refined solids, It contains a compendium of knowledge and memory - but not creative skills. So far it's only a machine, with help of which a possibility of creative expression is expanded. It only can solve problems for a human faster and more efficient way, does not have the ability to describe (formulate) problems. Even while providing a support, does it do that honestly? It means, does it support us in those of our doings where we truly need it?

Computers have enormous possibilities of use that are not exploited sufficiently and all the time new generations of yet quicker machines with unbelievable power are being created. Every new type of computer appears to be obsolete and insufficient within a few months. Insufficient for what?

It may seem to someone that this is just a trivial picture of our reality - the constant quest for time. The speed and power of computers increase while the programmes do not keep up with such a pace. Only the same values though could be created on and on, faster, more accurate, of a better graphics quality. The pictures created tend to blur the border between fiction and reality, but only in the final effect.

An architect past the moment of his work creation precisely knows how it would look like in space, eventual 3D renderings are being done nowadays mainly for investor. In connection to such a demand the whole process of work being done on a computer evolved in the direction to improve exactness and clean reading of a project, as well as creation of transparent presentation of designed forms. However, the main phase - the creation process - is neglected. The programmes accessible do not meet other needs of the designer. Are not useful in satisfactory degree at preliminary stage of a design - in creation of vision; not to say a final vision, because that is possible, but intermediate, transitional visions, their constant modifications, briefly speaking in design process. What the architect is able to create through the infinite number of lines drawn with a pencil, that is actually the very process of thinking out the architectural form on the sheet of paper, the present state of software destroys through its „barbarous” precision. The requirement of providing the exact data put on the designer in the initial phase of creation cannot be fulfilled because in the designer's mind such data is still vague at this stage. There

is a need for a programme which could help the architect to make a better use of the possibilities offered by the machine. Computers work in a different world - the world of numbers; the users conform to the ways of thinking in categories of possibilities and limitations of the programme. Computer aided designing interferes with free and unrestrained creation<sup>1</sup>, forces the architect into the deductive way of thinking about the project and makes him omit the reductive approach to the matter concerned.<sup>2</sup> The programmes existing aim mainly at enhancement of drawing formula and presentation and not creativity. Conclusion: draftsmen, who work as accurate as a computer in world of lines and points, expect to be served with each dimension and shape. The computer automation, such as we have today is needed by draftsmen, not by creative artists.

Programs useful in space modelling have been named modlers. They operate by three conventions of reading space<sup>3</sup>:

- Constructive Solid Geometry (CSG) - space building method used in CAD programs based on creation and assembling together of simple geometric solid (primitives) based on algebraic operations.
- Boundary Representation - defining of a solid through defining all points forming it surface.
- Distribution Functions - creation of curved surfaces..

Architects mainly working with CAD programs generally use convention CSG. Modelling is limited to operate on simple geometric elements: flat surfaces, cubes, or created from them derivative solids. A space model is being built on primitives level and simple geometric solids. At present the most close to creative way of architectural form shaping, using space solid definition is module AME of AutoCAD, nevertheless working with it is not convenient enough. What one can choose from are all other solids that can be added and subtracted and one can also look for intersections. The serious defect of the program itself is its small susceptibility to modifications of created solids, the necessity to upshape (solmesh) them constantly in order to see effect of your actions, lack definition of a semi-platform as well as limited possibility of spheric surface use. Very often it is better to create a new from rather than to change and rework the existing one in AutoCAD. The solids emerges as a set of broken lines and interpenetrating planes, seen as a grotesque tangle of lines, and not as a univocal form. The architect has no possibility of working on a view of the object in a form of a solid with hidden covered edges. The program does not permit for „easy change of

---

<sup>1</sup> A. Asanowicz, „Komputerowy model transformacji krajobrazu miasta”, II th Conference on Computer In Architectural Design, Bialystok 1994.

<sup>2</sup> Z. Pininski, J.M.Ullman, „Distinction entre estrategias deductivas y reductivas como base de la tecnologia en el diseno racional”, Comunicaciones, XII Congreso Mundial de la Union Internacional de Arquitectos, Madrid 1975, Artes Graf.

<sup>3</sup> K. Butelski, „O podobienstwach pomiedzy konwencjami modelowania komputerowego...”, II th Conference on Computer In Architectural Design, Bialystok 1994.



the proposal and for instant „replay” of what the effect of any proposed change may be, and prohibit the sort of instant interaction that we humans enjoy in and with our environment when we decide just to turn our heads.”<sup>1</sup>

The evolution of the software must head towards free from creation, towards sculpturing or moulding like in clay rather than assembling elements from blocks.

Architect is a creator of a form, in space. Visions developing in his mind do not represent a drawing as on a flat sheets, they are more close to a scale model. In this moment arises a problem in transformation of visions. For making a scale model we could know all its dimensions before constructing them, in the same way as in creation 3D objects in AutoCAD. In creative process often architect discouraged with difficulty in reproducing by a computer of a more complicated shapes simply gives up, what in a large degree makes the form itself less attractive - „It takes too long to change things, and it takes too long to redraw, and many shapes are so hard to construct and draw on the computer that we don't try”<sup>4</sup>. The ideal solution would be a program similar to modelling in clay or plasticine. Earen better if one could give certain dimensions and like a sculptor extract out of that space everything which is not our building. On display to facilitate such a way of design should be three projective plane and a mane view perspective or axonometry with light and shadows. Extracted or added shapes should be flexible - that is by Beziera lines their shape should be changeable. Program gives possibility of immediate evaluation, analysis and modification. It must in interactive way change (transmute) created form into plan, section and front view. That is the way of classic architectural practice.

There is no such program while computer with its all limitations has a dramatic influence on creative architect contiouness, and shape of design.<sup>2</sup> It might give definitely negative effect.

The biggest problem is that we deal with computers of increasing speed and with „user-friendly” and „useful” software, while there is no programme, not necessarily very fast, which could be adapted to the structure and needs of the creator. Such a programme should provide the real perspective of cooperation.

---

<sup>1</sup> R. Glanville, „Representations Fair, Honest and Truthful”, II th Conference on Computer In Architectural Design, Bialystok 1994.

<sup>2</sup> J. Ullman, „Od projektowania sekwencyjno-cyklicznego do projektowania iteracyjnego”, I th Conference on Computer In Architectural Design, Bialystok 1993



# Virtual Horizons

**Jack Breen**  
T.U. Delft  
The Netherlands

*This essay explores directions for Computer Aided Architectural Design. It focuses on the state of the 'art' in the Netherlands - a country which is renowned for a high density of planning, both in its cultivated landscapes and in its urban environments - and investigates in which ways computer aided techniques may be broadening the horizons of Dutch design practitioners and builders. An attempt is made to characterise recent developments within the architectural design community, with respect to the influence of (digital) design media on - stylistic - architectural developments and on the building methods of the nineties.*



# Virtual Horizons

## Investigating the influence of Computer Aided Methods of Architectural Design and Building Production in The Netherlands

### Reflections

The architectural 'landscape' of the twentieth century fin de siècle offers a constantly changing panorama.

The 'output' of the architectural practice - realised buildings, but also visual representations of plans which are not necessarily built - has attained an unprecedented level of attention in the media. There is a growing interest in the - often seductive - imagery of contemporary designers and an obsessive interest in the unpredictable outpourings by the 'stars' of the profession: the jet-setting international circus of the - often self proclaimed - avant-garde. Coming after the somewhat dull, bland building production of the sixties, seventies and early eighties, contemporary architecture has been 'discovered' by a broad public and even become 'fashionable'. A new generation of students is lured to the profession, whispering the names of the enigmatic gurus of these times and quoting sound-bites by philosophers that few have actually read.

At the same time, on a much more local, down to earth level the 'blessings' of the changing living and working environments are as hotly - if less eloquently - debated. The world is gradually, but noticeably growing fuller and many new additions to the built environment do not aspire to the higher intentions or aesthetic ambitions of the happy few balancing on the (media) tip of the architectural iceberg. Despite the technological advancements of the information age, many buildings still come across as poorly designed (or hardly designed at all), but are no less 'present' in the dynamic perception of the hastily mobile, on-line inhabitants of the 'first world'. The city of the late twentieth century increasingly comes across as a cacophony of singular 'actors', each trying harder to be noticed than the next, self-consciously conspicuous in appearance. Urban yuppiedom sprawling along the highway...

Although the world would appear to have become smaller by the increased interaction of 'information', this does not mean that the design culture has become more universal, on the contrary, overlooking the field of architectural design, the situation seems to be more 'pluriform' than ever...

There are designers working on creative levels within the international design scene that ignore traditional boundaries and cut through conventional cultures, inventing new solutions, often simultaneously.

Groups working in different places, yet communicating via new platforms such as "the Net".

On the other hand there are very significant regional and even local developments, which can be the result of a number of parameters specific to a given area, such as the cultural and political climate and specific constraints such as all kinds of laws and by-laws. Of great importance is the economic situation and monetary activity (which types of individuals or institutions are investing in which types of buildings in which place at what time).

Underlying all of these activities is a steady transformation of the building industry. Recent changes have affected both the disciplines connected directly to the *building process* (the building and engineering firms) and those active in the *design process* (the architectural firms and their consultants).

The changes which are taking place in the working methods and forms of organisation of the building disciplines - both in design and building production - can be contributed to a very large extent to the growing use of Computers.

What is the influence of computers on the built environment? Has Computer Aided Architectural Design (CAAD), heralded by many as a revolutionary design medium and an indispensable creative tool, led to more imaginative architecture, to technical innovation and durability, to more economical even more comfortable buildings?

Aldo van Eyck, considering the role of architectural designers, stated in the early eighties: "*Quality* as such is *not* important. What is important is the *quantity* ...of that quality!"<sup>1</sup>

Is it possible to claim that computers have led to a greater quantity of architectural quality, or have they helped make architecture worse? Are they contributing to a more stimulating design environment or have they just made it easier to make lots of money - and if so, by whom? By the architects or by clever entrepreneurs, busy marginalising the architect's influence in the design process?

What value has been *added* by the influx of computers into the architectural practice and what new blessings may be expected in the (not too distant) future?

A brief investigation of these developments, concentrating on the 'case' of the Netherlands...

## Designing the Netherlands

The Netherlands is a relatively small, but densely populated country on the western fringe of continental Europe.

---

<sup>1</sup> Aldo van Eyck speaking at the Faculty of Architecture in Delft and to NRC Handelsblad in 1980 (translation by the author).

A characteristically ‘horizontal’ county, dominated by low hanging, windy skies and the ubiquitous presence of water. For the Dutch, living in such low-lying lands, situated in the delta of three major European rivers and facing the turbulent North Sea, this has always meant that - if they wanted to keep dry feet - they needed to work together. This need of reaching a consensus concerning the course for - collaborative - action has led to a relatively ‘horizontal’ society with a strong communal tradition and a reputation for tolerance, mirrored in a religiously and ethnically diverse society. The outward-looking spirit, resulting from the country’s geographical position and relative lack of natural resources, has contributed to a national economy which is based more on (international) trade, services and (intensive) farming rather than on industry.

The economic activity is largely concentrated in the densely populated western part of the country, the so called ‘Randstad’ (literally: ‘Edge city’), a ring of cities and towns concentrated around a ‘green heart’ in the counties of Northern- and Southern Holland and Utrecht. For decennia, building production has been dictated primarily by social housing programmes and by the needs of commercial enterprises. Recent waves of privatisation and commercialisation have meant that the task of building development, previously carried out largely by (local) governments and subsidised building corporations, has increasingly been taken over by the large financial institutions seeking durable investments. After the collapse of the booming office market some years ago, project developers are presently concentrating on ambitious housing programmes within the framework of the government’s strategic ‘Vinex’ programme.<sup>1</sup>

The country has a very long tradition of planning. A proven method is the practice of reclaiming land from the water and then developing these polders for new purposes. Without much exaggeration, the Netherlands as a whole can be considered as a kind of grand, ongoing design project. Dutch decisionmakers often emphasise that the project at hand is never ‘finished’. A pioneering spirit still runs through the country’s administrative layers and there are few - if any - countries that are as thoroughly and comprehensively ‘organised’ as the Netherlands.

The atmosphere is generally ‘down to earth’ although experiments are not shunned. Designers are used to exercising their creative talents within strict (financial) frameworks, having to work within relatively narrow margins. The Netherlands is a country where creativity is respected, but the budget is holy!

It should be ideal to use computers to organise and control the different levels of such a country and indeed this is the case. Although the Netherlands were never a fore-runner in the field of automation, and digital machines were originally used principally for financial computation, the Netherlands now has one of the highest levels of computer density in Europe<sup>2</sup>. Computers are to be found in offices and homes and are involved in running and controlling just about everything.

<sup>1</sup> The political document which serves as a guideline for new housing developments is the so called ‘Vierde Nota Extra’ (Vinex) of 1990.

<sup>2</sup> According to statistical information from the CBS (the Dutch central bureau for statistical information).

This 'computer presence' can frequently be felt. If one drives down a Dutch motorway it is possible to pass under digitised signs which inform the motorist that there is nothing to report or even that the system is currently not in operation. Digital networks charting geographical and demographic information are becoming consistently more fine tuned and all-embracing, leading to discussions concerning the privacy of the individual. One of the most successful applications for CAD systems has proved to be Facility Management: creating interactive information systems in order to register and specify the existing infrastructure, monitor maintenance projects and integrate new additions and alterations. Many sizeable firms, corporations and municipalities have documented their domains digitally and, although these databases are mostly not yet linked with each other, the information web covering the country is steadily becoming more close-knit. A small step to go to a complete 'facility' network registering all facets of "Holland Inc."<sup>1</sup>?

Travelling through the country, one is aware of a constant building activity, with the landscape steadily filling up. The horizon is becoming increasingly obscured by new 'growths' of buildings and all the time designers and decisionmakers are hard at work preparing new - as yet virtual - realities that will further alter the country's dynamic horizons...

## Design Practice

Holland has quite a high density of 'official' architectural designers (the latest figures count 9145 registered architects<sup>2</sup> on a population of 15.6 million). The Dutch situation is characterised by relatively many small offices and few large ones (less than 10% of all offices has more than 15 employees and truly large offices (50 persons and more) amount to no more than 1% of the total; half of all the offices consist of only one person)<sup>3</sup>. In the eighties, the stagnation of building activity gave rise to a thorough reorganisation of the architectural practice. Many bigger offices either had to close or became considerably smaller, their place being taken in by smaller, younger offices with very little overhead. Although the building activity has since grown considerably, the architectural branch has not grown at the same rate. There is much competition and without guaranteed rates many offices have very small or almost non-existent profit margins, leading to a lack of structural investments.

This is one of the reasons why - apart from a small group of 'pioneers' - many offices were relatively slow at getting involved in computation. The starting-shot for most offices was the introduction of Word Processing on PCs, which was perceived as a revolution. Computer aided drafting (Cad) was adopted seriously by medium sized and larger offices

---

<sup>1</sup> "De BV Holland" in Dutch media jargon.

<sup>2</sup> According to the count per 1<sup>st</sup> of January 1997 by the Stichting Bureau Architectenbestand, the official institute guarding position of the architectural profession and registering those practitioners allowed to carry the title 'architect'.

<sup>3</sup> Figures published in Cobouw, 28 January 1997.



around the end of the eighties and beginning of the nineties, initially mainly in the technical office and still very little in creative design. Many of the small offices continued working 'traditionally', but for a growing number the computer has become an indispensable part of the organisation as a medium for 'shared' working...

Architectural practices in the Netherlands are notorious for their lack of job security. Commissions come in waves, and this often makes it difficult to keep up a group of regular employees. Many offices operate largely with temporary staff and some have even set up pools for sharing work with other offices. This practice has also given rise to a growing number of 'service' bureau's. Computer based firms have jumped out of the ground, offering specific services such as price calculation, energy-efficiency calculation, legal advice and complete technical drawing and project management facilities. The central medium is the computer, with information being exchanged via floppy and now gradually through interdisciplinary on-line collaboration. The most commonly used CAAD platforms are 'marketleaders' Arkey (an architectural program developed specifically for the Dutch market) and AutoCad (relatively little Mac).

The practice of 'linking up' with service bureau's has made it easier for relatively small offices with little overhead and a compact staff (often just a small, constantly changing team of designers and media specialists) to take on serious commissions. This concentration on their 'core' tasks does pose a threat. The role of the designer is constantly in danger of being restricted, losing control over the design as a whole after the early 'idea' phases and not being able to create a finished product. Architects are continually encountered with the struggle to keep influence over the total 'production'.

In this light it can be relevant to compare present-day architects with movie directors: feeling responsible for a creative project in an ongoing process, complete with a demanding 'producer' primarily interested in financial success, with difficult 'actors' and specialised technicians. The architect/director not only playing the central role as generator of ideas, but also trying to hold both the 'plot' and the team together, while constantly on the lookout for overspending.

The Dutch building situation, coupled with the compactness - and relative youth - of many offices, means that there is still a reasonable amount of room for a personal 'signature', for some experimentation and novelty. To stay in terms of movie-making metaphor, this does not often lead to streamlined -Hollywood style - productions but rather to a relatively large number of small budget 'cult' films.

This practice is reflected in the way commissions are divided. In the Netherlands. Particularly in the West, private commissions are scarce. Standard usage is that reasonably large housing or office estates are developed in one go, on sizeable locations. Vinex housing projects often amount to controlled development of some 50.000 housing units at a time. However, unlike the situation in previous decades, when there used to be a tendency to give large segments of developments to one - very large - office, there is now a tendency to divide projects up into medium

sized parcels divided amongst a number of different - small to medium sized - offices. From a financial viewpoint, such constructions are often only just interesting for the architects, but it is important to participate as this may lead to publicity and to new commissions. This competitive approach has contributed to more differentiated neighbourhoods with contributions by various architects attempting to distinguish themselves, quite often in somewhat exaggerated ways...

## **Design Media: Enquiry and Communication**

Architectural conceptions always need to be noted down in some way, so that the intentions of the plan can be specified and communicated to others (clients, builders etc.). This activity of *notation* is not only of importance in order to communicate with others, but also for the benefit of the designer him/herself and for other members of the design team. This recurring process of *imaging*<sup>1</sup> is the core of every creative architectural design activity.

In 'primitive' planning processes, the plan was probably drawn up 'in situ' by scratching the contours into the earth (using lines) or by marking the corners with rocks or sticks (using co-ordinates). Gradually designs were laid down in a system of two-dimensional projections (plan, cross section, elevation), drawn to scale.

Though the introduction of new techniques and instruments for design visualisation does not necessarily lead to revolutionary changes in the *products* of design, new tools have in the past given new impulses to the *practice* of design. For instance, the introduction of squared paper was instrumental in the development of many geometry-based, neo-classicist designs and transparent paper greatly stimulated freehand design sketching. Similarly, the introduction of pencils, fountain pens, felt pens and adhesive tone foils extended the creative palette of the designers in the past.

What is the influence of *computer* aided techniques on the practice of design and in what way has CAAD possibly changed design products? In order to be able to say something sensible about this issue, it can be useful to distinguish some characteristic aspects of design.

One distinction which can be made is between the design *activities* on the one hand and types of design *information* on the other hand.

Generally speaking, a design activity is either a form of *enquiry*, probing and testing the design at hand, with the intention of bringing it further, or an activity directed towards *communication*, for instance laying down information for a client or builder or for a design milestone, such as a presentation.

The kind of information involved in such activities might be primarily *practical* in nature, for instance concerning quantities, structural and technical aspects or rules and regulations, but can also be more

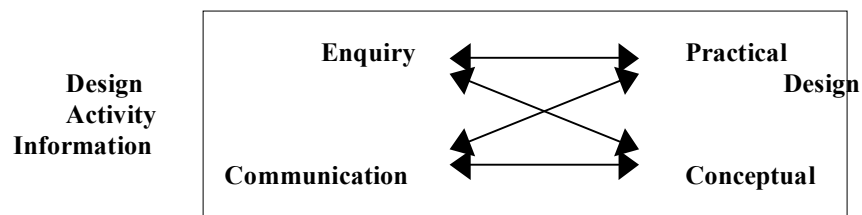
---

<sup>1</sup> Zeisel, J. : 'Inquiry by Design: Tools for Environment - Behaviour Research', Cambridge University Press, 1984.

*conceptual*, concerning aspects of a design which are often more difficult to convey to others but which are of great importance if a plan is to become a compositional whole, rather than merely a sum of separate solutions.

There are in principle four possible combinations of the above design aspects to consider (see the scheme). These four combinations are used here, as typological categories for design activity, in order to give an indication of the value of - existing and emerging - Computer Aided Architectural Design applications.

Scheme: CAAD Design visualisation applications:



A brief overview of the four combinations of design visualisation categories, appearing in the order of their relative success as CAAD applications - *in the Netherlands* - up to now:

### 1 Practical Communication applications

The first successful application, essentially CAAD used simply as computer aided *drafting* (Cad). Taking the place of traditional technical drawing (meant for the contract and realisation phases of design). Important assets of the computer in this respect have been the ability to work in different scales from the same basic drawing, the possibility to work in different layers and the use of changeable components.

### 2 Practical Enquiry applications

Another influential application of CAAD and other, more specific computer software. Useful applications, discovered relatively quickly by the architectural community, include the possibility to calculate items, such as the number and sizes of specific building components (in order to get an early indication of building costs), of measuring in the drawing and applications concerning the consequences of different technical options (construction, building physics etc.).

### 3 Conceptual Communication applications

Initially introduced as a 'sideline' to the more prominent drafting functions of Cad, computer visualisation for presentation purposes has steadily gained importance. At first anything coming out of the computer (including illegible wireframe drawings) was considered of interest, but recently - especially since the introduction of texture mapping techniques - many and varied, often sophisticated computer aided presentations (varying from 'realistic' imagery to more atmospheric, conceptual visualisations) are being generated.

#### 4 Conceptual Enquiry applications

Probably the application slowest to develop. Partly because complex computer modelling applications have recently become more efficient and accessible, this direction has gained momentum in the last few years. Initially adopted in the early design phases mainly by active Cad users, primarily by creating different design options simultaneously, comparing images and choosing the appropriate course for further action. Presently groups of architects are busy exploring and extending the possibilities of the computer as a design visualisation medium, creating images of new, dynamic architectural forms.

All of these aspects are of importance, in order to achieve success in a complex design. It is not opportune to over-emphasise the (early phase) conceptual idea phase, A brilliant conceptual sketch does not convince most clients and is certainly not enough to get a building off the ground. Computers, just like other design media, do not have to be used for *all* aspects of design and may be at their best when used for specific tasks in the design process. The prediction, made by computer enthusiasts in the past, that CAAD would completely replace all other design media has not come true. We currently witness an increased interest and renewal of all kinds media and creative designers often use different techniques in combination. The choice which media to use and when is up to the individual designer...

Although it seems justified to state that computers have initially been used most successfully in the more 'practical' aspects of design and that in many offices this is still the case, that there appears to be a steady movement towards more conceptual applications which influence the stylistic developments of contemporary architecture...

### Architectural Styles of the Nineties

There is no universal architectural 'style' of the nineties, but rather a complex, hybrid network of recycled previous styles and new influences. The Dutch architects of the nineties share an almost obsessive interest in the expressive qualities of architectural form and materialisation, feeling free to combine different themes. The mood of the twentieth century *fin-de-siècle* in the Netherlands could well be characterised with the term 'Radical Eclecticism', introduced by Charles Jencks<sup>1</sup> in his Post-Modernist manifesto, except that the situation does not correspond with the kind of ironic neo-classicism he anticipated.

Dutch architects have grown up in a Functionalist tradition and after the somewhat boring sixties, the 'cosiness' of the seventies and the free-for-all of the eighties, the atmosphere of the nineties is predominantly one of a playful, almost frivolous Modernism. Not a modernism in the sense of "less is more", nor of "bigness" and "smallness", but rather a modernism with an appetite for "muchness". The emphasis is on proportion and contrast, on pattern, texture, material expression and colour. The emphasis on composition and expression is such that one could almost

---

<sup>1</sup> Jencks, C. amongst others in: 'A Genealogy of Post-Modern Architecture', in *Architectural Design* nr. 4, 1977.

speak of architectural ‘fashion’. A recent architectural city-guide even introduced the term “Nineties-Look”.<sup>1</sup>

The traditional boundaries between disciplines are shifting, with architects getting involved in urban design, and artists, graphic designers and even cartoonists getting involved in architecture. There are attempts to give large scale housing developments a sense of ‘atmosphere’ and ‘meaning’ by introducing romantic, often pseudo-historic themes. Although this kind of alternative regime does sometimes give rise to the occasional post-modern, classicist pastiche realised in modern materials, the stylistic undertone is generally (neo) modern.

What is the influence of the computer in all of this? Has CAAD made architecture more interesting or more bland?

Both seem to be the case as the computer appears to make the architecture of ‘lazy’ architects even lazier (the computer makes repetition dangerously easy and many buildings lining the country’s motorways come across as manifestations of this trait), while on the other hand the ‘ambitious’ architects seem to have become ever more ambitious, using CAAD to cross traditional boundaries. Influential architects like Ben van Berkel emphasise the important role of computers in the creative evolution of their work.<sup>2</sup>

An attempt to characterise some notable ‘streams’ (of influential practitioners using CAAD) running through the Dutch architectural ‘delta’ (with the names of some exemplary offices per stream):

**1 Mainstream ‘Corporate’ approach** (Articon, EGM, Kraaijvanger, Bonnema etc.)

Mostly large scale ‘professional’ buildings created by the professionally organised, multi-disciplinary, larger category offices, mainly for corporate clients. Relatively ‘safe’ architectural expression, usually with considerable repetition of a limited number of elements and some occasional ‘playful’ articulation. The effect is often comfortably modern with ‘representative’ detailing intended to underline the corporate identity and importance of the client.

Cad absorbed into office organisation as necessary tool for working efficiently and competitively.

**2 Technological ‘Montage’ approach** (Zwarts & Jansma, Benthem Crouwel, Cepezed etc.)

Offices that started experimenting with ‘technical’ themes such as industrialisation and prefabrication and the innovative development of structural details and joints some years ago. Initially often forerunners in

<sup>1</sup> In the guide ‘Architectuur in Amersfoort, Een overzicht van de bouwkunst na 1800’, by Max Cramer and Anton Goot, THOTH, Bussum, 1995. For the period 1980 - 1995 the authors distinguish the categories Modernism, Historicism, Contextualism, Regionalism, Transformism and Nineties-Look (“Jaren ’90-Look”).

<sup>2</sup> Dutch Architect Ben van Berkel states: “To me the computer is a way of radically breaking with traditions. The mediation techniques enabled by the computers signify a complete overthrow of many architectural assumptions, from the typology of organisational structures, to the hierarchical order of planning a structure, ending with details. The computer entails a radical rethinking of the valuations implicit in architectural design. In this sense computational techniques could represent the first important development in architecture since modernism.” From: ‘Conversation by *modem* with Ben van Berkel, by Greg Lynn, El Croquis 72, nr. 1, 1995.,

the application of computers in design (preferably Mac), this type of office introduced CAAD as a logical step towards developing somewhat manifest hi-tech architecture. Computer-based techniques are often used particularly effectively in modelling building components.

**3 Articulated ‘Sculptural’ approach** (DKV, Christiaanse, Neutelings, Reijers etc.)

In the Nineties formal vocabulary, an important trend appears to be the (re)discovery of sculptural qualities in architectural composition, emphasised by the use of contrasting facade patterns, materials, surface textures and (semi)transparent materials. Though projects are often presented using a variety of means, including models, collages and even cartoons, CAAD techniques, applied primarily in design composition, include solid modelling techniques (combination, addition and subtraction of volumetric shapes) and texture mapping software (surface treatments, colour and lighting).

**4 Experimental ‘Solid Liquid’ approach** (van Berkel & Bos, NOX, Oosterhuis etc.)

Restless groups specialising in exploring novel, computer-generated environments. Originally on the fringe, complete with futurist/activist rhetoric and provocative predictions such as the imminence of “artificial intuition”<sup>1</sup>, these designers have recently gained influence by securing a number of prominent commissions. The computer is considered as a revolutionary new tool, central in generating new formal concepts. After a phase centring on deconstructivist computer-aided collage techniques, the latest direction has been dubbed “solid liquid architecture”, using a technique of flowing, cross-section based morphing.

**5 Sophisticated ‘Neo Modern’ approach** (Mecanoo, van Velsen, Coenen, Egeraat etc.)

A number of influential architects, the previous ‘young dogs’ who were catapulted into the limelight some years ago - before the influx of computers - have adopted computer aided techniques in the search for new architectural solutions. Their modernist work has become increasingly sophisticated though not predictable. Next to standard Cad, a whole range of techniques (digital and otherwise) is applied selectively, mainly as a means of bringing across architectural intentions, rather than as images in their own right.

The collection of design approaches listed above is limited in its scope and naturally not complete. It is intended to give an indication of typical issues and digital approaches in the Dutch architectural scene. There are no clearly defined boundaries between the groups and the particular techniques mentioned. Combinations are possible, working methods are dynamic and shifts - both conceptual and instrumental - regularly occur. A trend which may even intensify in the near future...

It should be clear that the developments of the many-faceted 90’s ‘style’ cannot be attributed solely to the influx of computers.

The excitement of being part of a fin de siècle, formal renaissance seems to be in the air, at least in the Netherlands. Part of this stylistic activism can be attributed to the attention of the media: particularly the printed

---

<sup>1</sup> Oosterhuis, K. : ‘Artificial Intuition, Arbeiten am Computer’, Aedes, Berlin, 1989.

media and television. In their quest for issues and photogenic items, these have 'discovered' architecture. This has made architects even more aware of the developments around them and fuelled their ambition to be a part of what's going on. To do so one has to produce designs that catch the eye, and preferably should be enigmatic enough to provoke a response from influential critics. To get noticed a lot of architects have learnt to change constantly and to shout, if not in words, then at least by means of powerful, seductive visual images.

In the shadow of the media-hype 'opinion leaders' of the Dutch architectural design scene, there is a vast group of more anonymous designers, busy absorbing and evaluating the themes and trends of the nineties, sometimes as 'followers of fashion' but often with an individual interpretation, and with varying degrees of integrity, originality and refinement...

Although the use of computers has contributed widely to generating influential imagery of new, virtual environments, this may not really be where the computer's greatest power lies. Possibly the most important benefit for designers is that the introduction of CAAD has contributed to creating circumstances in which new kinds of designs can actually get built...

## The Building of Designs

One of the most important qualities of computers is their *precision*. However, this quality is often seen as a major drawback for - more intuitive - creative design activities. Working with the computer, the designer has to adopt another way of thinking and learn to anticipate.<sup>1</sup> The computer-assisted designer does not draw abstract lines on a flat surface, but positions components in a virtual framework using a system of co-ordinates. The information is not scaled down but essentially scale 1 to 1. It can be viewed or printed out in different ways by zooming in or out. Because the information can also be represented in the form of three-dimensional projections, the computer offers the opportunity to approach a design in progress as a *model*, or even as a kind of *digital building site*.

The system of working with *components* means that there is a greater correspondence between the Cad method of notation and the built product than was previously the case with traditional technical drawing. Aspects of a plan can be changed without having to redraw. The computer-based method makes it easier to get insight into the numbers, sizes and different types of elements in a plan - and as such the cost factors - from the early phases of design.

The relationship between designer and builder has also changed, as computer information can be exchanged between architect and contractor, and because the building discipline itself has also become increasingly computerised. Although it is not often emphasised, the concept of *Cad-Cam* (Computer aided drafting, linked with Computer aided *manufacturing*) in the building profession has increasingly become a reality in the

---

<sup>1</sup> Bridges, A. : 'Computing as a Vehicle for Teaching Architectural Design', ACSA Proceedings Prague, Washington, 1993.

Netherlands. Whereas in the seventies the trend was towards limited series of standardised building components, which could easily lead to monotonous designs, computer aided *prefabrication* has made it economical to create specific components in relatively small series. Different elements are made beforehand in computer-supported workplace surroundings and assembled - using a *montage* approach - on the building site.

The opportunity of storing information in different *layers* has also given rise to improved communication between architects and building *consultants* who can add their building information to the computer model, using their own Cad layers. This has contributed to new forms of teamwork with service bureau's outside the architect's office.

Lastly, CAAD has helped to make complex forms *measurable*, and as such affordable. This means that even a relatively unconventional design can fetch a competitive price (as long as the information is clear to all parties involved). The creative collaboration between designers and builders in finding solutions for new forms and has meant that even relatively unusual building designs - quite inconceivable to many a few years ago - can nowadays actually get built...

### **Shifting Horizons**

With the maturing of software applications and the growing computer-literacy of designers, the computer is becoming less of an 'added' value for designer and more and more an intrinsic part of the design process.

As such the computer is steadily losing its romantic aura and becoming what it ought to be: a stimulating *instrument* for creative design.

The situation in the Netherlands, as we approach the third millennium, should not be viewed as a controlled experiment, but it may contribute to creating insights concerning the development of the design practice, its relation to the building industry and concerning the influence of CAAD.

Of course it is difficult to imagine how architecture would have developed without the computer and as such it is difficult to know what its influence truly is. Many of the design trends of the nineties were already starting up more than 10 years ago, when computers were still hardly used. Nonetheless it does not seem exaggerated to state that the computer has been very influential as an - interactive - means of charting, documenting and sharing information about both existing and projected environments. Its role as a generator of ideas is still marginal but clearly growing..

The device has been absorbed into both the design and building disciplines. Instrumental developments are dynamic and hard to predict. Just as when we move towards the horizon and it appears to be continually shifting and we can never be fully aware of what is behind it, so it is difficult to speculate about what new generations of computers will really have to offer. One thing we can definitely expect is that they will continue to become faster and have an even more extended capacity. With this it will become increasingly important to 'tame' the enormous amounts of complex information and to structure data imaginatively. Both structural



and desktop clarity<sup>1</sup> will need to be further improved in order to attain the kind of user-friendliness necessary to create truly *new* opportunities for designers - and researchers !

---

<sup>1</sup> Breen, J. and Stellingwerff, M.C. : 'A Case for Computer assisted Creativity through Clarity, Project 12Cad and beyond...', Proceedings Computer Creativeness conference, Bialystok, 1996.



**EXPLORER  
A Procedural Modeler  
Based on Architectural  
Knowledge**

**Vincent Brunetta**  
ISAFc La Cambre  
Belgium

*Cet article est consacré à la modélisation procédurale de configurations architecturales.*

*Les outils de CAO actuels reproduisent et figent la pratique traditionnelle du projet architectural, leurs modèles de représentation sous-jacents sont considérablement éloignés de la représentation usuelle de l'objet architectural. Il nous apparaît que les modes d'accès et de constitution "alternatifs" du modèle informatique (description textuelle et modélisation procédurale) représentent un champ d'expérimentation privilégié susceptible de questionner ces problèmes de représentation du savoir architectural.*

*Nous commencerons par l'examen de modélisations par description textuelle (notamment de façades néoclassiques et de l'architecture palladienne) pour ensuite nous intéresser à une série de modélisations procédurales à base de connaissances architecturales.*

*Nous verrons enfin comment cette réflexion, dans un cadre pédagogique, confronte nos étudiants à la fois à l'analyse architecturale, à une approche de la programmation structurée ou orientée-objet ainsi qu'à une utilisation "critique" des outils de conception assistée.*



## The House of Illusion : Extending the Boundaries of Space



## **EXPLORER, A Procedural Modeler Based on Architectural Knowledge.**

### **Textual description:**

Into the context of computer education for students in architecture, at the early 90', we were led to the conclusion that the simple learning of CAD tools was not sufficient. We won't extend ourselves on the subject which has already been largely discussed. But let us keep in mind that if the manipulation proposed by these tools is easy, graphical and interactive (focusing on the man-machine interface); the computer representation model is still largely remote from the usual representation of the architectural object. Notions such as layers, groups, colors, etc.. are effectively irrelevant to the architectural field. The first alternative to be kept in mind has been the textual description enabled by PovRay (a freeware for modeling and raytracing) (ZOLLER93).

PovRay enables the description of the geometry of objects based on graphics primitives, mathematical transformations and boolean operations (union, intersection, difference) on those primitives. One of the aspects that keeps our attention here is the hierarchical structure of PovRay's description. It enables the introduction of elements from the architectural vocabulary not only in order to name the objects but also to describe complex architectural configurations so that their constitution and composition modes should be revealed. Therefore, we deeply shared interest for the modeling of architectural objects for which the vocabulary, the rules of composition are known, identifiable.

The first exercise on this theme concerns the modeling of facades of the Place du Luxembourg at Brussels.



The work of the architect Trappeniers is not only one of the last examples of the 19th century's station squares but also a remarkable neoclassical unity in Brussels.

"Regularity, order, harmony and symmetry are the main rules of composition that have presided to the architectural design of the facades of the Place du Luxembourg.

When looking carefully at the 1854's initial project drawn by architect Trappeniers, the subtle game of composition based on several degrees of symmetry clearly appears. So, we can progressively decompose the 23 bays of the facade and better catch the complex relations occurring between them. On three levels, the 23 bays (unpair number) for wich the twelfth bay indicates the centre of the general composition, align themselves in five groups. The latter are themselves divided in a hierarchical order into three bodies (centre and extremities) and two intermediate zones. The central body at its turn counts five bays, the entrance door as well as the balcony of the first floor situated at the middle of the central bay largely strenghtening the axial effect."

(VANDENBREEDEN93)

In this extract that introduces a most complete analysis of the composition of the facades, we do find an excellent pretext to our exercise of modeling by a textual description.

The exercise unfolds in two stages:

-First:

Setting up of a precise drawing of the facade.

Architectural analysis of the facade (by decomposition).

To locate the different architectural elements (through an appropriate vocabulary).

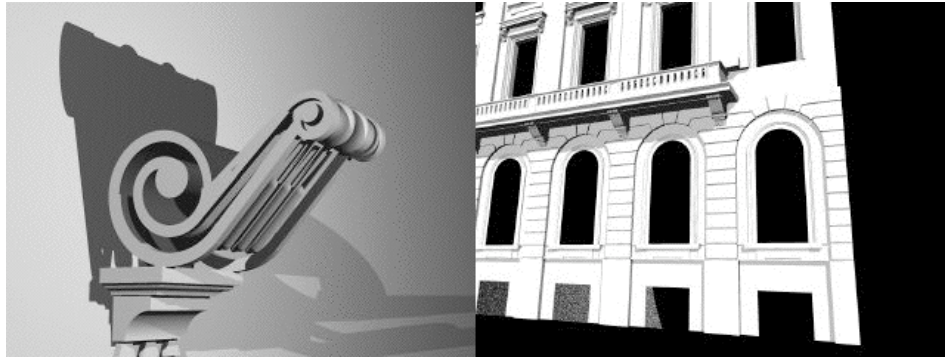
To draw hypotheses related to the composition.

-Second:

Textual modeling (by recomposition):

Actually, it consists in the description of the geometry of elements and architectural details (details of cornice, of console,...) located during the stage of analysis. Then we proceed with the recomposition of the facade so that the structure of the textual description reflects the structure of the architectural composition.



*Florence Corin 93-94**Group of students 93-94*

As an example, this is the way a textual description might look at the highest hierarchical level of the facade (PovRay syntax).

```
Whole_facade =
union {
    Left_body
    Intermediate_body
    Central_body
    Intermediate_body
    Right_body
}

Central_body =
union {
    Left_bay
    Intermediate_bay
    Central_bay
    Intermediate_bay
    Right_bay
}

Central_bay =
union {
    Arch_ground_floor
    Balcony
    Window_first_floor
    Window_second_floor
    Cornice
}
```

This, consecutively till the end of the precise geometrical description of architectural elements of less importance.

Modeling by textual description is both elegant and compact (50 Ko for the description in the slightest detail concerning the 23 bays of the neoclassical facade).

Today we are still using this technique of modeling for educational purposes.



*Defourny-Derycke 95-96*

*Auly-Barremaeker-Debar -Schreurs 95-96*

### **Procedural description:**

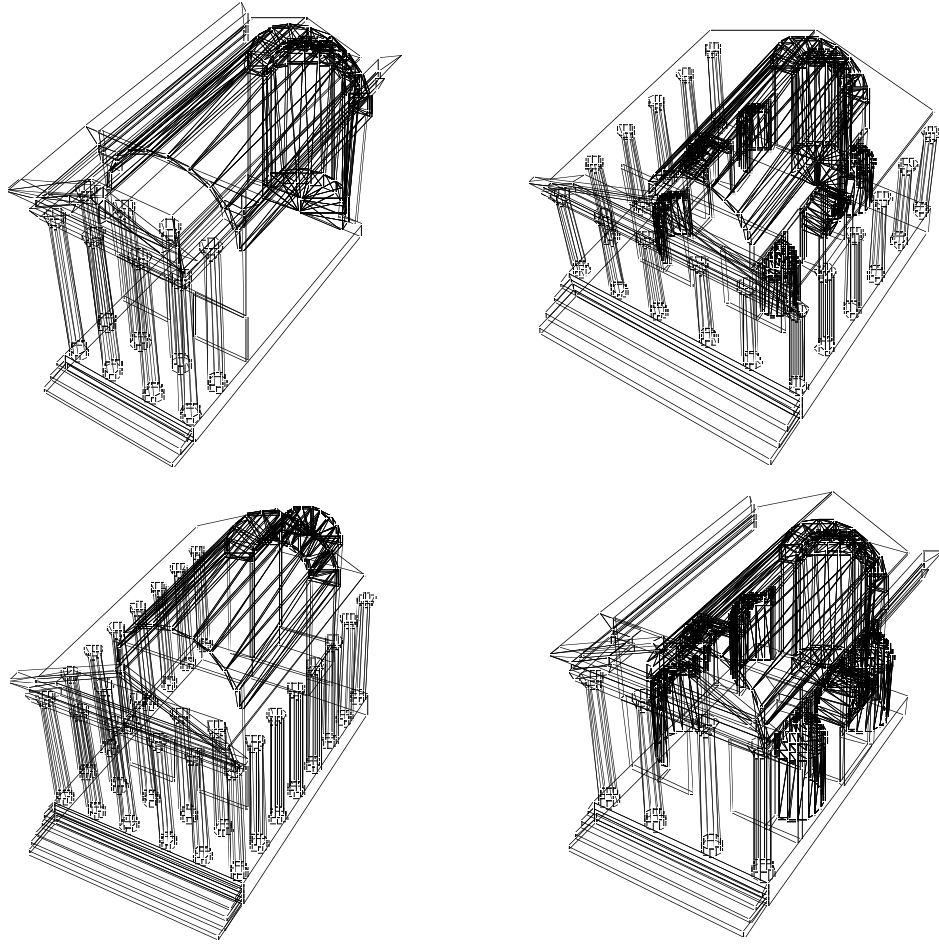
If the afore mentioned textual modeling partially responds to our preoccupations, we immediately asked ourselves the question of the description of families of similar objects, variations or instances of a type (MITCHELL89).

Effectively, if a textual description corresponds to an unique architectural object, from now on our attention is more kept on the basic rules generating objects than on the precise determination of the geometry for one of them.

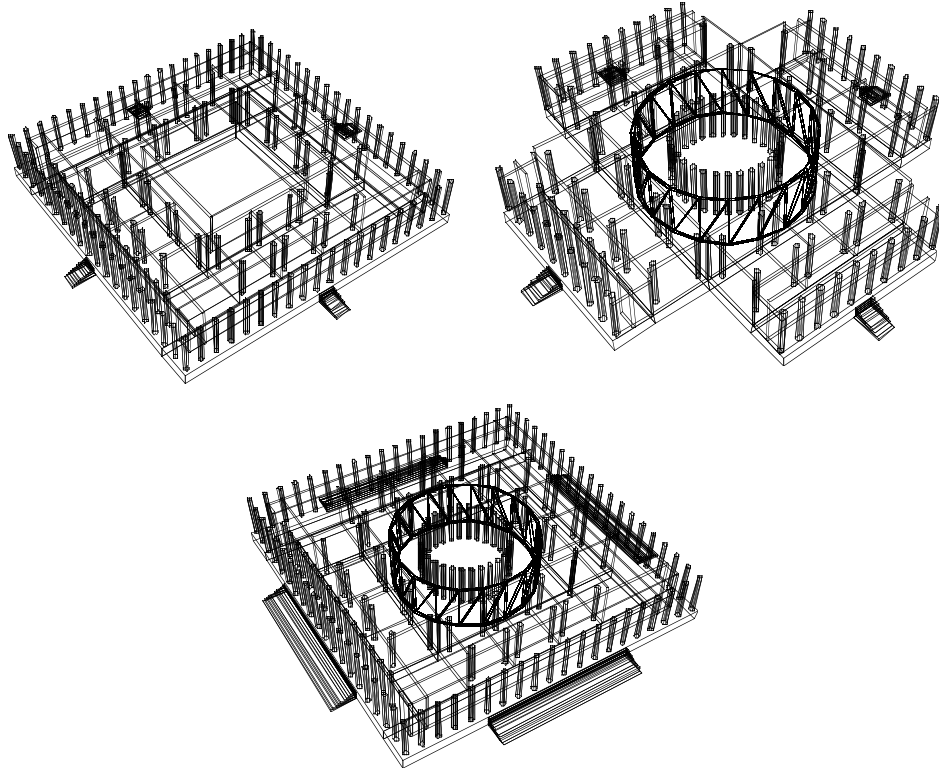
For us, the "shape grammars" seemed too remote from our architectural preoccupations. In effect, few elements and tools of the architectural vocabulary are put into operation.

Thus, we have fully developed a procedural modeler (FOLEY90), wich uses a syntax both simple and universal based on the C programming language. This procedural modeler, EXPLORER, keeps the characteristics of the textual description i.e. (the uses of architectural vocabulary, the elegance of the description) as it also brings a serie of new aspects like the possibility of generating a collection of objects more or less complex, the visualisation of these objects in real time (wich enables the swift evaluation of the configurations produced) as well as the possibility of exporting these objects under different formats like DXF 3D, VRML, Inventor, Rotater (Macintosh), PovRay, QuickDraw3D etc...

The article "I "templa" albertiani: dal Trattato alle fabbriche" (MOROLLI94) in wich Morolli describes the rules applied by Alberti in his interpretation of the etrusc temple, has originated one of our first procedural modeling (still in progress).



From an educational point of view, we propose the procedural modeling as a further development of the textual modeling. Find below an example of a current exercise, originated from the *Partie Graphique des Cours d'Architecture* (1821) of J.N.L. Durand.



*Gilles Hénin 96-97*

Currently, we explore the possibilities of object-oriented modeling (C++, but also JAVA). One of our objectives consists in architectural modeling within a VRML 2.0 environment thanks to JAVA and JavaScript scripts.

### **Conclusion:**

On the one hand, this kind of exercise faces our students to a strict and detailed analysis of architectural objects, which largely exceeds a superficial reading.

On the other hand, the students are led to a better understanding of computer mechanisms, notably in the field of the representation of architectural knowledge. The latter enables them to have a critical look towards CAD tools.

Finally, the pleasure for both students and scholars when observing these emergent configurations, sometimes unexpected, is certainly not a negligible aspect of this kind of experimentation.

### **Bibliography:**

(FOLEY90)

Foley, van Dam, Feiner, Hughes,  
"Computer Graphics: Principles and

- Practice", Addison Wesley, Reading, Massachusetts, 1990.
- (MITCHELL89) William J. Mitchell, "The Logic of Architecture, Design, Computation, and Cognition.", The MIT Press, Cambridge, Massachusetts, 1989.
- (MOROLLI94) Gabrielle Morolli, "I "templa" albertiani: dal Trattato alle fabbriche", p106-133 in "LEON BATTISTA ALBERTI ", Joseph Rykwert and Anne Engel, Olivetti/Electa, Milano, 1994.
- (VANDENBREEDEN93) Jos Vandenbreen, "L'architecture de la place du Luxembourg ou comment les lois subtiles de la symétrie peuvent régir une composition architecturale." in "Embellissement Projets pour Bruxelles Place du Luxembourg", Fondation Roi Baudouin, Bruxelles, 1993.
- (ZOLLER93) Jacques Zoller, "DKB: un outil informatique permettant une coordination pédagogique avec l'architecture, les arts plasiques et les mathématiques" in Actes du Colloque IMARA '93, Monte-Carlo, 1993.



# The Cost and Value of Animation for Architectural Designers

**Mark Burry**  
Deakin University  
Australia

*As computer laboratories or studios in architecture schools provide greater access to fast machines and sophisticated software, the opportunity for computer aided animation increases 1 dimension. Previously the domain of the most enthusiastic, it has now become a relatively simple task to move from 3D to 4D. If the impediments to a common access to these new possibilities (for architects) are no longer a matter of the cost and availability of hardware and media, what measures the extent to which we can value the contribution of animation to studio-based design? This paper reports on our progress in establishing some practical and theoretical benchmarks comparing the cost with the value of computer aided (or mediated) animation.*





## **The Cost and Value of Computer Aided Animation**

### **Animation and the Design Studio**

Design tasks involving computer use tend either to have been tailored to the perceived capabilities of media stuck in the groove of some previously acquired release or worse, tuned over-optimistically to the alleged capabilities of a forthcoming release, still to arrive months after being ordered. There has been difficulty in assessing what is a reasonable computer-based task for the calculable time available. In a traditional design studio, for instance, a student will be asked to produce designs with varying degrees of detail for a large building within, say, a semester. A greater number of people would be involved over a far longer timeframe for an equivalent project if it were actually intended for building. Beyond discourse, the student project is contrived to be a reductionist facsimile of a real world situation. The Professions place an expectation on the educational institutions in this respect, tending to view the students' exercise as a selective *précis* of the wide range of skills involved for a real building. The depth of their thinking at both an intellectual and pragmatic levels is a sampler of the decision-making they will later employ in an office, it is assumed.

The drawing, then, is a drawing, one of a set of a small number in design studio, similar to one of a considerably larger set in an office. A ten-minute animation, however, is the same in terms of scope in an architectural school production as it is when made in a special effects studios for Hollywood; the length of time remains the same placing similar demands on content. Whereas it is relatively easy for the student to gauge their production using traditional media, it is difficult to be specific about how the student can keep their computer-based work in proportion with the assignment grade. This is especially so when the working environment and creative opportunities in *3D Studio Max*, for example, are both limitless and intoxicating for the new possibilities for design (presentation) refinement that they represent. Often it is only insufficient access to suitable machines and a running out of available time that can actually bring the project to a halt for hand-in. A sense of proportion with other workloads becomes temporarily lost.

### **The Value of Computer Aided Animation**

Just as the perspective revolutionised the representation of space for the early Renaissance painters, so too has animation assumed an equivalent status. As soon as rendering algorithms began to provide the opportunity

for photorealism, the possibility for animating sequenced rendered images emerged as a natural corollary. The value of animation as a tool for incipient designers and practitioners is hard to contest. The assumption for many seems to be that the producer of the animated walk-through or fly-by is the modern equivalent of the perspectivist. The ability to take a client around, through or over an electronic representation of a building is regarded as a valuable resource despite the fact that very few practices can afford to do so except for large commercial work (Dawson 1996). This virtual walkthrough can proceed unchallenged by the client happy to pay for the disproportionate number of hours required to produce such polished VR simulation. Animated walkthroughs may be the most obvious use of the software in practice but it is more likely to be challenged in the design studio where it can be used as an obfuscatory device. The dynamic qualities of an animated presentation can be perceived more as rhetoric than suggestion in the case of the student who risks compromising a weak design by conspicuously spending too many hours preparing the animation.

If a student dedicates their presentation time to the production of an animation as their final, rather than as part of their final submission, they will probably seek to seduce their critics with a highly selective and manipulative piece of work. Indeed, studio projects have been presented where students have specifically entered the film world from an architectural position (Goldman, 1996). It is difficult for the critic to derive a purely personal feeling for the inner quality of a project through reading a combination of conventional drawings and sketches if they have been exposed to an overly elaborate and contrived prescriptive view.

Ironically, the less photorealistic the animation, the more other-worldly or ethereal the effect, the more the animation itself can be appreciated as a design tool. Curiously, by avoiding photorealism and accepting happy accidents and serendipity, or by using some of the sophisticated tools for unlikely and unintended adventures, extraordinary layers of richness can be added to the exploration of design that cannot be imagined in other media. An example is the examination of the interior and the exterior of a space by modeling walls with varying degrees of translucency. Lighting can be applied to accent or play down the degree of presence of objects and building fabric. Such contrivance, difficult to emulate using any other means, can be achieved satisfactorily using rendered still images. The challenge becomes the determination of what will be gained through the addition of movement. In many cases the answer is very little. Too many things happening in the frame can be very distracting. A change from solid to transparent, day to night or the passing shadows from a moving sun might be more effective when both the viewer and the building remain still. Other opportunities are the representation of aging and weathering. These images are less film-making and more architectural and painterly; they will have particular qualities that are paradoxically easier to achieve and truly personal. They also induce a sense of compressed time by revealing the accelerated effects of time.

## The Cost of Computer Aided Animation

Animation exploits a rare mix of creative, perceptual and technical skills. In the film industry, large teams have developed ways to collaborate seamlessly without the particular authorship of any one participant being identified. A director's desires are expressed as a storyboard that provides a scripted representation of the transitory. This linear format is a simple enough means to communicate movement for the technical implementation by a collaborating animator-artist. The act of animating itself is at once personal as it is collaborative. The fine-tuning of the many variables such as camera angle, position, number and colour of lights, camera tracking path, tracking speed, movement of object(s) in relationship to the camera and vice versa, combine with the refinement of the colour and texture of the subject. They are best determined actively by the animator whose individuality may be subsumed into the collective will of a group.

Animation in the movie industry tends to focus on action. Its application to architectural situations will most likely be one of providing mood or as an explanation of something unlikely to be revealed using other means. This may or may not include fly-bys and walk-throughs. My experience suggests that the quieter and more reflective animations can involve the least work but have greater value. At the other end of the scale are the animations which are compiled to show assembly. Whether the clip shows how hi-tech components come together and how they control movement and flexion, for example, or whether they are intended to demonstrate the construction sequence to the self-builder, there is a considerable task in both learning the software and implementation.

Having experienced computer applications teaching and the apparently disproportionate time students put into animations, we decided to count the cost in hours in learning software use and acquiring computer animation skills. Two students were given scholarships to spend six weeks (180 hours each) during the summer recess learning to model on the computer and to make animation videos. They came to the project with minimal 2D *AutoCAD* experience and no experience in rendering or animation. Their work was measured as a straightforward audit of their time and compared with the effectiveness (value) of their output. Despite the contrived and luxurious experience of having uninterrupted time to first learn then apply these skills (compared with the normal classroom experience) the experiment duplicated the typical situation of minimal tutorial support. Indeed, the brief determined that they would self-tutor as well as they could from the manuals and work together when appropriate. We were particularly keen to learn how much tutoring is actually needed; if less than previously considered appropriate, computer applications tutoring work might be tailored to more exacting intellectual tasks rather than purely technical. It would be better to devote more time to tutoring in the area of design implications of animation rather than design applications.

The results were encouraging and a little startling. Bearing in mind that these were two very motivated students (so not necessarily a representative group) it was interesting how quickly they gained access

to most of the high-level operations within each software (*AutoCAD*, *3DStudio Max* and *Adobe Premiere*). They chose tasks that were challenging and ambitious.

Three buildings were explored. The brief was to take a 3D representation from a book on construction detailing and to use animation to state something of the quality of the assembly that was missing from the drawings. They chose Paxton's Crystal Palace (by virtue of its virtuality), Renzo Piano & Richard Rogers' Centre Georges Pompidou and Richard Rogers & Partners' Inmos Centre. They commenced by modelling a few minor details in order to gain an impression of the opportunities and pitfalls.

The assemblies were modelled mostly using the *ACIS* modeler in *AutoCAD* - itself a difficult task. The models were then imported into *3D Studio* for a progressive rendering and assembly. This task included experiments in loosening the physical definition such as making some of the components semi-transparent, a contemporary version of the cutaway. Having made various clips, *Adobe Premier* was used to assemble the clips, stills, images and drawings with sound to make a polished production.

Their output was impressive, but possibly more for the amount the students had done from a standing start than the inherent quality of their production. 180 hours of intensive and uninterrupted application brought them to a point of competency; how many students get the opportunity to devote 180 hours to acquiring these skills? They were attempting one of the more difficult spatial gymnastic exercises: bringing many items into a central area, at different times and different speeds. Their conclusion, however, was revealing. By having to choose materials and construction sequences, they had learned more from the doing than they would have learned by simply studying the original drawing source. Regardless of outcome, the intensity of modeling the components had been a valuable task in itself. Animation is, as a minimum, an creative act that emphasises relativity.

## **Concluding remarks**

Taken individually, friendlier interfaces and more widely available increased computer power mean that each of the many variables can be tested quite quickly. Taken as a combination, the number of variables multiplied by the enormous range of subtle changes that can be effected within each variable present an abundance of choice. The more capable the software, the greater the degree of choice and time needed for the animating; the process is essentially one of iterative experimentation. Experience brings judgement, of course, but only after many hundreds of hours practice. The benefits of a course at film school may not be so easily acquired within the conflicting demands on the students and the equipment at a typical school of architecture.

I believe that it is appropriate for the architectural animator to be sceptical about the value of walk-throughs, for example. While such animation appears to be an answer to the architect's prayer for the

representation of space without the clutter of people, such work seems to carry a sterility which becomes worse the more realistic the work purports to be. The drive for more realistic rendering, and the subsequent thrust towards animation, has been sponsored more by those gifted enough to conjure and develop the required algorithms than those accustomed to thinking as designers. For students to devote too much time in animating an otherwise lack-lustre design the cost is too high, both in terms of the equipment being tied-up and the low value of the output. The cost, too, of dedicating time to learning technical craft in a higher education environment might also need to be questioned in relation to the use of other computer applications. Programming, for example, may be a better use of the intellect than experimenting with the myriad of variables with insufficient expert tutoring. Programming, of course, has much in common with design in terms of understanding a problem in order to resolve it.

We are probably at a watershed. The instinct to move headlong into animation was originally tempered by the relatively high cost of hardware and software. Now that this has been removed, and while schools are slow to introduce film craft to the curriculum, the chances are that the experimentation which has been unfettered by any scholarship in film theory or the practical insight gained from apprenticeship will yield surprising and valuable paradigms specific to architecture. The cost and value of computer aided animation may not have reached parity yet. But there is every indication that it soon will through the generation of design strategies previously not considered rather than simply making realistic 4D representations more simple to achieve.

## **Acknowledgements**

Acknowledgements: thanks are due to David Morison, Nick Stephenson and Elrond Burrell for their assistance.

## **References**

- Dawson, A., Computerisation of Architectural Practices: ITS Development in Victoria, Australia, doctoral thesis, 1996
- Goldman, G., Reconstructions, Remakes and Sequels: Architecture and Motion Pictures, Design Computation Collaboration, Reasoning, Pedagogy, ACADIA 1996

Burry

figuren pag1

figuren p2





**GACAAD or AVOCAAD ?**  
CAAD and Genetic Algorithms for  
an Evolutionary Design Paradigm

**Roel Daru**  
**H.P.S. Snijder**  
TU Eindhoven  
The Netherlands



## **GACAAD OR AVOCAAD ?**

### **CAAD and Genetic Algorithms for an evolutionary design paradigm**

#### **The Darwinistic paradigm in architectural design**

One of the dominant paradigms in architecture is about its creation: it is done by human designers supported by tools like sketching, drawing or modelling and evaluation tools. The Darwinistic paradigm demands a paradigmatic switch from drawing, modelling and evaluation to the breeding of forms with a much more integrated generation and selecting process embedded in the computer machinery. This means a paradigm switch from a designer as the performer of (sketch, draw or modelling) work to a machine driven creation and selection process of forms with the designer as the supervisor, fully entitled to steer the process in some preferred directions. The designer creates by establishing the evolutionary rules and making choices among the architectural creatures emerging in rapid fire mode through the synthesis performed by the machine. Natural selection is a metaphor: in fact the designer plays Nature (or God). The creatures allowed to flourish are not adequate according to laws of Nature, but to the judgement of the designer (or to the designing team).

#### **The Darwinistic paradigm made operational and computable**

Architects have a long tradition going back at least to the Greeks in studying nature in order to get a grip on its perceived perfection and to design in accordance with the rules (of harmony for instance) found in nature. But only after Darwin (survival of the fittest) and the discovery of the mechanism of genetic replication (mutation and cross over) came the study of nature beyond the analogical and metaphorical understanding of the rules involved and the possibilities to translate them to architecture (Steadman, 1979). With the arrival of the population based genetic algorithms of John Holland (1975/1992, 1992 & 1995) the Darwinian paradigm could be formulated for the first time in an operational and computable way. It offers the architect and everybody else involved in the development of buildings the prospect of a creativity enhancing assistant. An always attentive device capable of suggesting unexpected, original and still applicable design options instead of an also useful intelligent AI-based knowledge helper or a CAD-based drawing and modelling aide.

#### **Observations in the design studio**

Architectural studio supervisors are familiar with students taking on their design assignments by proceeding roughly as follows: they explore the

brief, the situation and the concepts applicable eventually in not predetermined sequences of documenting, sketching and thinking. But then, once the first implementable solution emerges their willingness and/or imagination to generate more alternatives diminishes. It shrinks proportionally to the success of the first choice in the process of incremental improving the solution tending towards consistency. Only if this procedure fails are they willing or compelled to consider new possibilities. This corresponds with a very common human frailty which March and Simon (1958) among others (i.c. The Carnegie School) once studied in economics (earning Simon a Nobel prize). What Simon and others observed was that people in reality were only rational in a limited way. They are not capable of reasoning about and contemplating more than a few decision factors at a time and are inclined to stop their information gathering activities as soon as possible. They are also biased in their judgements and willing to accept the first solution they hit upon instead of going on searching for the best solution available. This is what tutors also see their students doing in the architectural studio.

### **Enabling group creativity with handtools**

To discourage those anti-creative practices of fixation on the first design encountered, we conducted group oriented design sketch-exercises in our design studio, but succeeded only partially in our expectations. In the exercises students were asked to sketch their first imagined design concepts and exchange them on the basis of mutual support with everybody else in the group. Everybody looking at the first design concept given by someone, was then asked not to criticize but to contribute (with sketches and explaining text) to the solution with congruent ideas. The student-owner of the original first concept then reviewed the contributions and selected the ideas he or she preferred most for integration in a new concept or parti, whereupon he or she once again exchanged them in a new round with everybody else in the group. Discussions after the exercises and at the end of the studio assignment revealed a mixed reaction from very positive via positive-with-some-reservation to negative because they were either afraid to lose their best ideas to someone else or not willing to work in a group after having experienced group work in the studio for a few years. Working in a group was plagued, but to lesser extent, with the same problems as individual design: reasoning was still done with a few decision factors at a time, information gathering often reduced to a minimum, judgements largely biased and everybody mostly still happy to accept first instead of best solutions. If pencil-aided-architectural-designing (even organized in groups) only partly succeeds in enhancing creativity, will AVOCAAD succeed or do we need something quite different?

### **Absence of a natural picture-maker**

Another suggested reason for the difficulties encountered to support creativity is that we lack a natural visualizing organ corresponding to the way our mouth works in conjunction with our ears when speaking and reacting to what we hear. Pencil-aided-architectural-designing is the best

surrogate we have (Goldschmidt, 1991), but this does not work as outstandingly and consistently as ear and mouth, which allow perceiving sound as quickly as it is produced. Only very rough sketches are approximately able to produce images as quickly as we perceive them. In this respect CA(A)D still does not offer a better alternative. While the most fantastic environments can be modeled and rendered, they still do not play the role of sketches in the design process as a rapid feed-back, which is why people (rightly) still cling to their sketchbooks instead of embracing computers as sketching assistants. It is also questionable whether a trained and experienced architectural designer needs all the hyperrealistic sophistication available now and in the future, while still in the phase of the conceptual design process. The fact that designers do not surrender their sketchbooks is certainly not a question of technophobia, but of the unavailability of highly technized yet functionally superior surrogates.

### **Does CA(A)D come to the rescue?**

The most motivated computer literates among students and practising architects are applying the available modelling programs (usually AutoCad) in a traditional way, which replicates what the architect did in pre-computer days, when handing a sketch to an assistant to transform it into a buildable model: making a few design sketches by hand and then modelling them once to modify them extensively afterwards. Then (in the case of folding architecture for instance) the morphing and warping facilities of the programs involved comes to the rescue, delivering possibilities not available by hand (at least in a practical way; see for an example Oosterhuis, 1995). A disadvantage of this approach is the reduced time spent to conceptualize with the help of design sketches. This is not necessary but actually practised in order to get enough time to model and modify the design for presentation. The incredible amount of time students have to spend on computer modelling is by the way rather a hindrance than an added value.

### **Drawing or design support?**

Except for facilities like morphing and warping or parametric modelling, most functionalities of CA(A)D (and Paint) programs are still only applicable for drawing, not for conceptual designing. CA(A)D programs are too structured for the early phases of design. They require too much precision in a phase when the designer does not want to take those decisions (like the exact dimensions of rooms if he or she is only concerned with their relative positions). Paint programs on the contrary are not structured at all, making a identification of the parts in the whole of the picture impossible for more specific refinement and development and to establish links with databases. Basically CA(A)D and Paint programs are still tools supporting the motoric action of the hand, instead of extensions of the brain for intelligent and/or creative design behaviour. The draughting tables are disappearing from studios, but their imprint remain in the CAAD software and hardware which replace them.

## **Electronic Cocktail Napkin**

To support the designing brain, knowledge and rule based AI techniques are deployed. One of the most interesting developments in this field for the early phases of designing is suggested and implemented by Mark Gross (1996): the electronic cocktail napkin, a program to sketch in a more intelligent way by hand on a tablet (available now on internet for the Macintosh). In the program, a potato-like shape might be correctly interpreted as a rectangle. Also the spatial relationships between the shapes might be analysed and compared with earlier defined compositions. The program enables someone to sketch directly with a familiar pen and tolerates the input of inaccurate and therefore multi-interpretable shapes. At any moment it is possible to provide those shapes with additional meaning in order to work increasingly with more accurate, unambiguous and detailed interpretations of the shapes involved.

## **Embedded intelligence**

With the pattern recognition features of the program it is possible to use the embedded case base knowledge and ideas for inspiration. Because the cocktail napkin program is working with CA(A)D equivalent data, it is possible to import those data in CA(A)D programs for simulations, analyses and follow-up phases of the design work. This is made easy with a function to smooth the shapes of roughly sketched circles and squares, characters and numerals and whole configurations of more complex shapes. With the program it is also possible to simulate sketching with transparent layers. It support cooperative work and records all the sketch activities for analysis later on. Also the link up with visual and knowledge intensive databases is envisaged just as the possibility to interpret isometric 3D sketches.

## **AI restrictions**

Although the cocktail napkin program breaks through the passivity of the usual Paint and CA(A)D programs (even object driven ones), it does not go beyond the capacity of association encouraged by hand-sketch capabilities. Associations take place by precedents collected in a library and are therefore largely predictable and limited in scope. In design sketching it is not first order logic and the application of inferred rules and precedences which are pre-eminent, but more analogies and metaphors stretched out as starting points for designing. Like all AI techniques, the program might be sensitive for shortcomings and restricted in its application. Innovation of the whole coming from the interaction of the parts is also difficult to achieve because the parts are embedded in advance in the conceptualisation of the whole. This is an effect similar to shape grammars demanding anticipated specifications for their formal grammar and vocabulary and in doing so, engendering predictability. Last but not least, the maintenance of such a programme might be arduous and expensive.

## **Genetic algorithms as accelerators of sketching**

The main disadvantage of both the CA(A)D and AI approach is though that the generation of shapes is still not accelerated beyond all capabilities of the eye-hand- brain coordination. In order to make this much needed jump in speed to generate (related families of) shapes, genetic algorithms can be put to use. Usually, modelling is done once by the programmer and then triggered endlessly by the user. In some programs however even this first modelling might be created and imported by the user as a bitmap scan or vector active drawing. Like in nature, out of such a basic startup model an endless variety of shapes can be breded.

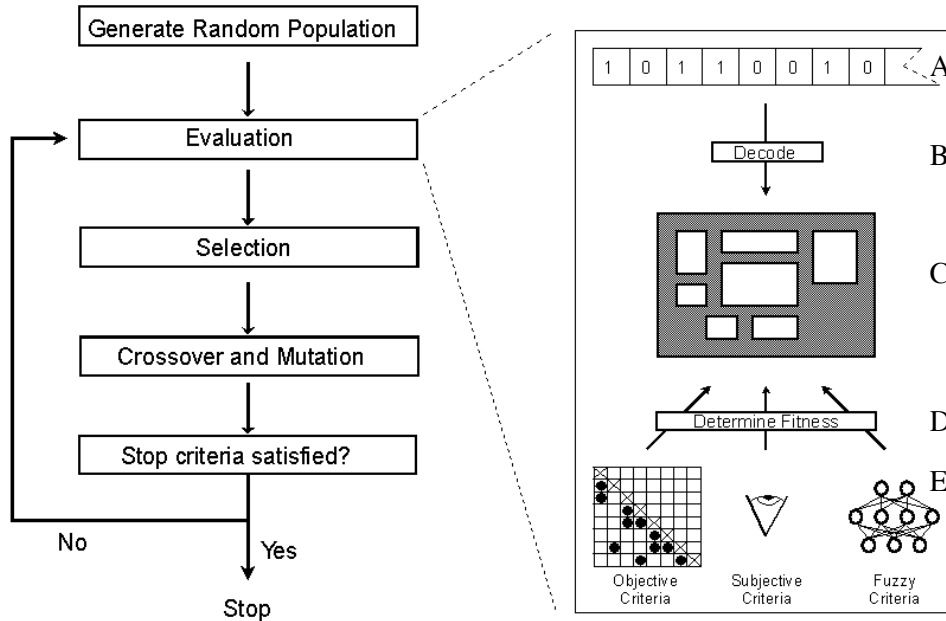
## **Genetic algorithms: complementing human cognitive limitations**

Not only a tremendous speed increase can be achieved in generating and drawing on screen with this type of programs. But also the incorporation of selecting criteria in an evaluation function might be accomplished. Both the generating and drawing of alternatives and the selection among them takes place in unison (figure 1). The automation of the selection process is possible if quantifiable (hard) criteria are employed. But also tacit (soft) expert knowledge (if captured within an neural network) can be applied within the evaluation function of the morphogenetic program. The clustering of people, departments or rooms for instance might be based on objective criteria and applied in an optimizing genetic algorithm but might also be based on subjective or fuzzy criteria and put to use in a trained neural network capturing the fuzzy knowledge of an expert. In this way the mentioned human reasoning restrictions to consider more than few decision factors might be avoided, necessary information incorporated, unbiased judgements implemented and best solutions aimed for. The introduction of extrinsic knowledge and preferences by the user is still made possible with the rapid visualisation facilities to picture the most promising generations of best fitting solutions (according to the applied evaluation function and incorporated neural network). This is accomplished by a visual display supplying the user with additional opportunities to select what he or she knows is best (thanks to some available additional information) or if the user is looking for aesthetically pleasing or otherwise interesting arrangements.

## **Artificial creation and universes of new creatures**

Authors of genetic programs (like Dawkins, 1986, Sims, 1991 and Todd & Latham, 1992) all mention their astonishment at the incredible variety they got confronted with when their programs started generating forms based on a few simple rules. They explained that they would never have found them in an other way and surely not in the comprehensive manner offered by their programs. They even wouldn't have the time to draw, model and render them all appropriately. Form breeding programs have the combinatorial capacity to produce immensely large sets of variants, without being troubled with the typical human effects of being satisfied

with the first applicable solution one has hit upon (love at first sight). Additionally, with their built-in evaluation function they are able to detect and select the most promising ones for presentation to the user(s). Subsequently, humans (and especially designers and critics) are very well capable of spotting quickly and efficiently the qualities of variants in the remaining presented subset of the most promising options. As a result of all this, innovations emerge spontaneous out of the forced and unpredictable interaction and combination of the parts.



**Figure 1:** flow chart for the genetic algorithmic procedure of the layout program by Philip Snijder with a detail of the evaluation function to test the fitness of the creatures (the layout alternatives). A= strings defining the geometry as a genetic entity; B= genetic entity decoded into Euclidean geometry; C. Layout as a generated form or shape; D= fitness test; E= types of test criteria: left objective and automatic executed criteria (of proximity for instance), in the middle subjective criteria introduced by selections of the user on screen and right fuzzy criteria applied by a neural network trained by an expert in the field (about orientation for example).

### Artificial creation and creativity

Creativity is about new thoughts, concepts or notions (Boden, 1994; Gero & Lou Maher, 1993; Runco & Albert, 1990; Sternberg & Davidson, 1995). It is about the ability to come up with new ideas out of either an unrecognized part of a pre-defined solution space or as an emergent result of transformation of some aspects of the conceptualized solution space. GACAAD applications are quite potent for provoking and supporting this kind of creative acts. They incorporate pre-defined solution spaces giving the opportunity to spot and explore the unrecognized parts of the solution spaces involved. And they offer the possibility of intervention in the pre-definition of the solution space itself in order to tinker with them or transform them partly or radically.



## **Working styles of designing and diffusion of the GACAAD idea**

It is left to the architects to determine how such programs might fit into their practice. From the point of view of working styles of architectural designing (van Bakel, 1995) the program should be designed to work from either a conceptual line of approach or starting from the brief or the site involved. In figure 1 the purely conceptual approach is provided for by the possibility of selecting subjectively by visual appreciation or by using fuzzy criteria. The approach from the brief is attended to by the introduction of objective or even fuzzy criteria. Last but not least the site as a framework is looked after by incorporating penalty points for overstepping the limits of the site involved. But even the existence of adaptable morphogenetic programs is not enough to get architects to apply them in practice. As the preamble of this conference states, media diffusion techniques would then be needed, accompanied by carefully selected case studies in practice, introduction of the results in workshops and training courses for students and professionals alike.

## **Genetic algorithms: suitable for design groups and everyone else involved**

In (AVO)CAAD sketching and drawing is the exclusive domain of the individual architect. Or at least restricted to individuals with some experience in visualizing. If groupwork is asked for, the most practical design procedure is to leave the sketching, drawing and modelling to the most skilled people (the facilitator or operator) whereas others can concentrate on reasoning, asking for new or corrected pictures and selecting options for further development. To do the sketchwork instantly during a meeting is a very laborious job for the the facilitator or operator. With GACAAD no amount of sketching, drawing or modelling is needed during the meeting. This is done by the program and everybody else is involved in the decision making process of deciding on criteria to be employed and selections between options to be made in a very fast and highly interactive way. Because good visual observation, interpretation and selection are much more widespread than skill at visualizing, the GACAAD approach has a clear advantage. With a visually based GACAAD the tools of CSCW (computer supported cooperative work) - yet still under development mainly verbal or computational- might be expanded to the fields of design, architecture and artistic production.

## **Integrating design research facilities and results**

Design research might be performed as either ‘about’, ‘for’ or ‘through’ architectural designing (Daru & Snijder, 1996). To investigate the first the process of designing the programs could be equipped with automatic registration devices to facilitate observations and analyses of behaviour performed on the machine. The results could be fed back for the redesign of the interface or the other parts of the program involved. Research done on instruments to improve the design (like wayfinding in buildings) could be embedded in the evaluation function of the morphogenetic program. Research of the third kind ‘through’ or by way of architectural designing (experimental designing) could take full advantage of the shape generating capabilities of the morphogenetic program to explore and discover new, meaningful and valuable forms.

### **Designers as Darwin Machines**

The functioning of a brain generating forms might also be seen as a Darwinistic system of creatures behaving within their environment. In a morphogenetic program, the creatures are the generated options and the environment is represented by the evaluation function together with the visual interface for selecting options to be reproduced in a next generation. Dennett (1995) makes a distinction between four types of creatures: Darwinian, Skinnerian, Popperian and Gregorian living beings. Morphogenetic programs are capable to support or even to simulate those types of creatures, according to the sophistication of both the creatures learning capabilities and the morphogenetic programs involved.

### **Darwinian creatures**

Expressed in the context of an architectural competition a Darwinian creature is a participating architect with his design entry submitted to the jury as the environment. The ideas embedded in the winning entry will propagate themselves in both the next projects of the prizewinner and the minds of competitors, due to its success in the selection process. Morphogenetic software is capable of simulating this type of Darwinian creatures: it is able to generate alternatives, carried out by the selection function, first randomly, and after each selection round, more and more goal directed. If the software is equipped with a visual selection display the software is transformed into an enabling tool. In morphogenetic art programs (like the paint program by Karl Sims (1991) or the sculpture program of Stephen Todd and William Latham (1992)) the applied genetic algorithms generate new images from pre-defined images, based only on visual selections. In an applied art like architecture, Fraser (1995) and Möller (1996) have done the same, but they developed also programs with some objective criteria inserted. Philip Snijder (Snijder & Daru, 1996) is doing this in the same vein with a layout generator for the earliest phases of architectural design (figure 1)

### **Skinnerian creatures**

Skinnerian creatures differ from Darwinian ones by their conditional plasticity: they learn by trial and error. Within the context of design

competitions this might be compared with an architect full of design ideas trying them out one for one, or in a variety of combinations in competition entries, until one hits a prize. The ideas applied in the prizewinning scheme might then be adapted for forthcoming competition projects. Those architects let themselves be conditioned by the jury environment. As newcomers (in an other country for instance) without any informal information about the vision and behaviour of jury members and how they will argue and select, this trial and error approach is perhaps the most appropriate to follow. The problem with this type of 'blind' respond in nature is that you might first try out by chance the least appropriate answer and get wiped out: there is no reinforced second chance to respond more suitably to the situation. This type Evolutionary Reinforcement Learning (ERL) is (perhaps for the first time) implemented in the program by David Ackley and Michael Littman (1992). They linked together a genetic algorithm with two types of neural networks: an evaluation network with fixed goals, giving reinforcements to a modifiable action network which maps the current state of the actual alternative to be used for an appropriate response in a next round of tryout.

### **Popperian creatures**

In order to avoid a bad start with the trial and error procedure of the Skinnerian approach Popperian creatures have developed preselection devices to make better-than-chance first trials. This feedback mechanism is structured like the outer environment and (based on lots of information) sorts out the best actions to take in a hostile environment. Within the setting of a design competition, an architect (relying on information he or she has collected) might for instance imagine how the members of the jury will behave (their ways of observing, reasoning and selecting) and develop out of those depictions an internal environment as a reflection of the real external jury environment. In that way the architect is able to reflect on the probability of positive impact that his or her design ideas might impose on the jury. Design ideas that survive such an internal criticism might have a better chance to succeed in the real world of competition judgements by juries. This type of thinking is simulated on behaving automata (on supercomputers in a very restricted and simplified way) by a team lead by Nobel laureate Gerald Edelman (1992), based on his neural Darwinistic population 'Theory of Neuronal Group Selection' (TNGS, Edelman, 1978).

### **Gregorian creatures**

Gregorian creatures are like Popperian living beings, but with the additional trait of informing their internal environment of the artificial world of man-made-things with the intelligence invested therein and apprehendable in them. As Gregory (1981, pp 311 ff) put it: a pair of scissors is not just a result of intelligence but also an endower of intelligence; when you give someone a pair of scissors, you enhance his potential to arrive more safely and swiftly at smart moves. Until now the best mindtool for designers is still the design sketch pencil, perhaps now

and in the future more and more amplified by devices out of the worlds of AVOCAAD and/or GACAAD. Deny a designer his pencil (or his sketchmodel) and he will suffer in (the fluency, complexity and consistency of) his imagination. Mindtools in designing are meant for both the generation and the evaluation of forms and form related ideas. For architects to support the generation and identification of potentially successful designs and for juries (being as it were the design environment) to select outstandingly fit and original design entries.

### **AVOCAAD compared with GACAAD**

AVOCAAD might for instance support the imagination about folding architecture with morphing- en warping functions and with the description of the geometry, compare the generated with the required areas, the costs per area involved and the construction or building physics consequences of the chosen geometry. GACAAD supports the same but then fully and consistently integrated. The user is not supposed to be kept captive in low level handiwork like thinking about where to draw lines and rectangles in order to get some meaningful pattern while in the meantime the computer stays idle waiting for instructions. Instead the user in GACAAD is thinking in high level semantics about the design concept, the brief and the situation while studying the results of the computer busy with calculating, comparing, selecting and drawing acceptable alternatives on screen. The acceptability is defined according to the quantifiable and fuzzy criteria introduced with care by experts beforehand and as used in the fitness function (figure 1). This intrinsic information processing is thus fully automated. The user can concentrate on everything else he or she might think of as important, enjoyable, pleasing or interesting for the selection process as presented by the computer as appropriate alternatives on screen. This user-steered selection process is called extrinsic information processing or 'breeding' and cannot be automated. It is here that the human creative power of association and analog thinking used for identifying novel and original alternatives can be expressed entirely.

### **State of the art worldwide**

On a global scale, GACAAD barely exists. GACAAD on the contrary has its own indexed bibliography (compiled by Jarmo T. Alander, 1996) with more than 452 titles and 663 authors. Compared with the total of GA papers GACAAD is however still lagging behind because it started more than ten years later, but is quickly gaining momentum (Bentley, 1995, Furuta et al., 1996, Rebaudengo et al., 1996 and Watabe et al., 1993). Considering the advantages of this approach for designing, it deserves more attention and research as a means of developing real design enablers instead of drawing or modelling tools. It has already led to the collaboration of practitioners of very diverse disciplines. Scientists in creativity (Boden, 1994) and brain researchers (Edelman et al. 1978, 1992 & 1992; Calvin, 1996) are working increasingly with GA-based models of creative behaving and brainfunctioning, defining the needed enablers to complement human capacities and shortcomings and scientists

(studying the interactions between buildings and people) specifying the evaluation function of the needed GACAAD implementations.

### **Taking on the challenge**

Designers and/or artists are already gaining experience with the developed programs as clients and testers, specifying the needed functionalities as a user, the needed geometry to realise buildings in the style of the moment and the performances needed to be evaluated automatically. But the architectural world has not yet taken on the challenge (except in rather metaphorical way; Jencks, 1995; Lynn, 1993), even though the Darwinian paradigm can add value to the designing process in a radically new way. We might hope for mutations following this move. But to become aware of all this implies a paradigm switch. A relearning of how we see and imagine the practice of design: either as a relatively slow but exhausting activity of conceptual sketching, drawing and modelling or as a much faster and nevertheless more relaxed effort of breeding and conceptual selection.

### **References**

- Ackley D., Littman M.: Interactions between learning and evolution, In Langton, C.G., Taylor, C, Farmer J.D. and Rasmussen, S., eds., *Artificial Life II*, Adison-Wesley, 1992
- Alander J.T.: *An Indexed Bibliography of Genetic Algorithms in Computer Aided Design*, Department of Information Technology and Production Economics, University of Vaasa, Finland, Report Series No. 94-1-CAD, DRAFT September 9, 1996 (available via anonymous ftp: site ftp.uwasa.fi directory cs/report94-1 file gaCADbib.ps.Z)
- Bakel A.P.M., van: *Styles of Architectural Designing, empirical research on working styles and personality dispositions*, PhD., Bouwstenen 34, faculteit Bouwkunde, TUE, 1995
- Bentley, P.j.: *Genetic Evolutionary Design of Solid Objects using a Genetic Algorithm*, PhD, Division of Computing and Control Systems, School of Engineering, University of Huddersfield, november 1996
- Boden, M.A.: Agents & creativity, *Communications of the Association for Computing Machinery*, 37(7) July 1994, pp. 117-121

- Boden, M.A. ed.: *Dimensions of creativity*, MIT Press., Cambridge, MA, US, 1994
- Calvin. W.H.: *The Cerebral Code, thinking a thought in the mosaics of the mind*, A Bradford Book, The MIT Press, Cambridge, Mass, London, 1996
- Daru, R. & Snijder, H.P.S.: Morphogenetic Designing in Architecture, resolving controversies in and between design, research and development, *proceedings of the third International Design and Decision Support Systems conference, Spa, Belgium*, 1996
- Dawkins, R. : *The Blind Watchmaker*, Penguin Books, London, 1986
- Dennett, D.C.: *Darwin's Dangerous Idea, evolution and the meanings of life*, The Penguin Press, London, 1995
- Edelman, G.M.: Group Selection and Phasic Re-entrant Signalling: a theorie of higher brain function, in *The Mindful Brain*, eds. G.M. Edelman & V.B. Mountcastle, MIT Press, Cambridge, Mass., 1978
- Edelman, G.M.: *Bright Air, Brilliant Fire: on the matter of the mind*, Basic Books, New York, 1992
- Edelman, G.M., Reeke, G.N.Jr., Gall, W.E., Tononi, G., Williams, D., Sporns, O.: Synthetic neural modeling applied to a real-world artifact, *Proceedings of the National Academy of Sciences of the USA*, 89, 1992, pp. 7267-71
- Fraser, J.: *An Evolutionary Architecture*, Architectural Association, London, 1995
- Furuta, H., Maeda, K. & Watanabe, W.: Application of Genetic Algorithm to Aesthetic Design of Bridge Structures, In *Microcomputers in Civil Engineering v10:6*, Blackwell Publishers, MA, USA, 1995, pp. 415-421
- Gero, J.S., Mary Lou Maher, eds.: *Modeling creativity and knowledge-based creative design*, Lawrence Erlbaum Associates, Inc. Hillsdale, NJ, US, 1993
- Goldschmidt, G.: The dialectics of sketching, *Creative Research Journal*, 1991, Vol.4(2) 123-143
- Gregory, R.L.: *Mind in Science, a history of explanations in psychology and physics*, Cambridge, Cambridge University Press, 1981
- Gross, M.D.: The Electronic Cocktail Napkin, a computational environment for working with design diagrams, *Design Studies*, 1996, 17(1): 53-69

- Holland, J. H.: *Adaptation in Natural and Artificial Systems*, University of Michigan Press 1975 (second edition: MIT Press, 1992)
- Holland, J. H.: Genetic Algorithms, *Scientific American*, 1992, pp. 66-72.
- Holland, J. H.: *Hidden order: how adaptation builds complexity*, Addison-Wesley, Reading, 1995
- Jencks, C.: *The Architecture of the Jumping Universe, a polemic: how complexity science is changing architecture and culture*, Academy Editions, London, 1995
- Lynn G. (ed.) : Folding in Architecture, *Architectural Design*, Profile Nr. 102, Academy Group Ltd., 1993
- Möller, C.: Organizing Random Chance, in Leeson, L.H. (ed.): *Clicking In*, Bay Press, Seattle, 1996
- Oosterhuis, K., Kas Oosterhuis Architekten: Vloeibare architectuur; zoutwatergedeelte / saltwater section, *Archis* 11 95, NAI, R'dam, C. Misset, Deventer, 1995
- Steadman, P.: *The Evolution of Designs, biological analogy in architecture and the applied arts*, Cambridge University Press, Cambridge, 1979
- Rebaudengo, M., Reorda, M.S.: GALLO: A Genetic Algorithm for Floorplan Area Optimization, *IEEE Transactions on Computer-Aided Design of integrated circuits and systems*, Vol.15, no.8, August, 1996
- Runco, M.A., Abert, R.S., eds.: *Theories of creativity*, Newbury Park, CA, Sage, 1990
- Sims, K.: Artificial evolution for computer graphics, *Computer graphics*, 25(4), 1991, 319-328
- Snijder, H.P.S., Daru, R.: Exploring floorplan solutions with a neural network driven genetic algorithm, *paper on the third International Design and Decision Support Systems conference, Spa, Belgium*, 1996
- Sternberg, R.J., Davidson, J.: *The Nature of insight*, A Bradford book, The MIT Press, Cambridge, Mass., London, 1995
- Todd, S., Latham, W.: *Evolutionary Art and Computers*, Academic Press, London, 1992
- Watabe, H. & Okino, N.: A Study on Genetic Shape Design, In *Proceedings of the fifth international conference on Genetic Algorithms*,

Daru and Snijder

Urbana-Champaign, USA, Morgan Kaufmann Pub., 1993, pp. 445-450



**Expertise CAO et Conseil  
Organisationnel :**  
**-diagnostic**  
**-precautions**  
**-gestion du changement**

**Christian de Buhren**

Conseil en Organisation - Management de projet  
France

*Dans un bureau d'architectes ou un bureau d'études, le choix d'un logiciel d'informatique graphique n'est pas sans incidences sur l'organisation du travail. On constate, à titre d'exemple, que l'autonomie des utilisateurs augmente en même temps que la coordination des activités par le dirigeant est rendue plus difficile. Pour augmenter son avantage concurrentiel, des changements dans le mode de gestion de l'organisation doivent être mis en place.*

*Construite dans l'esprit des normes ISO 9000 (normes internationales sur le management et l'assurance de la qualité) nous vous proposons une méthodologie pratique d'intervention. Un produit directement opérationnel élaboré sur la base d'une haute compétence technique et de savoirs acquis en organisation d'entreprises.*



# Expertise CAO et Conseil Organisationnel

## INTRODUCTION

Le présent article professionnel s'adresse en priorité aux architectes, bureaux d'études, et PME qui ont tous en commun d'être équipés de logiciels d'INFORMATIQUE GRAPHIQUE.

Non que je me refuse de proposer un savoir-faire aux grandes entreprises (je suis intervenu à deux reprises à France Télécom dans le cadre d'une expertise sur le logiciel de STAR INFORMATIC puis dans le cadre d'une intervention de conseil en organisation), mais bien parce que les dirigeants des grosses entreprises regardent souvent avec envie **la capacité d'adaptation et d'innovation** de leurs pairs des PME.

C'est cette vitalité et ce dynamisme des PME, orchestrés par des "personnalités", alors même que ces structures ont peu recours au conseil, qui me prètent à penser qu'il existe des dirigeants pour se persuader que si **le changement**, en tant **qu'adaptation aux mutations** de l'environnement économique et social, est nécessaire pour la croissance voire la pérennité de l'entreprise, il est complexe à mettre en oeuvre et demande l'intervention de spécialistes.

Cet article à donc pour vocation, en déroulant un argumentaire, de suggérer une intervention d'expert-conseil basée sur une expérience constituée simultanément:

**-d'une haute compétence technique en informatique graphique (expertise)**

**-de savoirs acquis en organisation d'entreprises (conseil)**

La difficulté de toute prestation intellectuelle réussie, de type intervention de conseil en entreprise, réside dans la matérialisation d'un immatériel.

La crédibilité de la profession souffre du trop grand nombre de marchands d'illusions, alors même qu'il faut proposer un **apport tangible**, délivrer un **produit**.

Les normes internationales sur le management et l'assurance de la qualité (ISO) rassemblent la somme de l'expérience et des connaissances diverses acquises et éprouvées par des experts du monde entier et fournissent un cadre méthodologique rigoureux à une nouvelle approche du management.

Ma propre activité de conseil s'inspire de la méthode comme de l'esprit de ces normes dont des extraits<sup>1</sup> serviront de "leitmotiv" tout au long de

---

<sup>1</sup> et tout particulièrement de la norme intitulée "Gestion de la qualité et éléments de système qualité, lignes directrices pour les services" (norme 9004-2).

cet article professionnel. Il est en outre proposé en annexe un ordinogramme d'intervention en six phases pour accompagner le changement, tant en ce qui concerne l'expertise en informatique que la dimension de conseil en organisation.

## I) L'EXPERTISE EN INFORMATIQUE GRAPHIQUE

### 1er: UN EXPERT. POUR QUOI FAIRE ?

“L'expert est essentiellement centré sur les problèmes techniques que lui soumet le client (.) Il cherche à fournir au système client le plus d'idées, de solutions ou de recommandations possibles (.) Le conseiller expert cherche à influencer le client dans le choix de la solution qu'il croit personnellement, de par sa compétence, la plus valable”.<sup>1</sup>

**Lorsque vous avez investi dans votre logiciel, étiez vous bien certain que c'était celui-ci qu'il vous fallait et non un autre? N'aviez vous pas été confronté à un problème de choix vécu comme plus ou moins aléatoire?**

Quand à la dépendance vis-à-vis du vendeur: comment savoir s'il cherche à vous sur-configurer, alors que la vitesse d'obsolescence du matériel suppose au contraire de considérer le premier achat comme une configuration d'initiation?

Certains fournisseurs ne proposaient-ils pas une “super affaire”, alors que l'expérience à montré qu'il s'agit rarement de proposer un système correspondant aux besoins?

**Bref, qui avait les cartes en main?**

G. LOVEMAN, professeur au MIT, étudia soixante départements informatiques de vingt grandes entreprises industrielles entre 1973 et 1984. Sa conclusion est nette: *“l'investissement en informatique a eu peu ou pas du tout d'impact sur la productivité du travail, car, ou bien les gains présumés étaient illusoires, ou bien ils étaient annulés par d'autres inefficacités”*<sup>2</sup>.

En d'autres termes il s'agit d'une part de vérifier l'adéquation besoin / produit -ce qui suppose une réflexion préalable sur la stratégie globale de l'agence à moyen terme- et d'autre part de s'interroger sur les incidences que fournit l'outil sur l'organisation du travail.

**Les entreprises devraient consacrer du temps et prévoir dans leur budget une assistance adaptée: lors de l'achat et de la mise en place d'un système informatique, puis afin d'assurer un suivi organisationnel et technique.**

---

<sup>1</sup> Y. BORDELEAU. La fonction de consultant auprès des organisations. Ed. Agence d'ARC inc. Ottawa 1986. p 15

<sup>2</sup> In J. BRILMAN. L'entreprise réinventée. Les Editions d'Organisation. Paris 1995. p 237

Jusqu'à 300 KF une configuration complète, c'est une erreur de management de se tromper, d'autant qu'il faudrait également prendre en compte les effets pervers et difficilement chiffrables, tels que la discrédibilité d'un système CAO (méfiance tenace vis à vis de la technique, perte à long terme de création de potentiel) ou l'influence psychologique sur les utilisateurs (sentiments d'incapacité ou de précarité de la fonction).

## **2eme: LA PHASE DE DIAGNOSTIC**

Lors d'une intervention de conseil, la première opération consiste à établir un diagnostic sur trois points: la corrélation entre l'avoir (la configuration) et le savoir, les connaissances théoriques et pratiques des utilisateurs du système, les méthodologies appliquées (l'expérience montre que si les connaissances sont réelles, les méthodes sont rarement optimisées dans le sens de la productivité).

### **La corrélation entre avoir et savoir.**

Lors de votre premier achat vous avez fait appel à une personne de l'extérieur qui vous a guidé dans votre choix et vous avez opté pour une configuration de base, voire même acheté du matériel d'occasion. Un an plus tard, après avoir bien peiné, le logiciel donne satisfaction, la productivité s'améliore et vous avez "vendu" à vos clients l'amélioration sensible de la qualité de vos services.

Il est à ce propos difficile d'évaluer le retour sur investissement d'un marketing bien compris, mais se trouver légitimé dans ses choix **par le client** est un critère fondamental, nous en verrons plus loin la raison, dans la décision de poursuivre l'amélioration de sa configuration.

Cependant, les connaissances acquises et la dextérité prêtent à penser aux utilisateurs que l'outil à disposition est bien lent, qu'il est édité beaucoup plus de plans que prévu, et que vous trouvez souvent les utilisateurs béats devant le traceur à plume. Il est donc temps d'opter pour une nouvelle configuration, le savoir acquis allant au delà de ce qu'offre l'outil.

Dés lors faut-il changer de matériel à court terme ou non et pour quelle configuration?

Et **quelle crédibilité accorder aux utilisateurs?** Dés que la structure compte une dizaine de personnes le dirigeant ne travaille plus sur le logiciel et ce sont les utilisateurs qui "revendiquent".

### **Les connaissances théoriques et pratiques.**

Il n'y a ici pas de règles générales : chaque utilisateur de chaque entreprise est un cas particulier. Mais ce n'est pas ce qu'il y a de plus

difficile dans le cadre d'une expertise, du moins pour la pratique, l'expérience et les nouvelles versions améliorant avec le temps la rapidité d'exécution et la connaissance des commandes dans leur rentabilité optimale. Ceci étant, il existe toujours des "**trucs et ficelles**" qui font défaut.

**En ce qui concerne la théorie**, j'ai très souvent constaté que les manuels d'utilisation avaient une fonction décorative dans les bureaux. Rares sont les utilisateurs qui ont pris la peine, suite à la formation contractuelle parfois liée à l'achat du logiciel, de les lire ou même de les parcourir, le sempiternel et supposé décisif argument étant le manque de temps.

Mauvais argument qui confond les moyens et les fins : la gestion du temps est un principe fort de l'analyse organisationnelle.

Or ces ouvrages sont une mine dans laquelle il faut savoir puiser. Nombres de questions trouvent leurs réponses dans tel ou tel manuel, à tel ou tel chapitre.

## **Les méthodologies et procédures**

Il n'existe pas une Méthodologie mais des méthodologies, selon l'entreprise et ses besoins, le degré d'urgence ou même la capacité d'invention de l'utilisateur. **Les bonnes méthodes ont en commun de gérer le travail de manière simplifiée** (transposition de la règle des 20 / 80) **et reproductible** : reproduction à travers un même niveau, d'un projet ou d'un répertoire à un autre, dans la gestion et l'utilisation de la bibliothèque, du 3D au 2D, et d'un utilisateur à un autre.

Les procédures décrivent, par écrit, les méthodes à utiliser dans le processus de prestation et doivent être particulièrement vigilantes à la codification des **échanges d'informations aux interfaces** des activités individuelles.

## **La formation**

De l'analyse des connaissances et des méthodes découle une proposition afin de **satisfaire les besoins en formation**. Besoins souvent exprimés par la carence en connaissances théoriques comme par la perte en qualité qu'induisent nécessairement les formations par transmission successive du savoir ( X apprend à Y qui apprend à Z qui apprend...)

Je voudrai faire remarquer que les formations que dispensent les fournisseurs suite à la réalisation d'une vente, si elles suffisent à prendre en main l'outil, sont très largement insuffisantes pour permettre aux

nouveaux utilisateurs de se servir du logiciel de manière satisfaisante, tant en matière de productivité que dans la mise sur pieds de méthodes de travail pertinentes.

**Et ce d'autant qu'ils seront soumis à la pression de l'encadrement** qui ne comprendra pas pourquoi, avec ce fabuleux outil à l'utilisation duquel ils ont été formés, les utilisateurs n'arrivent pas rapidement à sortir des plans vite et bien.

Communication et autonomie: Nous aborderons au chapitre III cet aspect fondamental.

### **La responsabilité de la conception**

Qui fait quoi, où et comment ? comment sont déterminées les tâches et les fonctions ? Qui planifie, prépare, valide le processus de conception architecturale, définit les procédures et contrôle leur mise en oeuvre? Questions apparemment de banale évidence mais qui conditionnent le bon fonctionnement d'une entreprise. Or l'expérience montre que l'introduction d'un système informatique s'accompagne rarement d'une mise à plat de ces questions dont le caractère prioritaire s'accroît pourtant avec l'incidence qu'a l'outil sur l'organisation.

C'est par ce type de réflexion que nous entrons de plain-pied dans l'analyse d'une organisation d'entreprise.

“Les responsabilités de la conception doivent être attribuées par la direction qui doit en outre s'assurer que tous ceux qui participent à cette conception ont conscience de leurs responsabilités (.) Prévenir des défauts à ce stade est moins coûteux que de les corriger.”<sup>1</sup>

## **II) CAS PRATIQUES**

Un phénomène sorti de son contexte perd beaucoup de son sens: l'introduction puis la pérennité d'un système CAO ne relève pas seulement d'une simple dimension technique propre au bureau dessin, mais s'inscrit dans l'organisation même de l'entreprise et de ses déterminants relationnels et humains. Dès lors, la nécessaire lecture **globale du fonctionnement de l'entreprise** pour s'attaquer aux causes racines des problèmes et des dysfonctionnements s'impose dans une stratégie de changement.

**C'est cette dimension systémique de l'entreprise qu'il s'agit de prendre en compte à la lumière des cas pratiques.** L'informatique graphique demeure le dénominateur commun à l'ensemble des cas, mais s'efface en devenant prétexte à l'analyse organisationnelle.

Nous verrons ensuite dans une troisième partie une approche générique des changements suggérés, changements opératoires dans deux cas pratiques exposés ci-dessous et qui serviront d'exemples.

---

<sup>1</sup> ISO 9004-2, 6.2.2

Les trois cas présentés sont tous **des cas réels** rencontrés lors de missions qui m'ont été confiées.

### Cas n°1

“Les processus de création sont plus souvent chaotiques qu'ordonnés, faits de petits pas, davantage basés sur la coopération que sur les relations de pouvoir. Ceux qui dirigent les processus en tenant compte de ce désordre ont davantage de chances de réussite que ceux qui prétendent mettre de l'ordre dans ce même processus en le structurant davantage”<sup>1</sup>

L'adjoint du PDG d'une entreprise industrielle employant 120 personnes m'appelle afin de savoir s'il est valable d'éditer un métré directement à partir de leur logiciel d'architecture. Mission apparemment classique. Rendez-vous est pris pour informations complémentaires... et je me retrouve autour d'une table à déjeuner avec le PDG et son adjoint, un membre du bureau dessin, un métreur, le responsable de la fabrication ainsi que celui des achats et approvisionnements.

J'avoue n'avoir strictement rien compris ce jour là au discours interne au groupe qui débattait en hyper technicien sur son activité, tentant de faire la part des choses entre ce qui était possible, souhaitable, idéal mais peu réaliste, l'organisation qu'il fallait modifier dans la foulée, etc... le tout avec des arguments parfois contradictoires.

Lorsque la parole me fût donnée, fort perplexe, je fis remarquer que les besoins n'étaient pas clairement déterminés: que voulaient-ils faire et pourquoi, quelles informations le métré devait fournir et donc quels étaient les composants techniques à créer, avait-on mesuré les incidences sur l'organisation ...bref qu'il s'agissait de conduire une réflexion pour structurer les idées et sur laquelle je puisse m'appuyer pour déterminer une faisabilité, un planning et des coûts.

L'adjoint du PDG me dit alors qu'il n'avait pas le temps de s'en occuper mais qu'il me confiait la mission dans un premier temps de conduire cette réflexion. La mission complète me prit six mois et alla bien au delà de la demande initiale relevant de la seule expertise technique.

J'apprenais à connaître l'entreprise et son langage technique en allant auditer les métreurs puis le bureau de dessin. J'établissais les besoins, puis la faisabilité d'un lien entre le logiciel d'architecture et le système informatique que possédaient les métreurs, enfin montais une bibliothèque technique. J'assurais une formation complémentaire et modifiais les bibliothèques graphiques. Je conseillais l'entreprise dans l'achat de stations puissantes après avoir constaté que le bureau de dessin, malgré la compétence des utilisateurs, tardait à fournir la production en plans (divergence entre avoir, savoir, besoins). J'apportais

---

<sup>1</sup> J.B QUINN. L'entreprise intelligente p 350-351. Dunod, Paris 1994.



ma contribution à l'amélioration des méthodes et à la qualité. Enfin je satisfaisais les commerciaux (et par la même et surtout, les clients) en éditant par un surcroît de travail tout à fait marginal des plans couleurs moins techniques et plus parlants, puis le personnel de chantier par des plans correspondant à leurs besoins réels.

Mais au delà de ce que j'ai pu faire et être autorisé à faire dans cette entreprise, le plus remarquable fut le contexte et l'entreprise elle-même dans laquelle cette mission s'est déroulée.

L' Adjoint du PDG me demandait simplement de lui rendre un rapport hebdomadaire précisant ce que j'avais vu et constaté durant la semaine et quels étaient mes préconisations pour supprimer les dysfonctionnements ou mettre en oeuvre des changements appropriés. Après validation, j'avais liberté d'aller et venir où et quand je le voulais pour peu que je me fusse assuré au préalable que je m'inscrivais dans le rythme de l'entreprise sans le perturber.

L'entreprise connaissait peut-être en tout et pour tout trois niveaux hiérarchiques. Personne n'avait de titre officiel et tout le monde était apporteur d'idées. Les équipes de chantier s'autogérait autour de "check-list" et contrôlaient elles-mêmes la qualité et le respect des objectifs, faisaient remonter l'information sur les erreurs de fabrication pour en déterminer l'origine et apporter les correctifs nécessaires.

Il n'y avait pas de syndicats, l'entreprise n'a jamais connu de grève, et le PDG laissait porte ouverte à ceux qui avaient d'éventuels griefs à faire valoir. L'ensemble du bureau dessin déjeunait une fois par mois avec le PDG, chacun apportant des idées et des critiques, et il en était de même avec tous les services ou tout groupe informel à constituer pour résoudre un problème particulier.

On trouve, dans la dynamique organisationnelle de cette entreprise, une bonne part des fondamentaux édictés par la norme 9004-2 et un exemple dont peuvent s'inspirer de nombreuses structures.

## **Cas n° 2**

“Le changement est avant tout une question d'individus. Pour qu'une organisation puisse se transformer, il faut que chacun soit capable de penser, de sentir ou d'agir différemment”<sup>1</sup>

En 1993 le cabinet X me contacte pour assurer la formation d'un de ses salariés et simultanément la réalisation dans les meilleurs délais de l'APD d'une maison de retraite.

---

<sup>1</sup> J.D DUCK. Le changement une question d'équilibre. L'Expansion Management Review. p 40. Printemps 1994

Ce cabinet possédait deux stations de travail depuis deux ans mais travaillait tout en 2D, ne sachant pas utiliser le 3D, et ce malgré la formation procurée par le fournisseur du logiciel.

Ils abattaient un travail colossal -et impressionnant- en 2D, mais avec une productivité nulle car ce logiciel 2D n'est vraiment pas ce que ce fournisseur a inventé de mieux dans son existence (et jusqu' à ce que son tout récent produit 2D nous démontre le contraire).

La formation fut assurée et l' APD réalisé dans les délais.

Trois mois plus tard, le cabinet X m'appelait pour étudier l'opportunité d'achat de nouvelles stations.

L' organe de presse du fournisseur (janvier 95) m'informe que M.L, la personne formée, s'est vu remettre un traceur à jet d'encre pour avoir remporté le 10eme prix lors du concours international qu'il a organisé <sup>1</sup>.

En 1996 le cabinet me rappelle. Ayant embauché un métreur, il s'agissait de déterminer avec lui la faisabilité d'un métré automatique puis de créer les bibliothèques techniques; établir des procédures et de nouvelles méthodologies avec les utilisateurs, nécessairement impliqués par ce changement.

Puis une enquête de satisfaction client m'était confiée afin de mesurer les forces et les faiblesses de l'agence.

Le rapport d'enquête permit à l'agence de cerner ses points faibles et présentait les préconisations pour mettre en oeuvre le changement. Ce rapport fut transmis sans modification ni amendement aux clients ayant participé à cette démarche qualité, ainsi qu'aux salariés de l'agence. Enfin, le cabinet adressa à ces clients une "lettre d'engagement" par laquelle il s'obligeait à résoudre rapidement les dysfonctionnements mentionnés au rapport.

Dans l'introduction du présent article, je parlais de la capacité d'adaptation et d'innovation, du dynamisme des PME orchestré par des "personnalités". En voici un exemple flagrant, dont le courage manifesté dans la prise de décision impressionna positivement les clients impliqués.

### Cas n° 3

---

<sup>1</sup> Je profite de cet article pour féliciter M.L et sa Direction, ainsi qu' un autre de mes "anciens élèves" F.D, dont le document fait la "une" du STAR NEWS d' avril 95, pour son 13eme prix obtenu lors de ce même concours.

“Si vous ne savez pas où se trouvent les gens qui dépendent de vous, c’est certainement bon signe: cela veut dire qu’ils ont dépassé les limites de la fonctionnalité, qu’ils sont chez des clients, etc.”<sup>1</sup>

Le cas d’un Cabinet qui fonctionnait avec le seul dirigeant, Mr J.B, assisté de manière sporadique par son épouse pour les tâches de secrétariat.

Le contrat portait sur la saisie d’un lycée 1200 dans le cadre d’une réhabilitation.

A la première minute du premier jour, il me fournit les clés de son agence, les coordonnées du proviseur et de l’intendant, et il était parti sur ce fait générer autrement plus de valeur ajoutée en visitant des clients, des partenaires sur un projet, des entreprises sous-traitantes...que s’il était resté à l’agence à gratter lui-même son projet !!!

Je devais donc travailler seul: je remplissais mon contrat en toute sérénité, me déplaçais au lycée autant que de besoin, répondais au téléphone et gérais ses rendez-vous en l’absence de son épouse, fournissais les coordonnées où l’on pouvait le joindre en cas d’urgence .

Je voyais aller et venir des dessinateurs, des architectes (rarement les mêmes), pour travailler un jour ou deux à l’agence et qui tous collaboraient avec lui sur le projet X, Y ou Z.

Lui-même faisait quelques rares apparitions pour coordonner les informations, savoir si tout se passait bien, noter ses rendez-vous et repartait dans la foulée.

Les choses se sont si bien passées que j’ai eu le temps, pour les délais et les coûts prévus au contrat, de saisir en plus un bâtiment de 60 logements!

Une première lecture de ces trois cas montre très clairement que, si un logiciel graphique est un superbe outil technique, cela n’est pas suffisant en soi pour qu’une entreprise devienne réellement performante. Il faut y rajouter une dimension nécessaire: un choix de management résolument orienté vers l’avenir et une organisation “ad hoc”

### **III) ACCOMPAGNER LE CHANGEMENT**

#### **Le rôle du consultant**

---

<sup>1</sup> T. PETERS. L’entreprise libérée p 161. Dunod, Paris, 1993.

“Le conseil “facilitateur” est axé sur la démarche par opposition au contenu (...) Il veut aider le client à résoudre ses problèmes en lui montrant comment comprendre les processus d’interaction sociale qui existent dans l’organisation (...) Le conseiller postule que le problème se situe à un niveau dynamique complexe, et guide le client dans l’exploration de cette dynamique. Il aide ce dernier à mieux situer sa propre expérience dans l’ensemble du vécu organisationnel. De plus, le conseiller fait le postulat que le client est sensibilisé, peut apprendre par la suite cette démarche et peut transférer cet apprentissage dans son activité quotidienne”.<sup>1</sup>

Nous avons donc opéré un glissement progressif du rôle de l’expert à celui du consultant. A ce stade il n’est plus question d’expertise technique, mais bien d’aider, de guider, **de transmettre**, à l’image du passage du témoin dans une course de relais.

**Ceci ne peut se faire qu’en partageant**, en construisant une compréhension réciproque. Nul ne peut prétendre être capable de supporter et résoudre tous les problèmes du monde (ici de l’entreprise) à lui seul : humilité et modestie sont des clés de réussite dans une intervention de consultant. Cette compréhension suppose un “changement du plan de référence” (j’utilise le terme à dessein, puisqu’il est également une terminologie technique de logiciels) qui demande souvent la force et le courage pour une nouvelle lecture, tant du système relationnel à l’intérieur de l’organisation que du positionnement stratégique de l’entreprise.

“Il incombe à la direction la responsabilité d’établir une politique relative à la qualité du service et à la satisfaction de la clientèle. La mise en oeuvre réussie de cette politique dépend de l’engagement de la direction vis à vis de l’élaboration et du fonctionnement efficace d’un système qualité.”<sup>2</sup>

## **1er: UNE APPROCHE DE L’ORGANISATION INTERNE**

### **L’incidence de l’outil informatique sur l’organisation**

“L’enjeu du changement en PME tourne souvent autour de cette dialectique entre différenciation (des fonctions, des compétences, des modes de relations internes) et intégration (partage des responsabilités, polyvalence, relations informelles et directes).<sup>3</sup>

**La coordination des activités** dans les petites structures est assurée par le supérieur hiérarchique, voire par le chef d’entreprise lui-même. Et cela jusqu’à un certain seuil où se pose le problème de la saturation du dirigeant.

L’entreprise s’organise en divisant le travail de manière verticale ou horizontale. La hiérarchie joue alors un rôle de conseil technique et d’assistance dans la définition du travail.

---

<sup>1</sup> Y. BORDELEAU. La fonction de consultant auprès des organisations p 15. (opus cité)

<sup>2</sup> ISO 9004-2, 5.2

<sup>3</sup> PME: Les logiques du changement . p 15. Le Mensuel de l’Anact. janvier 1995

Schéma au demeurant classique, mais l'introduction d'un système informatique complexe rend délicate cette **différenciation issue de la division du travail**. En même temps que cette nouvelle technologie laisse **plus de marge de manoeuvre et augmente l'autonomie** par rapport aux contraintes hiérarchiques, elle est aussi beaucoup plus gourmande en informations de tous types et **exige une aide** de la hiérarchie.

Or dans le contexte qui nous intéresse, si la hiérarchie (ou le chef d'entreprise) connaissait le processus de production dans le cadre classique de la planche à dessin, l'outil informatique la plupart du temps l'a dépossédé de cette dimension d'expertise, tant en ce qui concerne son rôle de conseiller technique que celui de coordinateur des activités, par le fait même de son ignorance technique relative au logiciel (méconnaissance des procédures et des délais de production).

Considérant dès lors son incapacité, il aura tendance à déléguer (d'où l'accroissement de l'autonomie et de la marge de manoeuvre), en fait d'abandonner toute volonté de contrôle, et ce d'autant plus facilement qu'il aura investi -parfois beaucoup- dans l'outil miracle qui produira mieux et plus vite, alors même que l'outil procure aux utilisateurs une dépendance accrue à l'information, l'aide, l'assistance, et entraîne une forte demande de convivialité.

Selon le mode de management en vigueur, le professionnalisme et le comportement de l'utilisateur ou du service utilisateur, celui ci pourra au mieux s'accrocher à l'assistance technique, dans le cadre de contrats de maintenance, comme à une bouée; s'isoler et se renfermer seul contre tous, ou pire s'instaurer en véritable contre-pouvoir: les services informatiques dans les grosses structures sont fréquemment un Etat dans l'Etat.

Travailler par projet oblige à échanger l'information, à créer la communication nécessaire tant pour la hiérarchie qui restaure un contrôle, que pour les salariés qui se trouveront valorisés par une expression possible dans un cadre formel.

“ L'entreprise est un système ayant pour finalité l'accomplissement de son projet. Le management a pour rôle de mobiliser les forces de l'entreprise (..) Chacune des personnes qui composent le système entreprise est un être doué de compréhension, d'initiative, de créativité, capable d'apprécier les encouragements et sensible aux reproches comme à l'indifférence. Le rôle des cadres et des dirigeants est de guider, aider, éduquer, encourager l'auto-contrôle et l'exercice de la responsabilité, en même temps que de contrôler ce qui se fait sous leur responsabilité.”<sup>1</sup>

---

<sup>1</sup> Concepts généraux des normes internationales ISO 9000

## **Travailler par projet**

Toute entreprise qui se veut efficace devrait travailler par projet, et la nature même des activités de l'architecture ou des bureaux d'étude s'y prête fort bien: les cas 1 et 3 en ont fourni la démonstration.

**Travailler par projet c'est**, dans le cas d'un projet d'architecture, **réunir sous l'autorité d'une personne désignée l'ensemble des intervenants qui concourent à sa réalisation.**

Le groupe de projet pourrait comporter, en fonction de la structure et du moment: un architecte, un coordinateur technique ou la personne qui se charge des appels d'offre, un représentant d'une entreprise sous-traitante, le dessinateur chargé de la saisie des données et le client ou son représentant...

N'avez vous jamais remarqué que les bonnes idées surgissent lors de réflexions entre client, fournisseur et vous-mêmes?

Les groupes de projets se créent dès qu'un besoin s'en fait sentir (résoudre un ensemble de dysfonctionnements..) et se défont dès le problème résolu, "empruntent" des compétences spécifiques (un consultant extérieur par exemple) et se réunissent en comité restreint ou séance plénière selon l'ordre du jour.

Travailler par projet permet de valoriser ses compétences-clés, à savoir des capacités détenues par chaque membre de l'organisation, se renforçant mutuellement, et que la concurrence aura du mal à plagier puis à dépasser. Il faut aujourd'hui considérer les salariés comme un actif qui doit être développé plutôt que de les identifier à des coûts à comprimer.

“ La qualité (quelquefois dite “qualité totale”) consiste en la mise en oeuvre d'une politique qui tend à la mobilisation permanente de tout son personnel pour améliorer la qualité de ses produits ou services, l'efficacité de son fonctionnement, la pertinence et la cohérence de ses objectifs. Cette définition fait apparaître une dimension stratégique, en faisant référence à des objectifs. “<sup>1</sup>

## **La valeur est générée par la matière grise**

“Microsoft n'a qu'un seul actif stable: l'imagination humaine”<sup>2</sup>

---

<sup>1</sup> Concepts généraux des normes internationales ISO 9000

<sup>2</sup> F. MOODY. New York Times Magazine. 25 août 1991

## 2eme: UN REGARD PORTE SUR L'EXTERIEUR

### LE CONTEXTE

“La crise est dans nos têtes (...) La richesse des Français n’a jamais été aussi élevée, le P.I.B a augmenté de plus de 60% depuis 1975. Nous vivons une crise de mentalités, de comportements et d’organisation. Elle vient du fait que nous voulons entrer dans le XXI eme siècle avec les institutions et les habitudes héritées de l’après-guerre”.<sup>1</sup>

### **L’activité économique et l’emploi en mutation**

Vouloir proposer et accompagner le changement n’est pas un effet de mode: nous sommes entrés de plain-pied dans “**l’éphémère permanent**”, pour lequel l’enjeu n’est pas seulement de s’adapter (s’adapter c’est suivre avec retard) mais d’anticiper, de développer des réflexions autour de ses compétences-clés pour instruire un avantage concurrentiel durable.

L’activité-même de l’entreprise est mutante sous les coups de boutoirs conjugués des nouvelles technologies, de la tendance à la tertiarisation de l’économie, et de l’âpreté de la compétition ( la terminologie en est “globalisation de l’économie” ou “mondialisation des marchés”).

Mutant également l’ancien modèle de l’emploi à plein temps: (annualisation, flexibilité, partage du travail...)

Il faut cesser de croire que tous ces mouvements ne sont qu’une adaptation conjoncturelle susceptible de rétablir le status quo ante, mais que **nous sommes bien dans un contexte de mutation structurelle** qui se confirme de jour en jour. Il n’est que de lire la pléthore d’ouvrages qui paraissent sur le sujet pour constater que, sur le fond, tous les auteurs s’accordent sur ce point.

### LA PORTEE

#### **se concentrer sur son métier et externaliser**

“la politique qui consiste à préférer la production-maison représente le chemin le plus direct pour arriver à l’inefficacité généralisée.”<sup>2</sup>

Après les années 70/80 qui ont vu une politique de diversification se propager tout azimut, on constate aujourd’hui un mouvement de balancier inverse consistant à **se concentrer sur ce qui est le coeur de**

---

<sup>1</sup> M. GODET. Le grand mensonge. sous titré: L’emploi est mort vive l’activité p 15. Fixot, Paris, 1994.

<sup>2</sup> T. PETERS. L’entreprise libérée p 279. (opus cité)

**son activité**, son “métier”, dans un souci d’adaptation permanente au marché et afin d’organiser de manière flexible les ressources de l’entreprise.

Parallèlement s’est développé un vaste mouvement **d’externalisation des tâches** identifiées comme n’appartenant pas au métier. **Gravitent** alors autour de l’entreprise et de ses dirigeants des spécialistes aux compétences rares, des sous-traitants, des prestataires de services, jusqu’aux emplois précaires situés au confins de la nébuleuse, selon la théorie des cercles concentriques.

Quel est le métier d’un architecte, l’activité d’un bureau d’études ? De l’administratif ou du secrétariat, de la comptabilité, du suivi de chantier ou de la coordination technique ? Editer des plans ?

Question délicate. Et tout cela peut (ou pourra de plus en plus) être confié à l’extérieur. Pour la simple et bonne raison, nous l’avons vu, que ce n’est pas là que se crée la valeur (illustration avec le cas 3).

Faire l’économie de cette analyse hypothèque la création d’un avantage concurrentiel durable. Se concentrer sur son métier permet d’entretenir l’entreprise sur les axes majeurs de la qualité (le client en est le juge de paix) des coûts, du temps ou de la flexibilité.

Nous l’avons vu avec le cas 3, le fait de s’entourer d’un réseau de partenaires extérieurs n’est pas lié à la taille de l’entreprise. Externaliser permet de réduire la durée du cycle de création, d’autant plus qu’il y a plusieurs sous-traitants. Cela permet de rester léger, “agile”, prêt à répondre dans l’instant avec un nouveau groupe de partenaires à une sollicitation imprévue.

Et quand vous constaterez la morosité du marché, il est plus simple “d’alléger” le nombre de ses fournisseurs ou l’activité à leur donner que de revenir sur les orientations prises en terme d’emploi ou d’investissements effectués en interne!

Quand aux logiciels graphiques, les prestataires ont logiquement fleuri ces dernières années (pour le meilleur comme pour le pire). Dès lors, la difficulté est de débusquer les meilleurs.

Le télétravail existe et va se développer de manière exponentielle : ordinateurs, fax, téléphones sous toute leurs variantes, centres de polyvalence équipés de terminaux pour assurer les tâches de secrétariat, de permanence téléphonique, éventuellement de traduction...

Et l’on peut aujourd’hui pour 15 000 Frs environ modifier en temps réel et de Paris, un plan sur votre station grâce aux interfaces RNIS-NUMERIS... quitte à partager l’investissement avec votre sous-traitant : il se battra ensuite pour vous donner la plus complète satisfaction..



## **une révolution copernicienne: le client au centre de toute chose**

“ La qualité d’un produit (bien ou service) est son aptitude à satisfaire les besoins de ses utilisateurs.

Le système qualité a pour finalité première la satisfaction des clients et utilisateurs des produits de l’entreprise. Cette finalité est prioritaire car ce sont ses clients qui font vivre l’entreprise. ”<sup>1</sup>

Nous avons déjà pu constater que cet article est émaillé de références au client. **Il doit être l’alpha et l’oméga de toute votre stratégie.** Nous sommes passés avec la “crise” d’une logique de la demande à une logique de l’offre. Ainsi qu’on le veuille ou non, le client pousse l’entreprise à mettre en place de nouvelles méthodes d’organisation ou de management : zéro défaut, zéro délai, le juste-à-temps, assurance qualité, qualité totale, certification ISO 9000, etc...

Ainsi la qualité d’une prestation ne réside pas dans ce que **vous** jugez comme bon mais dans ce que **le client perçoit** comme l’être, même à travers des notions aussi subjectives que le goût. Il s’agit de raisonner autour de ses besoins, de ce qui est important pour lui car, de fait, nous jugeons tous la qualité d’une prestation en fonction de ce que nous **attendons** d’elle.

Trop d’architectes, “Hommes de l’Art”, ont une fâcheuse propension à considérer que ce qui est bon pour eux est bon pour le client. Ils se sentent souvent investis d’une mission éducative et civilisatrice: transmettre l’esthétique au vulgum . Philosophiquement ont-ils sans doute raison, mais il s’agit là d’un “débat interne” intéressant fort peu l’économie de marché. Face au client, il faut savoir écouter.

**Combien d’architectes ont effectués une enquête de satisfaction-client** pour évaluer les attentes et les besoins, en quoi et pourquoi leur réalisation a été jugée bonne ou mauvaise ?

“La communication avec les clients implique de les écouter et de les tenir informés. Les difficultés de communication ou d’interaction avec les clients, y compris les clients internes, doivent faire l’objet d’une attention vigilante. Ces difficultés fournissent d’importantes informations dans les domaines susceptibles d’amélioration du processus de prestation de service.”<sup>2</sup>

“L’évaluation par le client est la mesure absolue de la qualité du service (...) Il est rare que les clients fassent spontanément part de leur appréciation. (...) Les clients mécontents cessent souvent d’utiliser des services ou de les acheter sans donner les raisons qui aurait permis d’engager les actions correctives.”

---

<sup>1</sup> Concepts généraux des normes internationales ISO 9000

<sup>2</sup> ISO 9004-2, 5.5.2

## **Savoir construire une équipe, choisir et conserver son personnel**

“La valeur réelle d’une société ne se trouve pas dans les actifs physiques qu’elle possède, mais bien dans son potentiel humain, ses bases de données, ses compétences dans la maîtrise d’une organisation, les images qu’elle représente, les systèmes qu’elle maîtrise, et enfin dans les alliances qu’elle tisse”.

“Chaque membre du personnel de l’organisme constitue l’une de ses ressources les plus importantes. Ceci est particulièrement vrai dans un organisme de service où le comportement et la façon de faire des individus ont une influence sur la qualité du service.”

**Il n’est de richesses que d’hommes.** Nous avons commencé à aborder le sujet au chapitre traitant du travail par projet: faire adhérer et partager l’information, créer du consensus. Apporter de la valeur pour un dirigeant c’est aussi se concentrer sur les motivations, l’ambiance de travail, assurer un rôle de conseiller technique.

**Attribuez des responsabilités** et de l’autonomie à votre personnel, laissez-les aller jusqu’à leur propre limite de compétences, Donnez-leur la possibilité d’aller au contact du client. Ce sont les ingrédients indispensables pour que se crée **la confiance réciproque**: elle est d’une nécessité absolue. Dans le cas 3, le seul contact que j’avais eu avec le dirigeant avait été téléphonique, et la confiance fut pourtant accordée d’emblée.

**Enrichissez** leur compétence et vous saurez les retenir. Distribuez des primes aux méritants, écoutez-les s’ils suggèrent d’enrichir le matériel

FIGUUR

informatique existant et **apportez-leurs** des explications si vous devez différer un investissement.

**Canalisez leur énergie et leur travail** sur les deux objectifs fondamentaux que sont les besoins du client et les objectifs de productivité.

**Et si vous devez recruter, ne considérez pas “l’assignat” du diplôme et les références comme des fins en soi. Il est infiniment plus avantageux de former un “combattant” sans diplôme que de recruter un orgueilleux qui en est bardé. Regardez plutôt la personnalité de celui qui est en face de vous, son potentiel de progression, la diversité de son expérience, son imagination et sa créativité, ses attitudes et son comportement.**

## CONCLUSION

“Tel est sans doute le défi de cette fin de siècle: comment faire évoluer des conceptions, des modes d’organisation du travail issus de deux siècles de développement à base d’industrie classique dominante, avec comme référence la grande entreprise hiérarchisée élevée au rang d’institution? Difficulté supplémentaire: aucun modèle n’existe. Il faut donc inventer ces nouvelles conceptions du travail. Se contenter d’imiter quelque modèle connu n’apporterait que déconvenues”.<sup>1</sup>

Dans le contexte contemporain, il faut savoir bouger, appliquer la flexibilité à ses propres schémas de pensée, se persuader comme l’affirme T. Peters que la seule garantie d’échec, c’est de ne jamais essayer.

Je vois se ruer la critique sur ce type d’engagement : que faites-vous de la gestion, du bilan, du compte d’exploitation ?... C’est **également** fondamental. Mais la bonne marche d’une entreprise ne se limite pas aux rapports (souvent conflictuels) avec le banquier pour être économiquement performante.

### Alors qu’est-ce-que la performance ECONOMIQUE ?

C’est **à la fois un résultat immédiat** (votre banquier vous en sera gré): productivité, autofinancement, rentabilité, compétitivité actuelle, **auquel s’ajoute la création d’un potentiel**: produit nouveau, comportement de perfectionnement permanent (c’est bien le sens de la démarche qualité), des technologies nouvelles, la compétence des hommes qui composent l’organisation.

C’est inscrire l’entreprise dans le temps et **assurer sa pérennité** qui est le moteur de mon action.

---

<sup>1</sup> P. MORIN La grande mutation du travail et de l’emploi. p 26. Les Editions d’Organisations, Paris, 1994.

Management moderne - management modeste: Soyons ouverts et valorisons le ferment créatif des personnes qui nous entourent. J de ROSNAY dans l'Homme Symbiotique écrit que les nouvelles valeurs du XXI eme siècle seront la solidarité, le respect de l'environnement, l'éducation (l'altérité) l'harmonie et l'équilibre.

D'ailleurs Quinn, triple lauréat du Mc Kinsey award, référence absolue en matière de consulting et par ailleurs fort lucide, dit qu'il n'y a qu'une chose qu'il ne faut pas sous-traiter: son âme.

## **BIBLIOGRAPHIE**

### **REVUES ET ARTICLES**

**Le Mensuel de l'Anact.** janvier 1995. PME: Les logiques du changement.

**Economie et Statistiques.** numéro 271-272 (1994) consacré aux PME.

**L'Expansion Management Review.** Le changement une question d'équilibre. Printemps 1994.par J.D DUCK, vice-président du Boston Consulting Group à Chicago

**Le Monde Initiatives.** Encart du mercredi du journal Le Monde. particulièrement ceux datés des 15 et 22 mars, 12 et 19 avril, 17 mai 1995

**La revue Star News Users** éditée par STAR INFORMATIC S.A

### **OUVRAGES DE REFERENCE**

**AFNOR** Gérer et assurer la qualité sous titré Qualité et efficacité des organisations. Ed. AFNOR Ouvrage collectif. 2 tomes. 5eme édition 1994

**BORDELEAU Yvan.** La fonction de consultant auprès des organisations. Ed. Agence d'ARC inc. Ottawa 1986. Enseignant à l'université de Montréal. Psychologue-Conseil auprès des organisations.

**BRILMAN Jean.** L'entreprise réinventée. Les éditions d'organisation. Paris 1995.Directeur international du Groupe CEGOS, Président et Vice Président de sociétés

**CROZIER Michel.** Essai sur l'impuissance des élites à se réformer. Interéditions, Paris, 1995.Théoricien des Organisations. Sociologue, Psychologue et consultant.

**GODET Michel.** Le grand mensonge. sous titré: L'emploi est mort vive l'activité. Fixot, Paris, 1994 .Professeur au CNAM, chaire de Prospective industrielle et consultant.

**MORIN Pierre.** La grande mutation du travail et de l'emploi.. Les Ed. d'Organisations, Paris, 1994 Professeur à l' IAE, Maître de conf.. à l'IEP de Paris et consultant.

**PETERS Tom.** L'entreprise libérée. Dunod, Paris, 1993. Dirige le Tom Peters Group. Ancien consultant chez McKinsey.

**QUINN James Brian.** L'entreprise intelligente. Dunod, Paris 1994Professeur au Dartmouth College. Triple lauréat du McKinsey Award.

**A Frame for Experimentation  
with Shape-grammars in  
Architectural Education**

**Michael Hellgardt**

STUTS Architects  
The Netherlands

**Sourav Kundu**

Kanazawa University  
Japan

*ATN's (Augmented Transition Networks) are an appropriate tool for the representation of architectural shape grammars. The application of this frame in stages of shape grammar codification is resumed. Problems of rule definition and of the connection to existing CAD software are raised. The paper is evaluated in the light of problems raised in the introduction and of what is understood in this respect by an Added Value Of Computer Aided Architectural Design.*





# A Frame for Experimentation with Shape-grammars in Architectural Education

## 1 Introduction

There is an enormous gap between the machinery available for the representation of design and computational tools available for the generation of design in its literal sense. The gap is threatening because it is part of a world governed by images which have become independent and self-sufficient - a phenomenon discussed in cultural criticism. But the gap is a challenge, too. Shape grammar can help to bridge that gap, and consequently is itself part of that challenge. The challenge is a double one: in terms of computer modeling, and in terms of an old unsettled account: the functioning of grammar in shape and space perception, in the built environment, and in architectural practice, thought and education.

In the literature on shape grammar we find grammars of particular architectural styles, or building types. There are also more fundamental investigations which, however, are relatively abstract and unrelated to such singular grammars. Both ways contain no answer to the gap between representation technology and computational tools that allow a more fundamental approach to architectural design. As a result, which we are not the first to raise (Coyne and Snodgrass, 1993), the impact of fundamental research in the fields of AID (Artificial Intelligence in Design) and shape-grammar on architectural practice and theory has been modest, if at all existing.

Though much of the work is done by architects, the new field of shape-grammar is dominated by standards of cognitive science and related problems and requirements of formal and computational modeling. One might argue that people defining models and writing programs should have more substantial knowledge of architecture. This is certainly not wrong, but not a structurally convincing solution. A structural solution would be to provide specific computational tools required for a computer aided investigation of shape grammar in architecture and spatial configuration. This investigation is primarily a matter of architects. At the other side we cannot expect architects to do the work of computer programming. A task of scientists is to provide tools that enables the use of a computer without doing that. To make this more explicit in the light of the gap raised: obviously a tool is required which is not restricted to the manipulation of geometric entities, to Computer Aided *Drawing* in other words, but which allows the manipulation of grammatical categories and mental representations in a way that corresponds to assumed intellectual and artistic performances in the brain, associated with architectural design and perception. Only such a tool can make the promise of Computer Aided *Design* real, and only such a tool opens a professionally unbiased computer aided approach to the account of *grammar in architecture*.

The best model for the work to be done is presumably Natural Language Processing. In earlier work we have shown the applicability of a tool widely used in this field, an ATN (Augmented Transition Network, cf Winston,

1984, chapter 9), for the representation of architecture and architectural grammars (Kundu and Hellgardt, 1996). In the present paper this frame is presented and discussed in a shape of generalisation which opens an approach to the problem raised.

## 2 A shape grammar ATN

### 2.1 The empty ATN frame

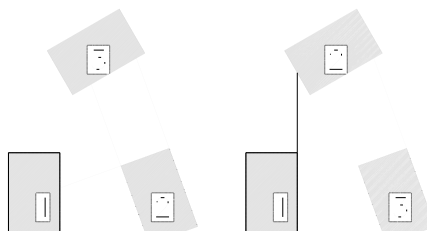
The nodes of nondeterministic networks, such as ATNs, are surrounded by *clouds* of possible choices. The notation of a node reflects that (figure 1). A node has one or more outgoing arcs which invoke functions to be evaluated. When a node is called in a network its first arc is evaluated and its remaining arcs are stored. These stored options are activated as long as no result from other arcs is given, or in case that more than one solution is desired, for instance for exhaustive search. In our application all arcs are of the form  $f(g(x))$ , where  $x$  is the register containing all information available at a given stage of network evaluation,  $g$  is the current and  $f$  the next function to be evaluated with the result of  $g(x)$ . In terminal arcs the  $f$ , the next node is empty, or of the class of the network where a network is embedded in (discussed in section 2.3). To this arc notation a tree notation of the network corresponds. The branches, or arcs of this tree are bidirectional, which means that we climb up and down in it from category to instance, and vice versa.

```
(defnode node          (defnode cat
  (arc(1))             (contin cat-next(1) <cat-rules>)
  ...                 ...
  (arc(n))             (contin cat-next(n)
<cat-rules>))
```

Figure 1, Basic ATN structure (empty ATN frame)

Nodes and arcs are defined as macro functions. Obviously all next functions in the arcs must be encoded as nodes. For the current functions that is less obvious. Corresponding to grammatical structures to be discussed below, rules are addressed as rule categories by the next-nodes ( $f$ ), and as instances of these categories by the current functions ( $g$ ). These rule instances are clustered to rule-sets (marked by  $\langle \dots \rangle$ ; brackets, 'defnode' and 'continue' are omitted in figure 2 and 6). They can be encoded as ordinary functions.

### 2.2 An empty space-between grammar ATN



In the context of machine-design a grammar can perhaps work as a machine designing machines. With respect to cultural, verbal or non-verbal, expressions this is less obvious. An ATN applied in this context is a machine, but not a grammar, a machine that can produce shapes - in our case - with the aid of grammatical knowledge. A machine that can be programmed with grammars. In this section we will outline how an empty ATN frame can be filled, or programmed, with *one* of presumably various possible basic shape-grammar structures. In another contribution to this conference book (Hellgardt, Kundu and Klinkenbijn, 1997) the same frame is applied to quite different structures.

Figure 2

Figure 2 can be read as an ambiguous expression. To the left from any added rectangle a new space-between (blank) results. To the right another order of sequence of rectangle allocation shows that more than one rectangle added can be required in order to result into an evaluable space-between. We resume that as follows: shape configurations can be read as a sequence of the allocation of solids in a way that voids, spaces-between between solids, result. New solids can be added creating new spaces-betweens, or making only virtually existing ones acceptable, and so on. Some experimentation with the work of the architect Scharoun has demonstrated that such a principle is relevant in professional architecture (Hellgardt, 1993 and 1994). A survey of non professional architecture (eg Caniggia, 1976) demonstrates that such structures are wide-spread. We can add the Amsterdam Canal House, the M'Zab building culture, array settlements in Japan and many other examples.

As raised in our articles mentioned the *space-between* appears in literature on architecture, in etymology and above all in philosophy (there rather in the shape of the distinction between spatium and extensio). Here we only discuss in general lines how a principle as raised with figure 1 can be translated into some basic principles of grammar and how an ATN frame can be programmed with that.

Resumed in terms of the general frame of figure 1, figure 2 underlies an extended network of the form:

```

space-between_generator      space-between
  extension space-between    cat-next(1) <space-between?>
  space-between extension    ...
                              cat-next(n) <space-between?>

cat-next
  cat-next(1) <cat-instance>  final-test
  ...                          () <final-test>
  cat-next(n) <cat-instance>
  final-test <cat-instance>
    
```

Figure 3, ATN applied for space-between grammar (empty space-between ATN frame)

When a space-between design starts there are two options (two arcs, figure 3, top left). The first option can be labelled *environmental design*: an environmental context is tested if some evaluable space-between is given, or can be elaborated in a way that a spatium design can proceed by possibly filling it and/or testing remaining 'rest'-patches. The result is passed to the next node, an extension. The second option is addressed if none of the available space-between elaboration rules returns a result. In this case the next option of the network is addressed which means that the design starts with an extension (arc 2 of figure 3, top left) creating a new space-between, to be addressed by the next node. If this new space-between is unacceptable the mechanism is repeated and another extension is added, until an evaluable spatium is given which can be filled and/or tested. This option can be called *tabula rasa* design, design in an empty context. The space-between this kind of design generates is no environmental context any more but a design context.

With that not yet a shape grammar, but an ATN implementation of a basic grammatical assumption for shape configurations, the space-between assumption, is outlined. Such a basic grammar frame can be filled with various grammars, the grammar underlying work of Scharoun for instance. Here we proceed with a global description of how it can be applied to model a phenomenon which is simpler in terms of computer modelation: Palladio Villa's. Grammar has to be elaborated to some minimum extent exhaustively at this stage.

### 2.3 An application

Main references are: the impact of the local, in particular Venetian building type (Ackerman, 1977) and Palladio's harmonic theory (Wittkower, 1973). A main feature of the Venetian palace is a central hall between mirrored wings. In terms of our approach the wings, unambiguously recognizable in Palladio floor plans, are extensions with a space-between between them. The wings are *chords* consisting of harmonically shaped rooms. Such wing-chords can be relatively easy generated by means of a multiple Cartesian product. This is a top-down approach which do not enter, resulting in some hundreds of wing instances reflecting Palladio's way of harmonic dimensioning which, as the literature demonstrates, was a conscious one.

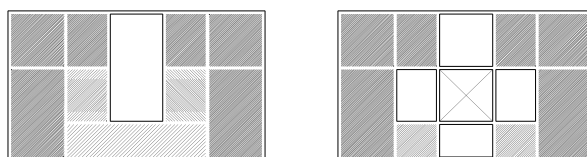


Figure 4

Figure 4 shows paraphrases of the Villa Badoero (left) and the Malcontenta, generated by a space-between ATN. The network starts with an array of solids (dark), called an *extension*, the mirroring of which creates a void, a *space-between*. Such space-betweens can be articulated in various ways. In Palladio villas we find tunnel- or crossvault (Malcontenta) articulations. Calling rules, the ATN tentatively fills such space-betweens, in the formalism represented as pixel-maps, with patches of color values representing room categories such as loggia (light grey), staircase (darker), niche, passage and fill-block. The patches are defined, roughly, by possibly empty xy-parameters and their position in an interpretation of the space-between in terms of zones and regions.

Important is the sequence of rule application. The Badoero paraphrase underlies a loggia-staircase sequence which would lead to an unacceptable appearance in reversed form. In other wing-contexts only such reversals are successful. The search for such different sequences is not possible in deterministic networks. However, the case of an interpretation of architectural design given here underlies the assumption of a grammar combining deterministic and non-deterministic search. Non-deterministic is only the *filling* of the space between. The mechanism *creating* a space-between is, at least partially, deterministic. The result of such search procedures can be represented as a tree which is not the network evaluation tree mentioned in section 2.1, though it reports a decision paths. These trees are essentially the same as *phrase-markers* (also *Structural Descriptions*, SDs; Chomsky, 1965). As an result of grammatical performances, or their simulation through computation, they are equivalent to a phonetic or, in our case, graphic representation such as figure 4.

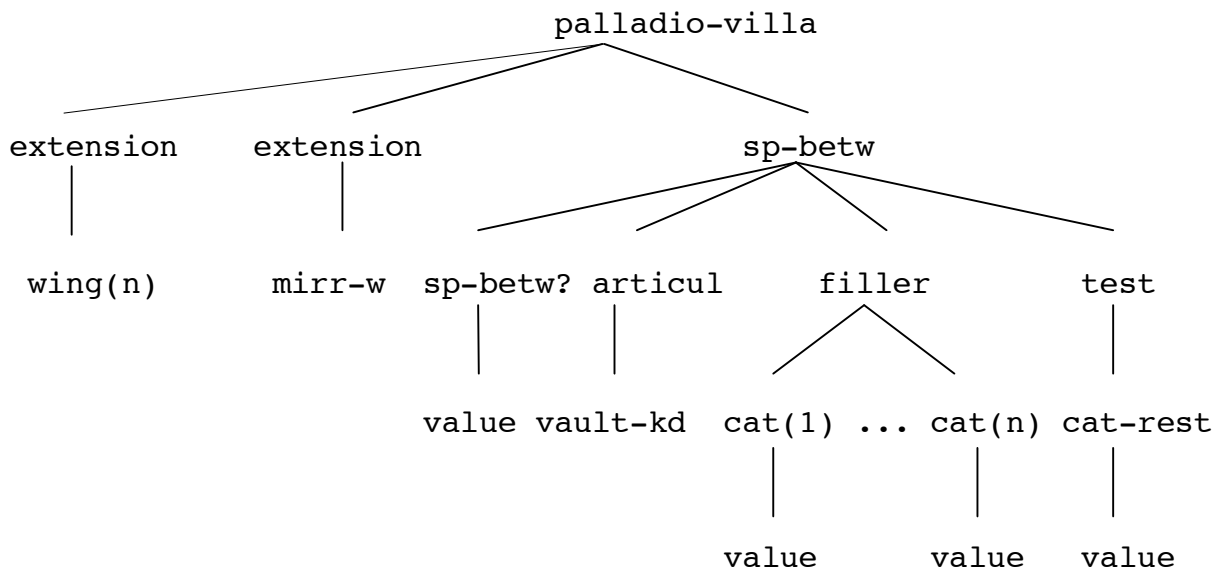


Figure 5

An important feature of generative expressions, in contradiction to stereotype ones, is that they are nested expressions, not in terms of objects, but in terms of recurring grammatical operations of a same type. In any room-category of the tree above another Palladio Villa can be searched for and inserted. More realistic is a staircase, for example, consisting of land-

ing-extensions and a resulting space-between possibly usable for flights, as shown with different color/grey values in figure 4.

With some more properties, ignored here, this simple network comes up with all possible variants of non-bisymmetric villas of one 'pitch' (we do not enter details about that) given with Palladio's legacy. And it comes up with a series of similar cases. The state space of legal rule combinations, selected independantly from evaluation, is large. Filled with rule-sets with only a few rules it soon amounts 1000's of paths for a single of some 100s of wing-instances. We experiment with GA(Genetic Algorithm) directed search in such state spaces of architectural design.

The tree above shows the result of a path in the following application of the frame of figure 2:

```

palladio-villa                                space-between
  extension <eval-context>                    sp-betw_art1 <space-between?>
  space-between <make-wing>

sp-betw_art1                                  fill-cat
  fill-cat(1) <vault-articl>                  fill-cat(1) <cat-rule>
  ...                                          ...
  fill-cat(n) <vault-articl>                  fill-cat(n) <cat-rule>
                                              test_sp-betw <cat-rule>

test_sp-betw
  () <test-rule>

```

Figure 6, space-between ATN applied for Palladio villa's

This network demonstrates, though in a rudimentary form, that a grammar is defined not just by rules but the interweaving of different types of rules in terms of what we can call grammatical functions of shape configuration.

### 3 Rule definition tools and connection to existing software

The distinction between categories addressed by nodes and rule-sets associated allows that rules defined independantly form an ATN frame can be called within a given ATN frame. This enables the implementation of shape rules in a grammatical context as extensions of commercial CAD systems (cf Fawcett, 1990). All the user then has to do in order to 'program' an ATN frame with a grammar, is to enter names of rule-categories and rule-sets.

The added value of a shape grammar ATN, however, is still restricted if no associated rule definition system is available. To an interpretation of architecture shape grammars rule-types correspond, not only in terms of their grammatical function, but also in terms of some basic design principle generally associated with particular drawing acts. Rules that combine labeled shapes for instance (Stiny, 1980). In our approach another rule-type of this rule-species is addressed: a kind of patches-distribution or *brushstroke* technique which works with pixel-maps and reflects an assumed way of

spatial orientation. If the functioning of such rule-types can be generalized, rule definition macros can be defined which write and encode rules on the basis of user-dialogs allowing graphic intervention on the monitor, if desired. A rule is called in an actual network evaluation of the kind discussed here with two arguments, the result of the previous operation and the evolving configuration, here a pixel-map. When a user defines a rule only the number of such arguments is specified, together with a series of arguments required for the automated encoding of a rule, such as the dimensioning and zone/region parameters mentioned above.

#### 4 Conclusion: aspects of architectural education

Rule definition procedures of the pre-structured kind described can make use of SDs, which enables the user to combine architectural design and grammar design and which can be compared to what is called *language learning* (cf Chomsky). Language learning is a good model for design learning. Education, seen in the light of this paper, is a combination of the application of rule-types provided by some basic instruction, enabling rule learning supported by a grammar frame of the kind presented. Concluding, we will discuss problems of the kind of a *symbiosis* of human and machine learning involved with that.

In the introduction we pointed to the danger of a self-sufficient image-technology, and of an inadequate impact of requirements of computer modeling on research. Stiny's and Mitchells (1978) simulation of Palladio Villa's, the importance of which we do not ignore, can be seen in the light of the latter. The underlying method of concatenating room configurations in 'tartan' grids is only loosely related to Palladio's work and related literature - as has been partially remarked by the authors themselves. We try to find a more deliberate anthropomorphic combination of technical knowledge required for computer modeling and of knowledge in fields of application of such modeling, such as architecture and architectural history and theory. The intention of our demonstration was to give an example of how an at the outset empty technical frame, the ATN, can be programmed in different stages with such knowledge.

Particularly when it can be used by architects and students without specific computer programming knowledge, a tool such as an ATN, that allows the mechanic application of grammatical knowledge, can enrich design practice. From an intellectual and artistic point of view, however, such a tool not only enables and supports but also challenges design experimentation and above all design knowledge at a more fundamental level: grammar. Certainly, commercial CAD systems widely in use today are also a challenge in that sense and can be of impact on design learning and trigger new approaches to design. But these systems are drawing, not really design systems. They provide no means to make the kind of learning and experimentation involved with, or even required for their use explicit in terms of computer modeling to the benefit of their *updated* use in future

As any kind of technological innovation, any kind of computer modeling is an ambiguous challenge to human learning. The powerful machinery of image production - *image-appeal*, in fact -available today can have a

destructive impact on design learning. This effect is based on the confusion of the appearance, or image of something with the something itself. Intellectual curiosity is addressed on a surface level in this confusion. Both in practice as in education, computer supported shape-grammar investigation would address it at a deeper layered and more constructive level: the one of understanding.

Grammar in architecture, as raised in the introduction too, is relatively unexplored, certainly in the light of grammar knowledge in language theory, linguistics, semiology and natural language processing. This situation is a matter of architecture and has nothing to do with computers, but today it can adequately and seriously be approached *only* with computers and computerised tools. The ATN frame discussed here is aimed in that direction. What makes such a tool interesting for any kind of, such as architectural education is that the user is not addressed as an idiot by a black box of software the intellectual working of with is unknown and inaccessible to him. In contrast the use of the grammar design tool outlined here is not possible without some knowledge of grammatical structures the tool is based on - knowledge that could be the initial information in a first years course on architectural design.

This is a kind of *dead* knowledge. The use of the tool proposed, however, is not possible without some *living* ideas, intentions, observations in terms of grammatical principles underlying architectural design, or a case of it. To some extent the tool must be neutral. At the other side it must be tailored to certain intentions etc. Section 2 demonstrates, though only globally, the necessity and functioning of that kind of combination. We think it is exactly such a combination that would challenge both the teacher and the student to explore structures of grammar with the aid of computers, not only in order to make richer designs, but also in order to make his understanding and intention in terms of architectural design, understanding and perception - without or *with* the use of a computer - explicit.

## References

- Ackerman, J.S. (1977). Palladio, Penguin Books, Harmandsworth, Great Britain.
- Caniggia, G. (1976). Strutture dello spazio antropico, uniedit editions, Firenze.
- Chomsky, N. (1965). Aspects of the theory of syntax, the MIT Press.
- Coyne, R. and Snodgrass, A. (1993). Rescuing CAD from rationalism, Design Studies 14.
- Fawcett, W.H. (1990). Shape rules for architecture, paper presented at EuropIA conference, Liège, Belgium.
- Kundu, S. and Hellgardt, M. (1996). A networks approach for representation and evolution of shape grammars, in J.S. Gero and F. Sudweeks (eds), Artificial Intelligence in Design '96, Cluwer Academic Publishers.



- Hellgardt, M. (1993). Syntaktische Aspekte der Arbeit von Hans Scharoun, Begründungen und Erläuterungen zu den im Begleitprogramm der Ausstellung 'Werkschau Hans Scharoun' vorgeführten Fragmenten einer Scharoun-Syntax, Akademie der Künste, Abteilung Baukunst, Berlin.
- Hellgardt, M. (1994). Dentro l'architettura di Scharoun, Housing 6, Etaslibri, Milano.
- Hellgardt, M. and Kundu, S. (1997). Objective casualty - an experiment with recognition and emergence in design practice, AVOCAAD conference book.
- Stiny, G. and Mitchell, W.J. (1978). The Palladian grammar, and: Counting Palladian Plans, Environment and Planning B 5, 5-15 and 189-98.
- Stiny, G. (1980). Kindergarten grammars: designing with Froebel's building gifts, Environment and Planning B 7, 409- 62.
- Winston, P. H. (1984). Artificial intelligence, Addison-Wesley Publishing Company, Reading, Massachusetts.
- Wittkower, R. (1973). Architectural principles in the age of humanism, Academy Editions , London.



**Objective casualty - an  
experiment with recognition and  
emergence in design practice**

**Michael Hellgardt  
Wouter Klinkenbijn**

STUT Architects  
The Netherlands

**Sourav Kundu**

Kanazawa University  
Japan

*Experimentation with an algorithm in practice is presented. Pattern recognition and emergence is controlled through user dialog in this experiment. The next step is to teach the machine to clone human perceptual performances involved with that. Some basic experimentation in this field, which is partially inspired by Hofstadter's more recent work, is reported. The transcription of the algorithm applied in practice into an ATN(Augmented Transition Network) to be evaluated exhaustively or by means of directed search is presented. Finally problems of connections between the formalisms presented and commercial software are discussed.*



# Objective Casualty - An Experiment with Recognition and Emergence in Design Practice

## 1 Introduction

The classic assumption that aims and means can be unambiguously separated and identified independently from the design act probably meets some species of technical design, but not its real nature and certainly not the nature of cultural, such as architectural design. This objection to premature claims of AI is widely accepted today (cf Mitchell, 1990, in the literature on AID). This paper is a report on some experimentation with a design formalism demonstrating that the computer can contribute to *learning* in the course of the design act by extending initial human, more or less subconsciously working design intentions mechanically. This approach contradicts a wide-spread reaction to criticism of the kind mentioned which considers the computer as a tool that can support rational but not irrational design, related to human intentions and emotions (cf Papamichael/Protzen, 1993). The paper claims the opposite, particularly in the context of cultural design: Most powerful, to some extent even superior to humans the computer is when simulating irrational design performances. The learning function mentioned above reacts on human interventions into design operations of such an irrational and mechanic kind. The paper will demonstrate that both can enrich real architectural practice.

## 2 Objective casualty

The impact of chance on thought and design is a current argument in the discussion on AI (cf Hofstadter, 1995), and it is not a new argument. Levy-Strauss' work, for instance, was influenced by a principle that has been called *Objective Casualty* in the Surrealist Movement. Life and thought seems to be a kind of balance between unexpected events and attempts to account for such events by rational inference. To simulate and to challenge such a balance we took recourse to the computer. A request by local authorities for a global proposal for the restructuring of old fortification works in a small Dutch town was a welcome opportunity to experiment with *Objective Casualty*. Some architects, Lucien Krol for example, deliberately work with random effects. Another source of inspiration was Hillier and Hanson's (1984) *hamlet syntax* which models rural settlements as horizontal random aggregations of cells (solids) around yards (voids). Our approach models similar, but vertical solid-void combinations. The formalism (written in Lisp) is called random-HAB-allocation. It generates such combinations and tests their HABitability.

## 3 Designing with an algorithm

The mechanism can be compared with a grammar producing random combinations of words and word-fragments to poems possibly transmitting some sense. The 'words' of our experiment are columns of packed cubes and voids. We started to work with an algorithm which subsequently randomly inserts voids, representing balconies, indented cubes and roof-terraces, into an initial 'full' package of solids:

```

1 random HAB allocation
2   WHILE illegal building
3     REPEAT for front and/or back zone
4       WHILE illegal zone
5         FORALL columns of RANDOM-ARRAY_zone
6           WHILE illegal section
7             SUBSTITUTE void random-solid

```

Here is an example of a zone 'designed' by the algorithm:

```
#2A((- 0 1 0 0 1 1 1)(- - 0 1 1 1 0 1)(1 1 0 1 0 0 1 1))
```

The lists of this 2-dimensional array represent the columns of a zone, the 1's solid, or full, and the 0's void cubes. The hyphens represent not used roof fields. Their distribution marks the silhouette of a zone and is generated randomly in order to define the initial array of a zone (line 5) as a combination of 1's and hyphens. The HABitability of the evolving design is tested by restrictions related to combinations of columns to sections (line 6), of sections to zones (line 4), and of zones to buildings (line 2). The test criteria applied reflect the nature of architectural design: they combine perceptual, or aesthetic, conventions with standards of use-value. We assume that HABitability is a matter of both. A perhaps questionable assumption in terms of architectural theory which is irrelevant, however, from the point of view of computer modelation.

With the proceeding of the algorithm the test operations become increasingly complex and use-value requirements more important. Some results were tested with real floor plan designs. But to formalise that remains a matter of future work. Until now usability was tested only with rules of thumb. Another restriction of the approach described here is that possible dwelling units deeper than a front or back zone can only be tested at the end in the top-loop. It is intended to transcribe this into a mechanism proceeding sectionwise from left to right with combined front and back sections.

A few relatively simple undesired properties, no more than two voids on top of each other for instance, served initially as test criteria. To these basic standards the computer proposes candidates to the observing and judging user. For the global sketch design this was sufficient. Searching visually for acceptable solutions our assumption was confirmed that the computer is a good work mate to achieve the kind of random effects we were aiming at. Figure 1 shows, in order to give an idea of the visual appearance in row-printing with the hyphens omitted, some examples of zone-candidates. The rejected cases are marked by 'x'. Figure 2 shows the front- and back-zones of six blocks 'designed' by the algorithm. How the

result of the algorithm, a 3-dimensional array, is translated into a 3D model is described in section 6.

```
> (row-print HAB-zone 0 14)

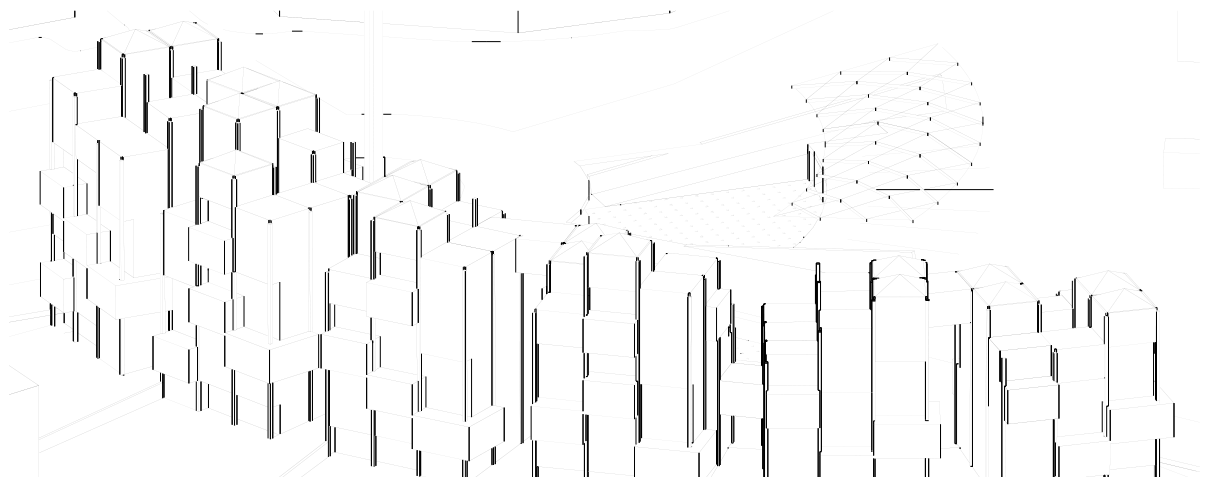
" 1    1    1    1    1    1    1    1    1    1    1    1    1    1    1"
" 01   11   01 11   11 00   11 01   1 1 1 0 1 0 10 11   01 10"
" 111 101 110 001 101 011 100 111 111 011 111 111 001 110 101"
" 000 011 000 100 010 110 110 100 001 100 011 111 101 100 001"
" 100 000 101 010 010 000 101 100 100 100 100 000 110 001 110"
" 111 110 111 111 101 111 001 011 010 111 000 100 010 111 110"
" 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111"
0x  1x  2   3   4x  5x  6x  7x  8   9x 10x 11x 12  13x 14
```

Figure 1

#### 4 Analog patterns

The kind of user dialog with a serial computer algorithm addressed, a kind of visual computer aided selection procedure, demonstrates that the recognition and conceptualisation of evaluational criteria is a matter of learning through experience. Even in such a simple case. Obviously we follow only un- or subconsciously working standards which have to be triggered by external stimuli, such as an appearing image, in order to manifest themselves and become conscious. By means of some similarity, or analogy, appearing images evoke reference-patterns which are known images. A good expression for that is *Leitbild*, in the literature on computer modelation they are also called *datum* (Winston and Horn, 1981).

A pattern-match compares a pattern with an ordinary expression, a datum, to see if and how a pattern can be converted into a datum, or an analog datum. The match keeps track of associations between pattern variables and datum elements. If a pattern, defined as a sequence of known elements and unknown variables, is matched against a datum, the value of the unknown variable can be returned. This corresponds to the completion of incomplete images. In case a known pattern element does not meet the corresponding datum element 'failure' is returned. If pattern



and datum are the same, another expression is returned ('nil' in the implementation discussed by Winston and Horn)

Figure 2

Illegal instances produced by the algorithm described above can be converted in this way. But this is restricted to one or more datum(s) defined prior to the matching procedure itself. The procedure applies knowledge, but does not perform any learning. More interesting is the matching, interpretation or *reading* by analogy. An analog reading and conversion of an expression is possible, if a reference-reading, an analogy-making rule, is given of the form: A has been converted into B. The analogy problem then has the form: if A has been converted into B, is some other expression C convertible too and if yes, how? Left to the comma of the expression below an example of a rule is given. This rule is the expression of our disapproval of horizontal bars in the little tower-like blocks of the kind shown in figure 3 below. On this background the analogy problem can appear, in row-printing, as follows:

```

      011    001    101
if 001 > 011, 001 > ?

```

Visually we identify immediately the #2A((0 0)(1 0)) combination as a neuralgic embedded pattern and its occurrence in reversed form, #2A((1 0)(0 0)), to the right side of the arrow. We can transcribe such observations into an extended pattern matching taking account of all known analogic configurations containing a neuralgic embedded pattern (here 4 are possible). This may be useful, but with respect to machine learning it is uninteresting. In this respect we have to teach the computer visual recognition. That this is possible has been questioned with the argument that the computer can perform only human prescriptions. Less questionable is to say that the computer can clone human performances, provided the human prescriptions are on a certain level of abstraction. We can assume certain operations, which are more abstract than the identification of known examples, the combination of which may result into the emergence and recognition of an image. That #2A((1 0)(0 0)) is an instance of #2A((0 0)(1 0)) in the occurrence to the right of the “?” can be interpreted as a concatenation of position (do something on a possible position), pairing (build a pair on a position) and reversion (reverse an entire pattern, or parts of it). We can say such performances are guided by devices which can be called *concepts*, even if they are fairly shallow ones. Combined with deeper concepts, such as sameness or similarity, the concatenation of these concepts can result into converted analog patterns. First the #2A(1 0)(0 0)) pair is identified not as a same, but as a similar occurrence of the #2A((0 0)(1 0)) pair in the left side of the analogy rule on the second position of the pattern in reversed form. This is an example of how the analogy procedure detects a bad pattern. These are converted then into good patterns by matching them with the corresponding datum, the right side of the rule, whereby the analogy-making performances, which have been resulting into the analog bad pattern, are applied.



This procedure can identify and possibly convert bad patterns which are not provided as a model, or datum, prior to it. It can scan recursively vertically all possible patterns within appearances as those of figure 1 in order to except, reject or edit a configuration. However, the procedure is blind to conditions outside the pattern frame. As a result good patterns can be destroyed by their conversion into patterns which are legal, but different from the destroyed expression. To prevent that we have to address some additional condition, defined outside the procedure itself. Or we have to extend the analogy making model with respect to embedded structures, which is planned as future work. With an added user-defined condition the mechanism recursively produced sequences of conversions, such as shown in figure 4. The first conversion produces a new horizontal bar of the undesired kind (the neighbored 0's in column 2 and 3). The neighbored 0's of the result to the right form no such horizontal bar (as some embedded configurations in figure 2 demonstrate in 3D appearance).

```
> (row-print (analogy-scan))
  1   1   1
11  11  11
101 101 101
110 110 100
010 000 010
001 011 011
111 111 111
```

Figure 4

The analogy making mechanism is implemented as an ATN (Augmented Transition Network) of the form:

```
concept
  concept_next(1) concept_current(1)
  ...
  concept_next(n) concept_current(n)
  terminal-concept_next(1) concept_current(1)
  ...
  terminal-concept_next(n) concept_current(n)
terminal_concept
  () terminal_concept(1)
  ...
  () terminal_concept(n)
```

The functioning of ATNs for shape- and shape-grammar representation is discussed in another contribution to this conference book (Hellgardt and Kundu, 1997). To resume in short: the nodes of ATNs are defined by one

more more outgoing arcs, the indented expressions above. These arcs represent options of possible paths to follow in the network. The two expressions in the arcs above mark the current expressions to be evaluated, and the next expressions to be addressed in case the current expression returns a non-nil result, otherwise one of the remaining options is addressed. Terminal arcs are marked by an empty next-expression.

The analogy making mechanism described is inspired by chapter 5 on analogy making in (Hofstadter, 1995) and in particular the idea of conceptual slippage discussed there. This chapter starts with the analogy problem:  $aabc > aabd$ ,  $ijkk > ?$ . Though it is more complex, in its simplicity this model is comparable with the one discussed above. We were immediately fascinated. In general and in particular, because this chapter is highly relevant for experimentation with visual recognition and emergence.

The concatenation of the 5 concepts described is a simple case of a conceptual slippage and the ATN above its implementation. As Hofstadter explains human understanding can be mapped as a coincidence of arbitrarily addressed concepts and conceptual linkages. Such linkages are controlled by conceptual distances in the work of Hofstadter and the 'Fluid Analogies Research Groop'. We ignored that until now. Instead, a pattern appearing in the scanning proces described is randomly *bombarded* by the five concepts. This is implemented by shuffling the arcs any time an alternative option is called. This method is primitive. But as a first experiment it already demonstrates that the constant shifting of conceptual *halos*, or *clouds* (favorite terms of Hofstadter) around nodes, and the connected constant re-organisation of the network, does work in the field we intend to explore. The search for a solution ending with no result, or with a terminal node expressing a pattern recognition, and possibly a conversion can include many interrupted paths and traverse the network in different ways. But the result is always the same.

## 5 A HAB allocation network

The algorithm discussed in section 3 can be transcribed into an algorithm calculating all possible legal HAB combinations. Provided we test only one type of section combinations evolving from left to right, and the resulting final combination, we get for the 'design' of a zone an algorithm of the following form:

```

1 Exhaustive random HAB allocation zone
2   WHILE set-of-columns_next is given
3     FORALL column-a of set-of-colns_current
4       FORALL set-of-colns_next of remaining sets-of-colns
5         FORALL column-b of set-of-colns_next
6           IF combine-to-section_column-a+b is not illegal
7             ADD combine_column-a+b to result
8         REMOVE set-of-colns_current from sets-of-columns
9   IF resulting-zone is not illegal
10  return result

```

This is a combinatorial mechanism which starts with a number of sets of legal columns of 0-1-hyphen combinations (see section 3) and tests all possible combinations of columns of a zone. The combinatorial explosion is remarkable. In our case of only 3 columns and 7 levels 18816 combinations were tested and 157 legal zones returned as result (figure 5).

If we combine line 3 to 7 of the algorithm above to a rule called 'combine/add-section' and line 9 and 10 to a rule called 'test-zone' we can transcribe the algorithm into a network of n nodes of the form below, where n is the number of nodes (we do not enter details of the start mechanism).

```
> (row-print result_exhaust-search 135 149)
" 10 10 1 1 1 1 11 11 10 10 1 1 1 1 1
"
" 01 01 01 01 01 0 01 00 01 01 01 01 0 0 01
"
" 100 100 101 100 100 101 110 110 111 110 111 110 111 110 110
"
" 010 010 011 010 010 011 001 001 001 001 001 001 001 001 101
"
" 101 101 100 101 101 100 100 101 100 100 100 100 100 100 010
"
" 011 010 010 011 010 010 010 010 010 010 010 010 010 010 010
"
135 136 137 138 139 140 141 142 143 144 145 146 147 148 149
```

Figure 5

```
section(1)
  section(2) combine/add-section_start
section(2)
  section(3) combine/add-section
  ...
section(n)
  () test-zone
```

This is a deterministic application of the ATN structure mentioned above. As discussed in our other contribution to this conference book, an ATN structure can serve as a tool for the definition of shape-grammars without specific knowledge of computer modelation. The network above defines a random HAB allocation grammar, a kind of perforation grammar. In

this case the user has to define a number of nodes corresponding to the length of the building to design. And he has to define the combination and test rules which can be done with the aid of rule definition tools for prestructured rule-types. As a method this is also discussed in the paper mentioned above.

Such a random HAB allocation network can be useful if an adequate set of test criteria and procedures, such as analogy recognition, is given and if HABitability can be tested realistically by means of floor-plan design, which can either make use of a library of cubes, filled with floor-plans, or of a floor-plan generator. The state-space of such a network is still much larger than the one specified above. Exhaustive search will soon exceed normal standards in terms of run-time. Multicriteria GA(Genetic Algorithm) network evaluation (Kundu, 1996) is an appropriate answer to that problem. Experimentation with this approach is ongoing. Its application in the context discussed here, is a variant, or an extension, of design directed by *Objective Casualty* in the way discussed in section 3.

## 6 Connection to commercial software

Random HAB allocation, in the form described here, elaborates the combination of components such as a standard cube, in- and outdented cubes, ground-floor, corner- and roof- variants, columns and roof-elements (figure 3).

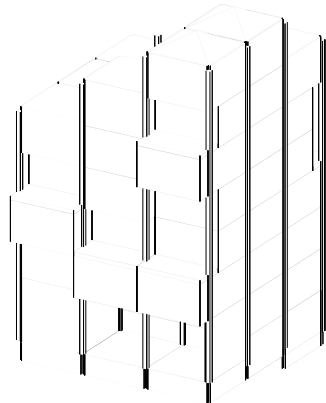


Figure 3

An executive algorithm runs for all fields of the result of the algorithm or network, the 3-dimensional array discussed in section 3 and 5, through a classification tree in order to select the required, context-dependant component and to write it to a new array, one of components.

We also have components which link random HAB blocks (see figure 2). Another executive algorithm evaluates arrays of buildings, in our case a polar array of six blocks, and selects such link-components. We do not enter details about that.

If the CAD package used provides the required facilities the user can automate the evaluation of the result of the executive algorithm(s) by writing a function, a very simple one, which activates an insert-command with the arguments of the field-values of the new array. Otherwise he can ask the software-producer to do that. Or he has to follow the prescriptions of the new array personally and to insert the components manually.

This, even in the case of a manual final operation, can be discussed as an example of an implementation of a shape rule formalism, the random HAB allocation grammar, as an extension of commercial CAD software, an obvioulsy urgent target (cf Fawcett, 1990).

## References

- Fawcett, W.H. (1990). Shape rules for architecture, paper presented at EuropIA conference, Liege, Belgium.
- Hillier, B. and Hanson, J. (1984). The social logic of space, Cambridge University Press.
- Hofstadter, D.R. and the Fluid Analogies Research Groop (1995). Fluid concepts and creative analogies, Basic Books, New York.
- Hellgardt M. and Kundu, S. (1997). A frame for experimentation with shape grammars in architectural education, AVOCAAD conference book.
- Kundu, S. (1996). A multicriteria genetic algorithm to solve optimisation problems in structural engineering design, Proceeding of International Conference on Information Technology in Civil and Structural Engineering Design - Taking Stock and Future Directions, Glasgow.
- Mitchell, W.J. (1990). A new agenda for computer aided design, in: McCollough, M., Mitchell, W.J. (eds), The electronic design studio: architectural knowledge in the computer era, MIT Press.
- Papamichael, K. and J.-P. Protzen (1993). The limits of intelligence in design, Proceedings of the Fourth International Symposium on System research, Informatics and Cybernetics, Baden-Baden, Germany.
- Winston, P.H. and Horn, B.K.P. (1981) Symbolic pattern matching, in: Lisp, Addison-Wesley, Reading, Massachusetts.



## From Literacy to Creativity in CAAD

**Ann Hendricx**  
**Ann Heylighen**  
KU Leuven  
Belgium

*The course on CAAD at the K.U.Leuven is part of the course on design methodology and theory from which it is the most recent and natural extension. Attached to this course a series of assignments has been developed which bring the students in 45 hours to a non-trivial level of acquaintance with CAAD. Rather than mimic the traditional pencil-and paper approach, the exercises encourage students to explore additional design opportunities that a drawing board cannot offer. In this way, the practical part goes beyond a mere preparation for practice. The assignments are built on top of AutoCAD to which we have added in-house developments in order to focus on specific educational goals within a very limited time. The paper presents and comments these assignments and shows results from the last 2 years.*





## From Literacy to Creativity in CAAD

### INTRODUCTION

CAAD has gone through many generations and philosophical perspectives. It all began in the early 1960s with the claim that architectural design could be moulded into systematic methods and thus carried out automatically by computers. Ten years later, attempts to automate the design process appeared to yield such disappointing results that expectations on the computer's role in architecture were lowered from designing to word processing, bookkeeping and drawing. However, the underlying confusion about the relevance of systematic methods to design and subsequently about the role of computers in architectural design still exists. Therefore at the K.U.Leuven the course on CAAD is not taught as a mere instrumental skill but is embedded in a more general debate on design theory. This course consists of 3 parts:

*Part 1* focuses on design epistemology: the discussion on the nature of design problems, modelling the design process, structuring the building programme, generation of ideas and selection of alternatives (the problem of weighing). It builds the argumentation for rejecting the idea of fully automated design. *Part 2* brings a critical study of design methods or so called design methods: notation methods, decomposition, patterns, morphological box, master planning. *Part 3* is devoted to CAAD including the topics: definitions, hardware and software for CAAD, physical and conceptual modelling, the state of the art, prospective uses like case-based reasoning, intelligent objects.

In addition to the theoretical part, which sheds light on what the domain really is, the course also has a practical component. CAAD practice can be taught at different levels. First of all, one has to become accustomed with hardware and software in order to explore the state of the art. This is the real *learning phase*. Secondly, the acquired knowledge can be used to customise existing CAAD applications to the personal needs of the user. Existing knowledge from different domains can be programmed and combined into helpful software tools. This *developing* step already assumes a more active attitude. Finally, *creativity* comes into play when students explore design facilities that a drawing board has to do without and thus might stimulate them to conceive new ideas. It is in this third phase that CAAD exceeds the mimicing of the traditional pencil and paper approach and really adds something to the design process.

The course on Design Methods is taught to 4th year students because we think the subject makes more sense to those who have already some

design experience (from the 3 previous years). They all have had a course on computer science and another on systems software before they take the course on CAAD, which allows us to extend the practical part beyond just using existing software. Whereas most exercises focus on the first two levels of acquaintance with the

subject, other were deliberately developed to allow students to penetrate into the creative phase. Subsequently, those who like can make a CAAD dissertation in their last year. Topics range from developing a specific CAAD tool (e.g. an intelligent zoom, menu monitored choices, a toolbox for making models on the urban scale) to exploring a more theoretical subject (e.g. artificial intelligence, virtual reality).

Since 3 years the practical course on CAAD is compulsory. About 60 students are attending it yearly. Since we have 20 PC's (IBM Value Point 486 with NEC 17 inch high resolution colour screens) in our computer class, we take them in 3 shifts of 2.5 hour sessions with one tutor per session. The first sessions are devoted to general introductions to Windows and Autocad. In order to avoid unconscious promotion of Autocad, we also invite other firms to give a demo of their software (Microstation, Star, Minicad). The other assignments are shortly described and illustrated in the following pages (*what*), this in the sequence they are taught. Each exercise adds some specific skills to the students' capabilities (*why*). For the sake of completeness, the time provided within the sessions and the time students really spent on the assignment are added.

An inquiry amongst students at the end of the course has produced positive reactions. Exercises where creativity comes into play appear to be the most appreciated, but also the most time-consuming. Some students would prefer the CAAD course earlier in the curriculum. In general, comments have encouraged us to continue our current approach.

## REFERENCES

- HENDRICX, A., NEUCKERMANS, H., NUYTS, K. & VANDVYVERE, H. 1996. "CAAD in pedagogical practice". Education for practice, 14<sup>th</sup> Conference of ECAADE, Lund 1996, pp. 199 - 210
- KINABLE, M. 1987. *Computergesteund gevelontwerp in de faze van het schetsontwerp (Computer aided façade design in the early design stage, in Dutch)*. Diss. Ir. Arch. Faculteit Toegepaste Wetenschappen, K.U.Leuven.
- NEUCKERMANS, H. 1992. "A conceptual model for CAAD". Automation in construction, vol.1, nr.1, pp.1-6
- NEUCKERMANS, H. 1994. *Ontwerpmethodiek (Design methodology, in Dutch)*. Course text, Departement ASRO, Faculteit Toegepaste Wetenschappen, K.U.Leuven.

SMARS P. 1992. *Etudes sur les structures en maçonnerie (Research on masonry structures, in French)*. Diss. for R. Lemaire Centre for Conservation, K.U.Leuven.

*CAAD-oefeningen, aansluitend bij de cursus "Ontwerpmethodiek, m.i.v. het computergesteund ontwerpen" (CAAD exercises, part of the course "Design methodology", in Dutch)*. 1995. Departement ASRO, Faculteit Toegepaste Wetenschappen, K.U.Leuven.



## **COLOPHON**

### **WHAT**

Inspired by the practice in the architect's office, we ask the students to create a standard colophon to use in all their future assignments. This colophon consists of a frame, alphanumeric information in form of fixed text and attributes, together with a logo for the student's imaginary office. This colophon is to be inserted as a 'block' in a DIN-A3 prototype drawing, where general settings are explored and appropriate layers created.

### **WHY**

*Jan Steenhoudt 1996*

Within a relatively simple example, AutoCAD drawing and editing commands are exercised. Stress is laid upon *accurate* drawing (in a computer, the 'more or less' philosophy is taboo). The importance of organising drawing is shown clearly in a prototype drawing. Secondly, the powerful possibilities of 'blocks' are explored: students have to see the great advantage a computer can offer by reusing (changeable) drawing components. Finally, to satisfy the need of exploring other window applications and to make this first acquaintance a pleasant one, the students are invited to use a simple drawing program like Paintbrush to create their own logo and import it into the AutoCAD drawing. Hereby, the difference between graphical packages (pixels) and design packages (vertices) is illustrated. Moreover, the possibilities of connecting and combining different applications are shown. To avoid confusion, this first exercise is kept strictly 2-dimensional.

*Kathleen Tierens 1996*

### **STUDENT RESULTS**

provided time within student's agenda: 2.5h  
average time spent: 5h

*some student logos, a prototype drawing with inserted colophon and a student colophon.*

## **DETAIL**

---

*Bart Geeraerts 1996*

*Yaël De Bruyne 1996*

*Frédéric Tack 1996*

## **WHAT**

In the architectural curriculum at the KU Leuven drawing of and reflecting on constructional details is very important. Standard 'good' solutions circulate within the faculty. Such a 2-dimensional detail has to be generated in an intelligent manner: logical organisation of layers, colours, hatching and text is expected. Finally, the finished drawing has to be scaled accurately in order to print it in combination with frame and colophon of the previous exercise.

## **WHY**

Drawing and editing skills are trained in depth. Moreover, this exercise emphasises the underlying organisation of drawing: students have to decide what is the most appropriate way to use layers, pen widths, colours, hatching ... A persevering attitude to do this consistently throughout the whole drawing session is required. The representation of architectural component (cross section, elevation) is considered. By combining real size frames (prototype drawing) and a scale mode topics as scale/plotting/unit ... are explored.

## **STUDENT RESULTS**

provided time : 5h  
average time spent: 7h

## **FAÇADE DESIGN**

### **WHAT**

Students make a 2-dimensional façade design using AutoCAD tools (grid, rotate, mirror, offset ...) and a built-in proportion system. This system is based upon historically important geometrical series like the golden section and the ideas of Le Corbusier in his Modulor and Les Tracés Régulateurs. It is implemented on top of AutoCAD and, in combination with some existing commands, gathered in pull-down menus for easy use by the students. Choices made by students are advised and adjusted by the program to fit these choices into the logic of the proportion system. This creates order into the composition. The student's design process has to be documented by way of a series of slides that ultimately, are combined in a slide show.

### **WHY**

At the moment, the computer is widely used to modify (already existing) designs, but rarely during the first design stages of rough sketching and exploring possibilities. With the façade tool, students are forced to fill this void. Next to practising graphical tools that provide modulation and symmetry, students realise that a computer can, instead of hampering the design process, be of great assistance. The software module and according menus that we developed provide a first glance at the customisation possibilities compared to AutoCAD. Finally, students learn to use slides and slide scripts for presentation purposes.

### **STUDENT RESULTS**

provided time within student's agenda: 5h  
average time spent: 9,5h

*documentation of the design process by a number of slides, based on the golden section, dutch commentaries are omitted (Wim Sufleleers, 1996)*

**EXTRACTION**

*BL:NAME*    *c015000*  
*BL:X*        *n015003*  
*BL:Y*        *n015003*  
*MODEL*      *c015000*  
*PRIJS*       *n012002*

*'KAST', 2.100, 5.700,'hoogte 180', 10000.00*  
*'KAST', 4.800, 5.700,'hoogte 150', 8000.00*  
*'KAST', 7.500, 5.700,'hoogte 120', 6000.00*  
*'KAST', 10.200, 5.700,'hoogte 120', 6000.00*  
*'TAFEL', 14.400, 6.300,'90x180', 4500.00*  
*'STOEL', 15.300, 6.000,'bureel', 8000.00*  
*'KAST', 2.100, 0.900,'hoogte 180', 10000.00*  
*'KAST', 10.200, 0.900,'hoogte 120', 6000.00*  
*'KAST', 7.500, 0.900,'hoogte 120', 6000.00*  
*'KAST', 4.800, 0.900,'hoogte 150', 8000.00*  
*'STOEL', 16.800, 3.900,'leeszaal', 3200.00*  
*'STOEL', 16.200, 1.500,'leeszaal', 3200.00*  
*'TAFEL', 15.300, 1.800,'90x180', 4500.00*  
*'TAFEL', 17.700, 3.600,'90x180', 4500.00*  
*'TAFEL', 15.300, 3.600,'90x180', 4500.00*  
*'TAFEL', 12.900, 1.800,'90x180', 4500.00*

*library room, extraction template and extracted text file (Jan De Greef 1996)*

**WHAT**

The extraction exercise consists of two major parts. Firstly, students extract attributes of newly placed furniture in a library room and export it into an external text file or spreadsheet program. The features of such a spreadsheet program are explored. Secondly, in the other direction, numerical data residing in an external database are linked to graphical entities in the AutoCAD drawing: a list of books is linked with the 'books' entities in the drawing. Small query orders are made using these alphanumerical and graphical data. Finally, students are invited to produce a short essay on applications of this technique in architecture and urban design.

**WHY**

Showing the potential benefits of an 'intelligent' system where graphical and alphanumerical data can be linked, is the main pedagogical goal of this exercise. Automatic generation of the bill of quantities and specifications, performing all kinds of tests on the model (energy, light, stability ...), deduction of production orders ... are applications based on this important linking. In the meantime, however, students get the opportunity to explore spreadsheets and databases.

**STUDENT RESULTS**

provided time within agenda: 2.5h  
 average time spent: within the limits of the time schedule



**CONTAINER***Jo Pycke 1996**Vicky Van Daele 1995**Steven Goossens 1996***WHAT**

Solving a design problem often means looking for a solution at an elementary level and gradually refining and giving it a concrete form. The computer can provide this refinement automatically by using a modular building system with few different building elements. In particular, students are asked to realise a 3-dimensional design using predefined container elements drawn at different levels of detail, in combination with some elementary editing functions (inserting and deleting wall panels, windows, railings ...). The aim is to conceive a weekend residence for a person with a very specific profile, for example an astrologer or a bungee jumper. During the design phase, students can easily switch between two different levels of abstraction.

**WHY**

Realising the strength of computer-aided substitution during the design process is the main pedagogical goal of this exercise. Concretely, students learn to position existing 3-dimensional elements in space and to manipulate topics as view and user coordinate system. The organisation of the graphical screen in appropriate viewports is another aspect. Next, the provided software routines are to be placed in pull-down and icon menus. Hence, a first acquaintance with the customisation of a package to the user's needs is obtained.

**STUDENT RESULTS**

provided time within agenda: 5h  
average time spent: 7.5h

## **SURFACE MODELLING**

---

### **WHAT**

In the previous exercise positioning existing entities in space was the acquire knowledge. The next logical step is to *model* 3-dimensional entities. After an introduction concerning different modelling techniques (wire frame, surface modelling, solid modelling) we provide the students with a simplified non digital model of an existing building. Until now this was a part of the Leicester University Engineering building by Stirling. A surface model has to be deducted. General drawing settings and layer organisation are chosen by the students.

### **WHY**

The different ways to model a 3 dimensional entity are explored. Concerning a surface model, the step from a 2D element with thickness to real 3D faces, polygon meshes and 3D object is taken. Students learn the principle of hidden line elimination and other more advanced rendering techniques. The previous acquainted knowledge about viewing a 3D object and wandering around in space is further trained.

Thus, we provide the basics for easy modelling of the project that students realise in the design studios at our department.

### **STUDENT RESULTS**

provided time: 2.5h  
average time spent: 4h

*wireframe, hidden lines removed and rendered representation of the obtained surface model*

## **FRACTAL TREE**

### **WHAT**

Beside its mathematical definition, fractal can be defined as a geometric structure with a high degree of self similarity obtained by a recursive procedure. Students first get a general introduction in the fascinating world of fractals. Secondly, the principles of the Autolisp programming language are explained. Finally, they are invited to explore and complete an unfinished Autolisp program that describes the generation of a 2D fractal tree. Or they can produce their own fractal object, based on the given routine and getting fractal inspiration in a provided reader about the subject.

### **WHY**

Apart from learning about fractals and their potential use in architecture, some additional computer and Autocad skills are trained. Programming recursion in Autolisp and programming in general is the first one. Linking such an external routine to an Autocad drawing is the next step. The advantages for further customisation of such linking are pointed out. The underlying structure of AutoCAD entities and command becomes clear. It goes without saying that a full understanding and knowledge of Autolisp can not be obtained in one single afternoon, this exercise is merely meant as an introduction. Students learn about Autolisp's existence and are invited to explore further for their own needs.

### **STUDENT RESULTS**

provided time within agenda: 2.5h  
average time spent: within the limit of the time schedule

*Dries Nijs 1995*

*Jan Steenhoudt 1996*

## **SOLID MODELLING**

---

### **WHAT**

In the second year of their architectural curriculum, students have to make a global analysis of a well-known house. At that time, a set of representative drawings were made by hand. In contrast to this representation with pencil and paper, we ask them now to make a digital model of that same building. First of all, a strong simplification of the chosen project is needed. This simplified version is modelled with AutoCAD's solid modeller AME. The student himself has to find out the most practical drawing organisation. Additionally, some good views and cross sections are generated and presented within the standard frame and colophon. These ready-to-print documents are realised using AutoCAD's paper space utility.

### **WHY**

Having explored surface modelling in a previous stage of the course, solid modelling is the next logical step. Since students model existing buildings (not designed to be modelled digitally), the possibilities as well as the disadvantages of the technique become quite clear. Stress is laid upon the internal organisation of the drawing and the importance of deciding in advance at which level of detail they want to represent the building. Moreover, the great benefit of splitting the modelling and representation phase (in contrast to traditional drawings) becomes clear by forcing the students to hand in printable documents.

### **STUDENT RESULTS**

provided time within agenda: 5h  
average time spent: 16h

## LIGHTING

### WHAT

Depending on the phase of the design process, a computer can provide the architect with interesting facts and data concerning his building model. The same test (for example calculation of heat loss) can be different from one stage to another: the crude and elementary application of rules on the first design sketches versus very accurate computations on the final design. Students use a very rudimentary program to test the illumination level in one single room, meant to be used during the early stages of the design. Only artificial light is taken into account. The assignment consists of modelling a lighting installation (choice of light sources and layout) for a particular classroom. While placing lights within the AutoCAD model of the room, a fast test of the required light level can be performed in an interactive way i.e. without leaving the graphical application.

### WHY

Being engineers as well as architects, we considered it important to show the integration of a graphical representation of design and at that moment relevant tests. The latter provides the architect with information he could never easily produce by hand, and influences further design decisions. The choice for the computation of illumination levels was merely a practical one, having the program available at our department as a result of previous research. It is obvious that in the ideal situation all these tests can be performed upon the same model, whereas at the moment every software developer constructs its own model of the building environment.

### STUDENT RESULTS

provided time within agenda: 2.5h  
average time spent: within the limits of the time schedule

*intensity of light in a given direction, ellipses that represent isoluxlines for a given light source and (below) the classroom configuration with armature layout*

## **PRESSURE LINES IN AN ARC**

### **WHAT**

A software program has been developed to compute the centre of pressure line in arcs based on the graphical technique. Implemented on top of AutoCAD, it gives the designer the possibility to design and check the stability of arcs in an interactive way. Several arc configurations can be easily checked while being in the design stage of a project. In this way it is a tool easy at hand to help the designer to make the right decision while conceiving. The program can do several things, going from the calculation of the two extreme centres of pressure lines within given constraints, to a proposal for the ideal geometry of an arc starting from the computed centre of pressure line. The nice thing about arcs is, that as soon as you find any feasible centre of pressure line, you can be sure that the arc will act upon it and be stable. During this exercise, students are invited to design a configuration of arcs and explore its possibilities in an intelligent manner. The program (until now only worked out for planar arches) calculates automatically the dead weight of the arc. External forces can be added in an interactive way.

### **WHY**

As with the previous exercise showing the students the possibilities for integration of drafting and calculating is the main goal of this exercise.

### **STUDENT RESULTS**

provided time within agenda: 2.5h  
average time spent: within the limit of the time schedule

*the graphostatic principle to determine the centre of pressure line and some student experiments (Toon Van Borm 1995, Greet Houben 1995)*

**CAAD and Architecture -  
Fields of Transformation**

**Adam Jakimowicz**  
Technical University Bialystok  
Poland





## CAAD and Architecture - Fields of Transformation<sup>1</sup>

Thinking of using computers in architecture, we have probably already learnt that there is much more than just one general way of doing so. At the same time, the general description of the field - i.e. the 'title' Computer Aided Architectural Design' has become a rhetorical figure - actually it covers much more activities than those just aiding design.

To some extent computers change architecture introducing new values into it. This does not mean that they change architecture at all, but these new values begin to exist parallelly to the already present and accepted ones. In such sense architecture is changed - one of the possible branches of development is the one related to computers (no matter how complex this branch itself is).

Architecture is in a constant change - and it is a cultural condition. There is some confusion nowadays when interpreting the state of architecture. Can it be suited to the general situation of the modern (post - modern) culture? Some state that can't. Peter Eisenman wrote in 1992 that during the 50 years after II world war we had faced a paradigm shift - a shift which should have influenced architecture. The paradigm changed from mechanical into electronic one. According to Eisenman architecture did not change as much as other spheres of culture, so it is not a relevant participant of the current times. From the point of view of CAAD - I think that in most cases we can agree with Eisenman's opinion. When we use computer as a drafting and data storing device, we still work in an old manner. If we look for a creative relevance of computers in architecture, we have to say that they can change architecture only when they are used in ways which are different from the use of traditional tools and media of architectural design. New way which is different, but conscious and productive. Of course it is people who constitute changes, not machines. However, the new environment inspires (can inspire) new thinking - and this perspective of computing should be opened via, for example, architectural education.

Architecture really influenced by computers can be one of the adequate ways of 'suiting' architecture into the specific of the present and future times.

But now we can try to name the changes which actually go on in the sphere of junction - where architecture meets computing and vice versa. There are some spheres where some basic, but essential changes have already happened or differences which are just characteristic comparing the old and new environments of design.

---

<sup>1</sup> The following paper is partially based on the paper 'Architekturta Nie Wsponmagana - Architektura Przetworzona', written for the conference 'CAD Space', held in Bialystok in April 1995.

## 1. Transformation of the tool.

Traditional tools - paper, pencil, table, etc. - can be described as set of autonomous, single-task devices, which gathered together, can create an environment of designer's work.

Computer - is a system of linked, fully interdependent elements, which in sum create one device (from the technical and 'material' point of view). It is one tool with a changeable profile. In a specific linkage with a user, enabling him to communicate - it is a complex unity, autonomous, multitask system, itself is an environment.

## 2. Transformation of the medium.

According to McLuhan, the medium is the message. When the medium changes, the message does as well. In architectural design, transmission is based on a direct and physical notations (records) of the subsequent stages of design. They are the direct result of the design activity. Notation is equivalent to transmission.

Notation transmitter

Author  $\Rightarrow$   $\uparrow \downarrow$   $\Rightarrow$  Notation  $\Rightarrow$  Transmission

Notation carrier

Computer, at the present stage of its development, seems to be an 'intermediate element', which transforms traditional notation, putting it into a completely different, electronic environment. This is a different kind of record - basically it is an indirect notation. Notation is not equivalent to transmission.

Processing  
(signal transformation)

Author  $\Rightarrow$  'signal'  $\Rightarrow$   $\uparrow \downarrow$   $\Rightarrow$  Notation transmitter  $\Rightarrow$  Carrier  $\Rightarrow$  Transmission

Notation

This 'indirectness' of computer is either a cultural condition (difficulty, resulting from the need to learn how to use it, which shall disappear, when computers become as normal and common devices as TV sets) or the technical one, with the inborn unavoidable characteristic of digitalisation of the input data (for the non-informatician it just means

that data which is inside the computer box is not the same as what is on the screen).

### **3. Transformation of perception, imagination and thinking.**

This point concerns mainly those who are more or less familiar with computers, because it says of the computer influences on the user. The tool always has an influence on the methodology of the work done with the use of that tool. So we can't deny the influence resulting from the use of computer - and thinking of architecture it is not only a negative and destructing influence. I am going to illustrate it with just one example - resulting from my own experiments with 3-dimensional modelling.

Peter Eisenman stated in the already mentioned text, that perception of architecture nowadays was still based on the linear perspective principles, and planimetric system of presentation, which had been discovered in XV century. This tradition is still untouched, Eisenman says, as it enables projection at all - as a way to represent 3-dimensional space on 2-dimensional plane. We can now say that computer based 3-dimensional modelling enables us to overcome this limitation (under the condition that we agree with Eisenman that it is limitation) - almost every modelling software package makes it possible to choose the way we can look at the model - we can see plane views, axonometric views, perspectives, and they all can be placed on the same screen at the same time. This is just one aspect, resulting from the objective possibilities of the software. On the other hand, on the computer screen, we can see the object in a new way, using for example undesirable, intermediate phases, views of designing - modelling - vector based views, where all lines, objects are seen at the same time, when they overlap, when the spatial orientation can be questioned, when we freely change the parameters of viewing. This can be a source of completely new perception and new visual consciousness of the designer, because he can reach new visual experience, following (not blindly, of course) the way computer displays the object. This is not fully suitable of course to the projects which are created according to the traditional methodology and traditional perception of architecture and its project, however can inspire. This is rather to search for architecture of the unexpected, new space, which cannot probably be conceived without the new medium, the computer is. The main problem here is to evaluate the achieved results.

Computer based modelling at the same time gives the enormous opportunities to easily create and analyse the structure of the architectural object - either from simulative or creative point of view.

### **4. Transformation of communication and collaboration.**

This sphere is probably the most dynamically developing sphere of computing nowadays at all, and the most revolutionary contribution of computers into the culture of contemporary civilisation. The whole sphere of computer networking changes the way we communicate - making communication easier, more accessible, but it also changes

deeply its participants. The consciousness of Cyberspace, which is present and invisible, changes the way we seen the world, as *'the cybernet, the sum of the all interactive computer-mediated systems and telematic networks in the world, is part of our sensory apparatus'* (Ascott, 1995).

There are many projects going on, which try to examine the networked designing nowadays. And it seems to be exciting to collaborate with the design teams located on the other side of the globe, working together, staying in your own room. This is also the process of the great cultural importance, as the local cultural differences can influence us more easily. From the technical point of view, computer networking, makes it possible to eliminate some intermediate stages of design process (see, for example Novitsky, B., J., 'Gehry Forges New Computer Link', Architecture, 8/92), reduce the time of the information exchange and support the decision making.

## **5. Transformation of methodologies.**

The most important thing in this sphere is the possibility to change the order, the traditional hierarchy of the design stages. Computers can help us even reverse the design process - or rather to 'play' with the stages, making the process more simultaneous, according to which aspect of the project we consider primary (at the given moment) - form, function, structure. Again - the aim is not to replace traditional design environment with computers, but creatively use it as an additional, one more design medium. In the design teams, different aspects can be developed with the use of different media - according to the designer's preferences and needs.

## **6. Transformation of architecture.**

There are two main levels of searching for the new in architecture (in the context of computing):

- new influences, new formal, structural, functional, etc. inspirations, 'proposed' by computer space, which can be realised in traditional way;
- search for a completely new carrier of architecture, resulting directly from the development of electronic media and technology;

*The media of architecture are changing i.e. new ones are introduced. New media give new kind of message, or at least new form of message - and this inevitably changes the contents.*

*New electronic media change architecture very dramatically, though unconsciously.*

*It is an unconsciousness of users, architects using computers and teachers teaching computing in schools of architecture. Unconsciousness of the new message.*

*Architecture is being changed by machines: electronic media - they change modes of thinking of their users.*

*Architecture can be changed by users by means of these machines, where individual mode of thinking uses and transforms machine's features to produce and introduce new, different values to architecture.*

*New media of architecture here is understood not rhetorically, but as the environment to construct architecture, neither to simulate nor represent it, where traditional components of architecture are replaced by clearly electronic transmissions, messages, which would shape the space in a new manner, where the only interface is electronic, but real architecture itself. (Jakimowicz, Kadysz, 1995).*

Maybe it is futurology, but surely the tools and media deeply influence the final product. Therefore new, electronic forms of architecture will appear - first as ideas, later as new kind of architecture, electronic architecture, where the space is shaped not by material means, but by electronic transmissions.

*'Architecture will continue to stand up, to deal with gravity to have 'four walls'. But these four walls no longer need to be expressive of the mechanical paradigm. Rather they could deal with the possibility of these other discourses, the other affective senses of sound, touch and of that light lying within the darkness' (Eisenman, 1992).*

## References

1. Ascott, R, 'The Architecture of Cyberception', in 'Architects in Cyberspace', AD, vol. 65, 11-12/1995.
2. Eisenman, P., 'Visions Unfolding: Architecture In The Age Of Electronic Media', Domus, 1/92.
3. Jakimowicz, A., 'Architektura Nie Wspomagana, Architektura Przetworzona', in the book, CAD Space, Technical University of Bialystok, 1994
4. Jakimowicz, A., Kadysz, A., 'Architecture Of Many Media', in the book 'Multimedia And Architectural Disciplines', Univ. Of Palermo, 1995.
5. McLuhan, M., 'Understanding Media', Routledge & Keagan Paul Ltd., London, 1964.
6. McLuhan, M., Fiore, Q., 'Medium Is The Massage', Bantam Books, London, 1967.



**C AD VANTAGE for  
Communities, Professionals  
and Students**

**Jen Kokosalakis**

Liverpool John Moores University  
United Kingdom

*I propose to consider how added value for professionals, and the consumers of their buildings and students of these processes might be attained. Through the vehicle of new technologies including the humble 'CAD' system a fuller collaboration in design decision-making is aided through representation of 3 dimensional design ideas and their comprehension from different 'vantage' points. Thus computing may enhance opportunity for more informed dialogue involving verbal and visual responses between the intentions of the architect and client and promise to open up more of the architectural design process to participation by the building consumers, bringing 'advantage' to all actors in the design process. More liberated sketching at the system is becoming evident as programmers, and users' skills adapt to the search for more enabling, creative and easier tools, procedures and interfaces freeing responsiveness to consumer wishes. Reflection from clients and practitioners brings hope that a more informed dialogue is enabled through computer supported designing. The beginnings of CAAD support to community groups acts as a facilitator. Contacting and working with community groups follows effective 'Community Development' precedents established in the Liverpool of the sixties; to contact, activate, enable and provide necessary skill supports for community-driven striving for resolution of housing problems. Results of this, ploughed back into CAD teaching for Environmental Planners, brings increased awareness and visualisation of environmental, architectural and human issues and promises to begin a new cycle of more informed participation for citizens, architects, planners and consultants.*





## **C AD vantage for Professionals, Consumers & Students**

### **Introduction**

The main focus of this paper is on the particular advantage which CAAD may bring for effective informed, involvement of the consumer in design decision-making with the architect. The use of the term consumer is used to highlight the fact that architects design a product for people to own, use and observe. The term is also used to infer a right of choice in the design and accountability of the designer. Earlier papers define and discuss participation more fully. (Kokosalakis, 1996a & b). The author has held a professional interest in participation since the sixties as a town planner working with architect/planners. A process of documenting the role of *CAAD* as a vehicle to assist informed involvement of the client in the building design, began in the context of documentation for courseware, as an appointed Teaching Fellow. This paper describes continuing investigation to extend suitable case studies for further documentation. Many of the case studies follow up practices known, studied and informally monitored for periods of up to 25 years. Others constitute new contacts. The cases explore client perspectives on their dialogue with the designer regarding ability to elucidate their own wishes and to comprehend the designers' ideas. They also focus on the architect's perspective of the dialogue. Action research and participant observation are being considered to promote procedures and programs advisedly and explore their potential to serve effective participation. Advantages through computing enhancements (**C AD vantage**) can be gained for the professional architect in freeing design potential. Architects present variety in methods for CAAD-based dialogue to achieve consumer satisfaction. The more this dialogue is based in intent to illustrate ideas early in the design process, continuing informed involvement and input through to the finished design, the less likely failure to meet the clients' intentions will become, bringing added value to them. Educational activity is enriched through case studies, particularly where consumers viewpoints can be appreciated. Ultimately **C AD** may **AD vantage** all concerned.

### **Professional liberation to design more freely with improved computing**

A continuum of approaches to computer facilitation of consumer/designer dialogue

Computing enhancements are gradually freeing up opportunity for increased flexibility to respond to consumer demands within the architect's CAADesign. A continuum of consumer-serving approaches may be considered. Improved & consumer-operated visualisation opportunities (such as QuickTime movies and Virtual Reality worlds, extend potential architect/consumer dialogue. This technological end of the continuum involves greater time in preparation of the material, but

facilitates distant negotiations. Next on the technological scale, hidden line and colour printed visualisations are helpful to the client, particularly when the architect is able to sketch new consumers' suggestions over them. Simply, cheaper on hard copy costs, but taking time in the consumer dialogue, is the approach of seating the client at the system to view, comment, request changes and see them implemented for further consideration. This end of the continuum tends to be time-saving in preparation and clarity of what is agreed, but time-consuming during the meeting. The more traditional approach of CAD based 2D plans and elevations are cheaper, in the short term, but may bring the costs of failure (to explain successfully to the consumer what is intended, thus bringing costs at the extreme of demolition e.g. Southgate, Runcorn (Morton, 1994) and Netherley, Liverpool (Kokosalakis, 1996a &b)).

### Software facilitation

The limitations of CAD systems to facilitate modelling of complex 3D forms has been lamented in CAAD literature for perhaps 2 decades. It appears now that acceptance amongst researchers and programmers, has brought a new determination to positively seek to resolve these limitations through enhancing computer support. Relatively simple processes are being enhanced and more complex processes are being simplified, e.g. Triforma developed by the Bentley programmers, Visual GDL from the GraphiSoft stable, etc., potentially announce this tendency to bring greater ease and flexibility. For the consumer this trend suggests the future may also enable the architect to be more responsive therefore, to client design requests which might otherwise have met a technical difficulty from the CAAD aspect. Thus more liberated sketching at the system is becoming evident as programmers, and users' skills adapt to the search for more enabling, creative and easier tools, procedures and interfaces in preference to slavish use of limiting software.

#### Software user skilling

As CAAD users become more informed about the full potential and background programming of even the CAAD systems they use at present, this has a tendency to be less constrained and more innovative. This in turn can reduce anxieties in their response to demanding clients, assisting participation to flourish. A paper in preparation deals with a change of policy regarding CAAD education at LJMU. One aspect of this, was to introduce new parametric library object creation and manipulation through simple Geometric Description Language programming commands within version 4.12 of ArchiCAD. This appeared to establish a better conception of the nature and potential of the system and freed up a range of design opportunities not otherwise possible through the normal plan-generation of 3D objects. The development of 3D forms by this group became far more ambitious, creative and dynamic.

#### Sketching with clients

Two recent observations relate particularly to freehand **sketching** as a medium for participation of clients: One emerged from a video-documented interview by Jon Moorhouse (1996) of architect Richard

Dudzieki demonstrating how he combines fish eye views of 3D interiors initiated in AutoCAD with a digitising pad to sketch in modifications and colour during dialogue with clients about the design. The other was referred to in a video conference organised by the CTI Cardif. A new **virtual whiteboard program**<sup>1</sup> - distant parties are able to interact and draw on the board. Video conference computer interfaces and cameras to physical whiteboards were also presented. Again, (though presently expensive), these devices enable increased and more effective intervention by the consumer during design development.

## Initial Case Studies

Considering the potential and actual role of CAAD as a vehicle for participation of the consumer in the design decision-making process, I have interviewed various practitioners and clients. Some constitute new case studies, some revisit cases to reflect on the role played by computing for consumer participation, others continuing monitoring of client/CAAD experience.

Case 1. Nick Spalton - Client for the Aldham Robarts Learning Resource Centre - JMU

The architects, Austin - Smith:Lord were major Intergraph users. I had provided ArchiCAD support to Nick Spalton to assist his participation in this project. An earlier co-authored paper (Kokosalakis, Farrow and Spalton, 1993) had related the CAAD processes involved to some extent, but had not really weighed the value of the contribution of CAAD from the consumer's perspective. This paper presents Nick Spalton's reflection on this issue retrospectively. Both Nick and I are users of the building now - he as an information management professional and I as a user of the resources housed there. The whole of his account of his participation in the design, is italicised and in quotes, with my comments in parenthesis.

*"How CAAD facilitated the design*

*The original design for the building was presented to us by the architects on 1:50 scale plans". (The architects mainly presented plotted working drawings from their Intergraph system. They also had some pc based MicroStation systems). "My (Nick Spalton) task was to see what were the possible internal arrangements which we could adopt and which of these led to the greatest ease of use.*

*Despite some familiarity with plans of this kind and also with an architects' scale rule, it was difficult to envisage what it would be like to 'walk' around the building either in the guise of a user of the building, or as a service provider". (Some visualisations of the exterior and context had been made available).*

---

<sup>1</sup> The whiteboard software is named EMBONE and uses Internet Protocol. See Jeff Constable and

Dr. Mark Retcliffe of Aberystwyth, on the NEAT project (Network Expertise Advice & Tuition)

within JTAP subcommittee of Joint Information Services Committee.

*"What flexibility was there, in terms of the arrangement of the shelving bays? Could they be aligned on a N-S axis as well as an E-W axis? What was the spacing between tiers of shelving? Was this the same for all shelving bays throughout the building? How did this spacing compare with national standards? Could the shelving bays be arranged in such a way as to minimise noise? Was there enough space for the material we had to store? What was the lighting going to be like? How would the lighting of the building be affected by different arrangements? How would people move through the building? Where could queues be expected? Where would streams of traffic cut across each other? Could anything be done about this? These were the sort of questions we asked ourselves.*

*The original response to these questions was to cut out the objects we wanted to place in the building, using graph paper, scissors and glue".*

(Here, Nick was taking photocopies of the rather traditional CAD working drawings the architects had drawn and plotted. Whilst the CAD was accurate, the cut outs were incrementally enlarged by the copier).

*"This worked fine for a while, but it was slow and not particularly accurate when working with small objects. The errors involved and the tedium of working through the number of different arrangements eventually led us to the use of CAD".*

(For ease of comprehension and use by Nick, I translated the proposed building data for each floor to ArchiCAD. Thereafter, we sat in front of the screen and Nick described what he wanted and I drove the system in response).

*"We were then able to fairly speedily work out a number of 'ideal' solutions to the internal arrangement of the building and report our findings back to the architects and the other participants on the design team." (User Group)*

*"A number of problems arose at this stage. The internal arrangement adopted by the architects we discovered were guided by the combined lighting/ceiling units. The placement of these was in turn guided by the modular grid of the building. Yes we could move the shelving bays to an 'ideal' arrangement but if we did so they would be out of phase with the light fittings. They would also clash with pillars. The only possible way of arranging the shelving bays was that which had been initially proposed by the architects.*

*Despite the attempts of the architects to involve the clients in the design of the building the project was at too advanced a stage to contemplate any changes. It wasn't that it was impossible, it was just that we would be changing the design brief. That would cost money. There wasn't any money.*

*We accepted the design as provided by the architects whilst making some changes by having some shelving bays here and not there. We rotated some through ninety degrees to help baffle noise. We tried to ensure that there were clear lines of sight from the staff areas in the centre of each floor to facilitate supervision. And we looked at the ways the material could be arranged e.g. by subject, by form, by shelf number and by*

*academic discipline, but basically the internal design was as given to us by the architects".*

*Discussion*

As a key consumer, (the site librarian), found ArchiCAD helpful to visualise, explore, test, clarify and communicate his requirements. **He regrets that this input was not elicited at the early conceptual stage, when it would have been possible for incorporation of his ideas and professional advice.** The significant differences in the early and later stages were that later:

- a) the CAAD model was in front of him and accessible to him,
- b) he could direct what plan or 3D data he would view
- c) he could explore alternatives of his choosing (with my help)
- d) direct metric data entry rather than scaling complications was easier and
- e) immediate reassurance of accuracy and access to associative dimensioning was helpful.

It should be said that this was the first time the job architect had engaged in the CAD system himself rather than leaving CAD draughtsmen to enter the data. He and the LJMU consultant architect acting for the User Group found tremendous advantages in this, particularly the ease of modification of the 2D CAD drawings after each meeting, where changes were considered for acceptance and modification, even though the fundamental changes which Nick felt were relevant were not possible as he says without major additional funding. One exception was that his stock allocations to his alternative shelf planning CAAD options, did establish the need for more floor space, which was met not by modification of the new building design, but by an extension through to an adjacent existing building to be renovated.

Case 2. Tony Barrett - as client - Barclaycard

Tony Barrett echoes the librarian's mourning of missed opportunities, in a report (Stockdyk, 1996). PERA, Engineering Consultants had created an Interactive Virtual Reality model from architects' Fitzroy/Robinson's AutoCAD model. Barclaycard were able to view and respond. One change was made to the colour scheme, but Tony Barrett for Barclaycard bemoans the fact that it would have been more useful six months earlier.

Case 3. Chris Pritchard - architect at Austin - Smith:Lord, Warrington, Merseyside

An interview recently conducted by Jon Moorhouse<sup>1</sup> with Chris Pritchard also of Austin - Smith:Lord, indicated his particular concern to capitalise on CAAD in dialogues with the client, for their extension of MOMI, Bradford. He had concentrated on maximum economy in cost/benefit of effort/design production, including rapid production of renders,

---

<sup>1</sup> CAAD research student at Liverpool John Moores University, School of the Built Environment.

innovative use of MicroStation and completion of 14 options on CD for the client. Chris Pritchard named his activity with the clients "*Optioneering*".

#### Case 4. North British Housing Association - architects, Manchester

In earlier studies (Kokosalakis, Moorhouse, 1995a & Kokosalakis & Moorhouse, 1995b) of these architects, on reflection, they had perceived themselves as designing at the CAAD system. This was seen to be generally the case though it did vary between members of the team, from "almost totally", to "never". They already proclaimed the benefits of 3D CAAD in negotiating with lay people such as planners and with organisations responsible for setting housing standards.

In a more recent interview, I established that they consider that they have extended this in a number of ways. They mainly, (but not exclusively), design dwellings and residential layouts for branches of North British Housing Association throughout the country. Clients include smaller, unassociated housing associations. Design work does extend beyond housing.

NBHA are very interested in participation as involvement by relevant parties in the building design decisions. This may include some people, for whom training and experience may have covered issues about urban design, building structures, maintenance and even architecture, (for example, housing managers, housing association project development officers, planning control officers and elected local authority planning committee members). However more usually, the professionals, councillors, owners and potential clients, etc. with whom they negotiate have been *almost exclusively*, neither architects, designers and often not even particularly computer literate people.

They have found clients really start to understand the design and issues relating to it when they, the architects present CAAD output to them. Their clients seem "*to really appreciate more realistic details being added such as brick lintels*". They have moved from preference for hand rendered hidden line perspectives, to rendered images, in their more recent brochures. Generally they have extended their efforts to use ArchiCAD and associated Artlantis rendering and QuickTime Virtual Reality technology to illustrate the designs more realistically to their clients.

Several stages of consultation occurred with a recent sheltered housing scheme and chapel for ageing, infirm brothers of a Silesian Monastic Order. The Board of Trustees Steering Committee were invited into the architects' office to explore a few QTVR movies (previously output from ArchiCAD), viewed on a 19" monitor. The committee included members of the management hierarchy, two external professionals and some elderly Silesian brothers, who would be future residents of the sheltered dwellings. (Clients are actually able to explore QTVR independently with the cursor).

Gordon Snape told me that the clients "*got to really understand the building and were able to grasp security and access issues better*". The

event seemed to trigger requests for yet more movies, as a basis for decisions, *"including the interior of an individual flat"*.

Another case study involved the Monsall Infill Site Scheme, Manchester, where NBHA worked on designs for the clear sites amongst the main Local Authority refurbishment. In a QuickTime movie I had developed from an interview with John Rhodes, it was already clear that virtually all his work consists of Computer Aided Architectural Designing. He had explained how he valued the opportunity to use hard copy of hidden line views from the system to improve informed discussion about the design with non architects.

He now explained to me that he has extended this activity in his residential site layouts based on 3D animations and QuickTimeVirtualReality output from ArchiCAD and further enhanced textured rendering through Artlantis. He finds the use of CAAD *"infinitely better"* than the traditional methods, particularly for the client. He referred to a case where CAAD figured in debate regarding concerns about the proposed development potentially causing overshadowing problems for the occupant of a neighbouring council house dwelling. In this particular case the ArchiCAD models' sunlight study facility showed there was no problem and the participant did not need to seek change of the design as a response.

In a new NBHA development, Gordon Snape is about to embark on a roadshow, using a overhead LCD panel interfaced to a PowerBook, loaded up with a PowerPoint presentation, which incorporates video clips from QTVR 360 degree movies of ArchiCAD models for 4 of their standard dwelling types.

The presentations are to new local area housing association directors, who will utilise his office's architectural service. Whilst this appears to be mainly a self marketing exercise to non architectural colleagues, their housing experience coupled with 3D visual exploration will provide them with a real reference point for their own informed participation in debate on the designs. The next stage will involve Gordon distributing movies (for consideration) to the computer DeskTops of these distant directors, via networking from his Manchester office.

NBHA (not unusually), rely for much of their work on competition entries. Gordon is disappointed that there is still insistence on paper entries. They do submit computer generated output, but he would be delighted to have the opportunity to use the advantage of directly viewed computer entries. This would also give them a tremendous lead over their competitors, since they became so expert.

#### *In conclusion*

Whilst much of this activity could be defined as resembling marketing, or persuasion, and is only starting to enter a fully participatory arena, nevertheless, by opening up access to CAAD for the client/consumer, empowerment begins to move more towards their grasp, even in simple terms of being able to point to something specific in the visualisation, and question, raise objections, or request an alternative which springs to

their own mind. This is particularly so in QuickTime Virtual Reality movies, where the consumer has greater control to actually explore and position the viewpoint, (even though at present constrained by the range set up initially by the architect).

Case 5. Ainsley Gommon Wood - architects, Birkenhead branch, Merseyside

Peter Gommon (of Ainsley Gommon Wood practice) is a firm believer in client participation in design. He is a member of the RIBA Community Action Group. The practice have used MicroStation for pcs for some years. 3D CAAD paper-based output is normally used for communicating with clients. Steve Vant, their CAAD technician rates CAAD highly for its "ease of production, visualisation, novelty and clarity". The partners are pleased to have now embarked on a new initiative to bring the client to the computer. Steve initiated such a meeting recently with clients of their Market Wells Foyer project. (*See Fig. 1*). This building will accommodate the "homeless". To a group of the clients, he flicked through a few 3D views for them, (his quiet understatement of his own effort). I sensed a tinge of disappointment in that he said it had to be rather rushed between other activities in a rather heavy present schedule. He recalled that the clients mainly talked amongst themselves about what they were observing. However, the main point is that this is now an established technique for participation, whereby, given sufficient time, the clients' views can be coaxed out of them.

Case 6. Dave King - architect, Liverpool

In contrast to NBHA's move to more time spent on high quality visualisations, Liverpool 'paperless' architect, Dave King, related to me recently that he much prefers to work with clients directly at the Mac, rather than spending time on rendered images or CAAD drawings on paper. He finds that it transforms the facility for client comprehension and architect's response.

He referred to a house design (noting that the residential client is probably the most informed in terms of potentially having the best understanding of what is wanted from the design). This suggests a tendency to accept that most clients are fairly well informed of their expectations from the design, which is rather borne out by his particular interest in responsiveness of his work to the client. He described his preferred approach to client participation. Seated in front of the CAAD system (MiniCAD with StrataVision in Dave's case), the client is in a much better position to articulate their desires, whether in reacting to a range of pre rendered and hidden line views, which Dave will always have ready in a folder to consider with them, or (as he prefers), by working through and around the MiniCAD model. Since he always holds backup copies on the optical drive, he has no anxieties about making requested modifications to explore instant investigations of the impact of client suggestions through the model. He does have some concerns about the time that visualisations take in MiniCAD. He also fears that animations and rendering may be too seductive.



### *Discussion*

This account confirms the impressions from Nick Spalton and Tony Barrett that access to the actual CAAD system at an early stage of the design might bring greater potential for consumer interventionary dialogue and responsive design modification by the architect.

Regarding Dave King's sense that animations and rendering can become too seductive, there is an argument for suggesting that (whether consciously or not), the architect will probably intend animations and rendering to act as devices to persuade the client rather than to offer them full rights to modification, or rejection. Clearly changes to designs involve more work and are therefore costly, often prohibitively so. The more time, cost, effort, ownership and emotion is invested in a design, the more likelihood there is that the architect will be reluctant to make changes to it.

It is heartening to find increasing use of CAAD serving consumer involvement in design decision making, particularly in NorthWest England, where CAAD was slow to be implemented initially, possibly due to the general poverty of the region, which has now been recognised through Objective One status in the European Community.

## **Community CAAD**

In response to requests for academic support from a local community, Dr. Rob MacDonald, Reader at the JMU Centre for Architecture in the School of the Built Environment, recently embarked on a new initiative.

Later, I was invited to introduce the committee to the potential of CAAD as a vehicle for their negotiation of urban design, environmental design, housing refurbishment and new architectural design of facilities.

Both Dr. Rob MacDonald and I had observed and been in contact with various community groups in Liverpool in the previous decades. (Kokosalakis, 1996a & 1996b), he more directly than I. Issues of the ideas or approaches to community development accepted as important in this project have been referred to by Bailey (1975) as follows: *"It is the work of community development . . . to ensure that all concerned are properly represented, taken account of when decisions are made and that they compete on equal terms. . . . methods used must produce changes in people"* . . . (including officials) *"which will lead to increased discussion, understanding, co-operation and experimentation "* . . . (including) . . . *"to produce situations, in which there is a possibility that feelings can be changed . . . Local groups are formed over particular issues. What is being asked by the community is a share in the decision-making process,, . . development of people, self-awareness, (including) . . . the process of change in one's self "*. . .(as community worker) *"modification of attitude, self examination"* . . . to contain *"the ideas of 'process', 'emergence' and 'change'"*.

The community worker should never be seen to represent, only to enable representation.

With this in mind, I embarked on enablement in matters of design by assisting the community to utilise CAAD modelling as a vehicle to communicate their ideas of what is needed on the estate. It was seen as essential to establish community control from the start. Following best learning principles I started with familiar data, i.e. their dwellings, rather than considering potential new developments. Accurate architects working drawings were not found. They were assumed lost during the transfer from New Town status. The community gathered alternative, archived photographic, written and sketched material on the house plans, etc..

I supervised a voluntary CAAD placement student, giving him the estate house models as training focus. Steve Cawood proved to be an exceptionally useful student. There proved to be considerable discrepancies in the archive data, as much of the estate plan material was in public exhibition format and out of scale. Data was not available for window and door positions. The residents responded by sending us dimensioned drawings from their own surveys.

A meeting was arranged with the Residents Association committee to use the trial house models for initial explanation and training introductions to CAAD usage. Armed with the PowerBook, we embarked on our first session. We met at the acting Chair lady's house. (*See Fig.2.*). The first item on the Agenda was the CAAD introductory session. I explained concepts of data entry, dimensions, coordinates, scale, and library objects within the context of the part complete 3D estate model. This included explanation of use of menus and palette tools. I changed role from driver to instructor early in this process to bring the residents into active participant learning mode. After orientation by reference to the scanned estate plan and the generation of 3D projections of a few house models and a sample model of an existing terrace, they soon explained slight differences in house types, which could explain discrepancies between the various estate plans to some extent. Each member then proceeded to try out a few commands and moves. Non and computer literate members all made slight changes to the models. Almost instantly the visualisations at the screen prompted design issues.

#### Problem 1

The main issue focused on the space created for access. The continuity of the front half of the terraced row of each house type is interrupted by the ground access area for each dwelling. The design of these building types cuts a paved area into one half of the terrace width, cutting out the front pitch right back to the ridge.

(*See Fig. 3, 4, 7 & 8*).

Adjoining neighbours share this space roughly in the proportion of 4:1, although there is no physical indication of the line of demarcation on the ground or the back wall. (*Indicated by dotted line on Fig. 3*). The front door of each dwelling is positioned in the extreme left corner on the left wall and the neighbour's bin cupboard door is located (ironically) more

visibly on the extreme right corner, but on the facing back wall. (See Fig.4).

Residents consider this to be:

- i wasted space
- ii insecure, dark, dangerously open to attackers and thieves
- iii indefensible, space and
- iv lacking clear visual or physical definition or deterrent, despite clarity of legal ownership.

#### Problem 2

A number of residents pointed out that structural problems are occurring at the upper joints of the ridge and the perpendicular walls

#### *Learning and Action*

The residents began to enter new walls to enclose these spaces on the CAAD model. This one discrete, design move, accurately positioned with the aid of the intelligent cursor, evidences the catalytic role which accessing CAAD might bring. They immediately projected the idea of two alternative solutions: first to completely build up the space by two floors of wall (*Please note the inserted walls in Fig. 5*), and roof and second to only introduce a ground floor structure over this existing paved area and build a terrace over the top. They experimented with introducing table and chairs and people on the terrace to consider the ergonomics of the space available.

The members were extremely well informed about their estate, housing, contacts, officials, and elected members. They had identified failures of structures and design on the estate and gave us a site tour and house tour to illustrate this. Regarding uncertainty on inaccuracy of the supplied data for the house models, they volunteered immediately to point out the various house types on site and photograph and measure controversial dimensions.

#### Problem 3

emerged during the site tour, when the committee members were endeavouring to obtain information about the bungalow dimensions for the CAAD modelling. The bungalows had been located in a manner which totally enclosed a small yard to each. The middle bungalow in each group had no access from the yard for bins and garden rubbish, except through their carpeted hall. This meant that council workmen refused to help them, despite their infirmities. (See Fig. 6).

#### Problem 4

These bungalows had deteriorating felt roofs, yet the dimensioned 3D models soon pointed up to the members visually that the roof slopes were considerable and probably suitable for tiling. this was confirmed when they discovered an archived photograph, showing one of the bungalows with a tiled roof in place.

Shortly afterwards they unearthed elevational drawings from a window replacement scheme. The accuracy of the dwelling models was improved. Committee members came into LJMU to see how the next stage of defining attributes of materials and rendering was achieved and to check the success of the visualisations. They arrived armed with photographs to match-check colouring of walls. Their comprehension of the process and its potential was rapid. Conversation moved to animations and the question of key frames and in between frames. A quick reference to well known morphed images in TV adverts was sufficient to begin to describe the inbetween frames as morphed stages and they were ahead, or in Liverpoolian, star learners!

The house type models were saved as library objects and positioned on a scanned site map. During this time the committee were busy extending the network of activity, interest and commitment. Although many are now owner occupiers, they assist the development of a Tenants Management Organisation with a Section 16 grant and they attend training courses in Community Development, committee organisation, etc. from CDS Housing Association's trainers. Though, they rightly proclaim that recognition of their skills, awareness of the need for democratic community action and decisions, and how to achieve this, have been acknowledged. In the most recent visit the flourishing of these skills was evidenced in an exhibition they mounted for fellow residents. I attended to start a wider process of involvement eventually of the whole community, starting with familiarisation with CAAD through verification of the discussion of the problems to be resolved.

### **Ploughing back material for Student learning**

In preparation of the 1997 material for CAAD modules for two groups of Environmental Planning students, I decided to include the new house library objects as potential alternative dwelling types. Since they included bungalows and two and three storey flats and houses they presented a real choice for the students. (*See Fig. 6, 7, & 8*). (I had previously used CAAD models of another estate to teach residential estate layouts and the CAAD for this task). The project site was a difficult one, slotted in between mostly 4 and 5 storey buildings and overlooked by the Catholic cathedral. The intention was to illustrate through practice to (non architect) planners, the potential of CAAD to assist their visualisation of and assessment of suitability of alternative mixes of house types regarding scale, space, mass, height, rhythm, etc. in relation to the surrounding urban forms. Their enthusiasm, 3D visualisations and critiques of these in reports showed achievement of the objectives. They have subsequently found that this course has assisted them with the urban design course. Some of them actually requested to use CAAD for a later Urban Design project. The Residents Association have volunteered to come in and discuss design issues with them from their perspective.

### **Conclusions**

Added value appears to accrue to consumers in providing a device (through CAAD), to enhance their comprehension of the design ideas and details being proposed to them by the architect. The more realistic the image the more potential for the consumer to be able to articulate their own ideas and preferences for the design with reference to the aspect of the CAAD model in view. Economy of effort and potential for satisfaction may be best served by simplicity of positioning the startpoint of the role of the CAAD model in participatory dialogue early in the design sequence. Though it can be argued that more investment in time and kit may enable much more effective client comprehension through use of attributes of materials, textures, lighting, and walkthrough effects, including QTVR. The latter approach (and any consumer-controlled viewing) brings the added value of time for reflection and possibly consultation by the client with colleagues or family members or neighbours.

Added value for the CAAD proficient architect/designer may include improved ease of: use, generation of options, modification, dialogue with the client, satisfying the client, negotiating with officials such as planners, input and output of other professional data, self appraisal of the design and in some cases development of design ideas. Much of this has not been covered in this paper, as the intention was to focus on the added value of CAAD to assist the architect in serving his client.

Added value is certainly offered by CAAD to the student, particularly to those who find 3D visualisation difficult in their mind. In terms of the exercise referred to, the added bonus was the residents' articulation of their estate design problems through reference to the CAAD model and transference of understanding of those issues to the students.

For the residents it is evident that CAAD immediately enabled them to refer to potential design solutions they had in mind and to start to introduce these in the model for exploration.

Added value from CAAD as a vehicle serving participation of consumers of architectural and urban design, appears to have varying degrees of possibility. Ultimately, success in participation depends on comprehension, two directional communication, responsiveness, intention, commitment and even accountability, to name a few difficult issues. If CAAD helps with any of these, it will bring **advantages** to all concerned. I therefore entitle this paper - '**C AD vantage for Professionals, Consumers & Students.**'

## References

**Bailey, S.H.** (1975) *Community development as a process of emergence* in **Lees, R. and Smith, G.** eds. *Action-research in community development* Routledge & Keagan Paul, Ltd, London, reprinted by Unwin the Gresham Press, 1977, Old Woking, Surrey ISBN 0 700 8310 6

**Kokosalakis, J., Farrow, J. and Spalton, N.** (1993) *The introduction of 2D and 3D CAD into the Library & Information Studies curriculum*, in

Smeltzer, G. (ed.) *ECAADE '93 Conference proceedings*, Eindhoven, Calibre Institute, Eindhoven Technical University.

**Kokosalakis, J, Moorhouse, J.** (1995a) *Student Centred Learning in CAD: researching and courseware responding to changing usage* in Hernandez, S. and Brebbia, C.A. (ed.) *Visualization and Intelligent Design in Engineering and Architecture II* Computational Mechanics Publications, Southampton Boston. ISBN1-85312319-6

**Kokosalakis, J. and Moorhouse, J.** (1995b) *A documentation methodology for multimedia recording of architects computer aided architectural designing* in Colajanni, B & Pellitteri, G, (ed.) *Multimedia and Architectural Disciplines*, eCAADe'95, Dipartimento di Progetto e Costruzione Edilizia, Universita di Palermo, ISBN0952368714

**Kokosalakis, J.**, (1996a) *The Computer Aided Architectural Composition 3D model as the focus, seat or vehicle for effective participation with the design's client, observer or user* in Asanowicz, Dr. A. & Jakimowicz, A. (1996), *Approaches to Computer Aided Architectural Composition*, Faculty of Architecture, Technical University of Bialystok, Poland, May

**Kokosalakis, J.** (1996b) *The role and status of computing and participation of design clients in the curriculum*, in Education for Practice, eCAADe '96 Conference, School of Architecture . Lund University, Lund, Sweden, Sept.

**Moorhouse, J.** (1996) *Teach a man to catch a fish* in Education for Practice, eCAADe '96 Conference, School of Architecture . Lund University, Lund, Sweden, Sept.

**Morton, J.**, (1994) *From Southgate to Hallwood Park - 25 years in the life of a Runcorn Community*, Merseyside Improved Houses, Liverpool

**Stockdyk, J.**, (1996) *Simulation saves floor in reality*, RIBA Connect, November p4

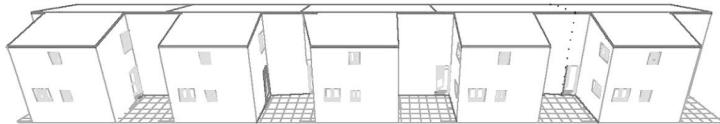
*C AD VANTAGE for Professionals Consumers and Students*



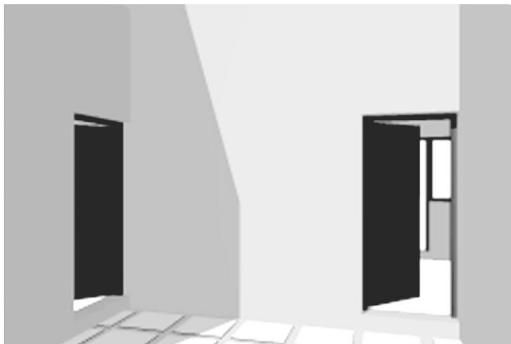
*Fig.1 Market Wells Foyer project : Ainsley Gommon Wood, Birkenhead*



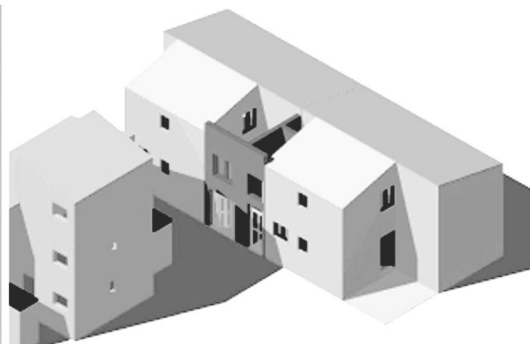
*Fig.2 LJM team @ NCFRA acting chair lady's house— visualisations prompted design issues.*



*Fig.3 Continuity of front half of terrace is interrupted by ground access paved area cutting back to centre ridge point*



*Fig. 4 Left houses' front door in left corner.  
Neighbours'bin cupboard door in right corner.*



*Fig. 5 Residents' ideas' to build up the paved space,  
showing their first 2 walls entered in ArchiCAD*

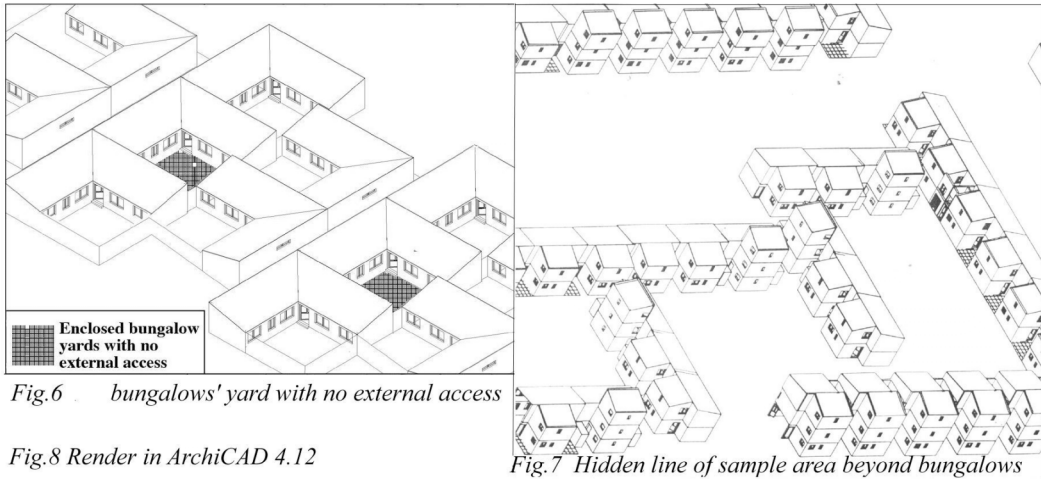


Fig.8 Render in ArchiCAD 4.12





## Testing the Benefits of Animation

**Kevin McCartney**  
**Andrew Jacobs**  
University of Portsmouth  
United Kingdom

*This paper presents the results of an attempt to empirically test the hypothesis that expanding the range of graphic formats used in architectural communication can lead to an increase in effectiveness. To be specific, the comprehension of users was tested to measure the effectiveness of computer generated animation in comparison with still images. The dynamic functioning of a natural ventilation system was explained to two matched groups of building users. The explanation was presented in an animated video to one group and in still images to the other group. Immediately after viewing the group which viewed the animated version demonstrated a superior comprehension in a multiple-choice questionnaire test.*



# Testing the Benefits of Animation in Architectural Communication

## Introduction

Whilst much of what is done under the title of CAAD is simply an amplification of the draughtsman's function, one of the truly innovative functions which CAAD brings to architects is the ability to create animation. This might be compared to the quantum change which takes place when a designer shifts from plan and section, to perspective and/or axonometric representation. Eastman (1970) presented results from experiments which demonstrated that architects working with three-dimensional drawings were able solve functional problems in room layouts which were not even perceived by architects working in two dimensions. A similar enhancement of ability can be hypothesised for architects who work in four dimensions in comparison with their colleagues restricted to three dimensions.

However, little evidence exists to support such a contention. Indeed there is anecdotal evidence to the contrary. The availability of technology which makes it possible for every designer to indulge in the kind of fantasy which many associate with the medium of the moving image, appears frequently to result in the indiscriminate adoption of animation as a gimmick to demonstrate technological capability rather than as evidence of the effective communicator's skill of selectivity.

The animation used in this experiment was created in Superscape VRT, a virtual reality creation package. Devlin and Rosenberg (1996) have warned that "Attempts to use VR ... have been ... problematic. In the specific domain of the construction industry the main problem is that the virtual world presents users with too much information. This makes it too difficult to abstract all, and only the information relevant to the task in hand". It is therefore not certain that new media will always prove superior to existing solutions. They must be used selectively.

The resources available to the communicator (transmitter), the particular needs of the audience (receivers) and the nature of the material to be communicated (message) must all be considered. This experiment is made possible by the increased resource available to the architectural profession in their role as communicators. An audience of architectural students has been selected in order to ensure a basic level of interest in the message and an inherent ability to comprehend it. Finally it was decided to test the new medium with a message which previous experience led us to expect would benefit from the use of a time-based medium.

## Appropriate formats for specific content

The use of more elaborate graphic representations, such as iconic formats representing the appearance of the built environment, has been recommended by McCartney (1985) in situations where the message is

complex in terms of its sensitivity to design characteristics, particularly formal variables. Iconic formats were also recommended when the audience was not completely familiar with the message and required assistance in relating the new information to previous knowledge. McCartney and Rhodes (1991) presented the argument that the difficulties faced in attempting to comprehend environmental phenomena is often due to the mismatch between the essentially dynamic nature of most environmental phenomena and the static techniques architects adopt to present them. Their comparative experiments indicated the possibility of using task based measurements to discriminate between the effectiveness of 2-D animation and still-frame based presentations in assisting designers to predict wind movements through urban environments.

Few built environment phenomena are more essentially dynamic than air movement. The students who participated in this experiment had recently moved into a new building which featured five prominent towers which were an integral constituent of the building's natural ventilation system exploiting the convective circulation which occurs in stacks. The nature of air circulation through the studios and towers, and the techniques of controlling the flow, constituted the referent content, or *message* which was represented in both static and animated formats.

## **Experiment Design**

A class of 79 first year architectural students were divided into two groups. Each group received a presentations explaining the design strategies for natural ventilation for the building they occupied in one of two alternative presentation formats. One group were shown a video created from a virtual reality 3-D model of a building using animated analogue elements with a tracking viewpoint. The second group were given a presentation of equal length using 13 key frame images selected from the animation. (Examples of the still-frame presentation are shown in figures 2 and 3). The duration of each presentation was equal (4 minutes), and there was no verbal commentary. A comprehension test applied to both groups was intended to test the effectiveness of the specific function of animation in communicating the ventilation strategy.

## **Test**

Unlike Eastman's experiments, the effect of the means of representation on problem-solving capability has not been tested. Instead, the more fundamental condition of comprehending the nature of the built environment phenomena which are represented was the subject of test which comprised eight questions. Multiple-choice questions were used to facilitate consistency in marking the responses.

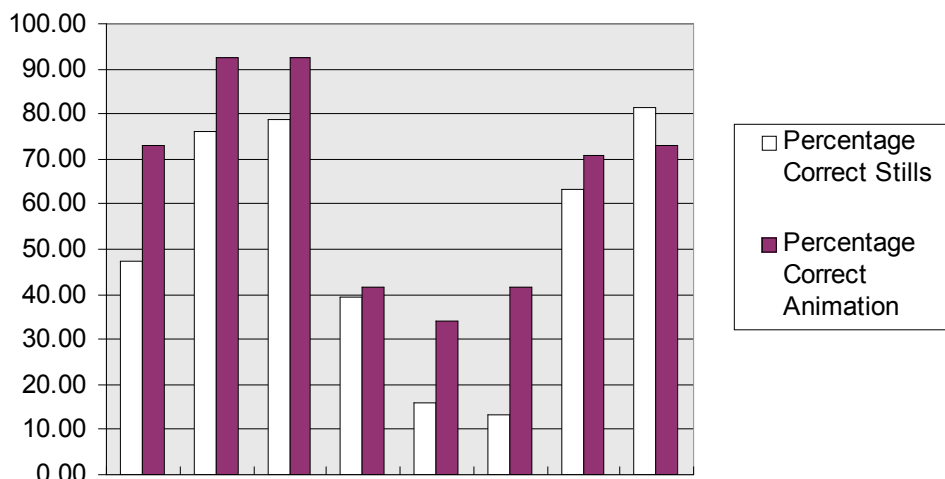
The questions were intended to test comprehension of the presentation, rather than prior knowledge. The questions are therefore highly specific, referring to information which was conveyed in the presentations. They deal with different aspects of the ventilation system which is illustrated, including questions of quantity, recognition of actions and components, identification of component position, and direction of movement.

1. *What action does the automatic building management system take to induce natural ventilation within the studio spaces?*
2. *What action can the building users take to initiate natural ventilation within the studio spaces?*
3. *Where are the inlet grilles to the ducts in the studio located?*
4. *How many smoke dampers are positioned in the duct between the studio space and the stairwell?*
5. *Within the duct, how many times does the air flow change direction, before it reaches the stairwell?*
6. *In what direction is the airflow moving when it leaves the duct and enters the stairwell?*
7. *In case of fire, how would the automatic building management system prevent contaminated air passing from the studio spaces into the stairwell?*
8. *If the building overheats, how can the automatic building management system increase the rate of air flow after the windows have been fully opened?*

*Table 1 Questions used in the Comprehension Test.*

## Results

In seven out of eight questions used in the test, the group which had watched the animated presentation achieved higher scores than the group shown the static, key-frame presentation (fig. 1). Averaged over all eight questions the difference between the scores of each group was 13



percentage points. Statistical analysis using the Kolmogorov Smirnov test, showed that the difference in performance of the two groups was significant at a level of  $\alpha = 0.05$ .

Question (8) concerned the operation of two large fans at the top of the tower. It is perhaps surprising that this was the one question in which the group who received the static key-frame presentation recorded a better score. As the fan blades were shown rotating in the animation, it might have been assumed that this additional graphic cue would have drawn additional attention to them. However the difference recorded is small (81% cf 73%).

In questions (1) and (6), the differences in percentage scores were 26 and 28 respectively. Question (1) is similar to (8) in that it requires the identification of a moving component. Question (6) on the other hand concerns the identification of the direction of air movement.

The three questions which both groups found most difficult to answer correctly are (4), (5) and (6). Both groups achieved an almost equal score of about 40% for (4) which was quantitative, in that it required subjects to recall the number of smoke vents in the ductwork. (These elements had been represented as moving in the animated version, and had broken arrows to indicate movement in the still frame presentation). In both (5) and (6) the group which had watched the animated presentation scored more than twice as many correct answers than the group who had watched the still frame presentation. These questions both required respondents to recall, or infer, directional information.

### **Comment on experiment design**

It is a well known problem in experiments with alternative graphic formats that it is difficult to establish conclusively that two alternative formats are equivalent. They might differ in either their ability to represent the class of formats, or in the information content. It might also be necessary to alter modes of symbolisation to suit the special needs of a specific graphic format. In this experiment, the symbol adopted for air movement in the still-frame images, is a twisting, two dimensional arrow. When it came to viewing the air movement in a three dimensional animation this symbol would disappear if viewed from certain angles. Therefore in the animation, a cone shape was substituted for the arrow to symbolise air movement and to indicate the direction of flow. It may be that the mode of symbolisation affected viewers.

However, a survey of architectural journals showed extensive use of the arrow format to represent air movement, and no use of cones. (In the year ending in July 1995, the weekly *Architects Journal* published 118 examples of different types of arrows being used to illustrate air movement through buildings Jacobs (1997)). It is not unreasonable to

assume therefore that architectural students would therefore be more accustomed to interpreting the still-frame images, and that the improved comprehension exhibited by the animation group was achieved in spite of a potential disadvantage with regard to the mode of symbolisation.

## Conclusions

The experiment presented here demonstrates that it is possible to measure significant differences in audience comprehension when comparing alternative graphic formats, such as animation and static representations. In this case, comprehension was shown to be significantly greater in the audience which was presented with information in an animated graphic format.

However, in the experiment described here, there is considerable variation in the differences between the two test groups in answering different kinds of questions. The variation in responses reinforces the introductory comments regarding the importance of selectivity in the preparation of effective communications, and the necessity of matching the media and the message. The experiment presents evidence of the large improvements in comprehension which can be attributed to the superiority of the animated presentation used in the experiment particularly with regard to questions of direction of movement. But surprisingly, less improvement is shown in responses to questions concerned with the identification of mobile building components.

It is also difficult to draw reliable generalisations due to the difficulty in comparing both the graphic quality of the two presentations used in this experiment and the extent to which they might be claimed to represent the categories of “animated” and “static” presentations.

Animation has been shown to make significant improvements in the effectiveness of communicating specific types of information to certain types of audience. But with some types of information content, animation might actually distract some audiences from the intended message.

## References

- Devlin, K. and Rosenburg, D. (1996) “Language at Work: Analysing Communication Breakdown in the Workplace to Inform System Design,” GSLI Course Notes No. 66, GSLI Publications, Stanford University.
- Eastman, C. (1970) “On the Analysis of Intuitive Design Processes” in G. Moore (ed) Emerging Methods in Environmental Design and Planning, MIT Press, Cambridge Mass.
- Jacobs, A. (1997) “Evaluating the Potential of Virtual Reality Software as a Tool for Visualising Air Movement Within Buildings” unpublished MSc Independent Project, School of Architecture, University of Portsmouth.

McCartney, K. (1985) "An Investigation of the Nature and Significance of the Graphic Characteristics of Architectural Energy Design Aids" unpublished PhD Thesis, Royal College of Art, London, p228.

McCartney, K. & Rhodes, P. (1991) "Modelling Wind Building Interactions Using Computer Animated Graphics" in S. Alvarez et al (eds) Architecture and Urban Space, Proc. of PLEA-91, Kluwer Academic, Dordrecht.



# **A Hypertextual Didactic Tool for a Maintenance Oriented Design**

**Claudio Molinari**  
**Cinzia Talamo**  
Politecnico di Milano  
Italy

*This paper presents a research concerning the theme of the support didactic tools for a maintenance oriented design.*

*The work takes a starting point in two remarks: the first is the importance of maintainability requirements prevision for the correct planning of a project and for the formulation of maintenance strategies; the second is the lack of information (examples, references, laws, quality and performance plans) easily available for students and designers.*

*The tool that has been pointed out has the aim to provide the information - belonging to different categories of knowledge - useful for a maintainability conscious design, according the free navigation modalities typical of hypertextual applications.*

*Starting from a matrix that associates building subsystems and maintainability requirements the student has the possibility to navigate into a network in which it is possible to have information about: european laws concerning maintenance, examples (drawings, pictures and description) of architectures and of industrial components that regard particular maintainability solutions and a plan in which are schematized the appropriate dimensions and the morfological configurations for the maintenance activities.*

*This hypertextual didactic tool has two different educational applications:*  
*1) during design training courses, it can support in self-training about maintenance aspects;*

*2) it can become a specialistic module inside an integrated CAAD system developed to combine the graphic representation with different performances evaluations.*



# A Hypertextual Didactic Tool for a Maintenance Oriented Design

## Objectives

The objective of the hypertextual didactic tool is to support the development of maintainability conscious projects.

This tool can be used either by students during design training-courses or by architects.

The didactic tool provides data about maintenance according to five aims:

- 1) to collect and organize all the heterogeneous information that it is necessary to know in the conception of a project and in the development of construction details. The tools are guide-lines for design and for self-learning;
- 2) to evaluate and self-evaluate the maintainability of projects and construction details and to select the solutions easier to be maintained;
- 3) to extract information useful for the realization of check-lists and of operative tools like maintenance manuals and maintenance plans;
- 4) to spread the maintenance culture through design training-courses;
- 5) to include operative problems inside the conception of the project.

## The didactic functions of the hypertextual tool

The hypertextual didactic tool has four functions:

- 1) the *problem setting*. It has to provide the knowledges necessary to identify, to formalize, to systematize and to organize the design problems connected with maintenance operations;
- 2) the *problem solving*. It has to provide the information and indications (optimal dimensions, morphological configurations, disassembling and assembling schemes, and so on) necessary to solve the maintenance problems;
- 3) the *self-learning*. The students can develop different and personalized learning paths according to their specific design needs and interests;
- 4) the *teaching support*. The teachers can prepare lessons or didactic modules realized on the base of the different design phases in which the students are engaged.

## The requirements of the didactic tool

The tool has been developed according to a list of requirements depending on the established didactic aims and functions:

- to use the tool without the support of manuals or the need of training;

- to use the tool according to the associative cognitive paths typical of the design activities;
- to move freely and speedily inside informative networks without predefined paths;
- to add new data and new categories of knowledge in the time;
- to associate freely different forms of information: schemes, different scales drawings, photographs, descriptive texts, check-lists, diagrams;
- to associate freely different categories of maintenance information: design and operative instructions, national and international regulations, assembling and disassembling schemes, repairing modalities, ergonomic dimensions, examples of architectures and construction solutions, references of building components selected between market products;
- to associate typological and technological configurations to specific maintainability subrequirements (accessibility; diagnosticability; modular structure; components interchange, assembling and disassembling; standardization; possibility to be cleaned; possibility to isolate elements and parts);
- to extract morphological rules useful for the architectural design;
- to extract precise dimensional and geometrical data useful for the details design;

The hypertextual environment (software Toolbook) appears to be the most appropriate for these requirements because it allows:

- to navigate freely and easily inside informative networks;
- to process and connect many and heterogeneous information through key-words;
- to associate images and texts.

### **Didactic and knowledge transfer**

In the last years an intense debate about building maintenance has been carried on inside different contests - universities, research centers, voluntaristic regulations, real estate agents - and a complex scenery of organizational models, skills and maintenance services is emerging.

But it is to stress the fact that as far as design process very few operative maintainability instructions have been pointed out till now. Nowadays there is a lack of information for architectural designers, even if the need is more and more growing: real estate agents and maintenance managers are realizing that a significant rate of maintenance costs and of depreciation of the buildings is due to design mistakes; the recent laws about public works include maintenance plans between project documents; changes in the building market are drawing attention to the intrinsic quality of the building and to their conditions of preservation; the users are becoming more and more conscious of quality requirements. This scenery points out a double need of competences: on one side designers able to develop maintainability conscious projects; on the other side project maintenance managers, that is to say specialists operating inside design team, able to support the designers suggesting and verifying architectural configurations and details, simulating maintenance operations on the proposed solutions, interfacing with specialists,

interacting with components producers and suppliers, realizing maintenance manual and plans.

Many of the information necessary to the education of these competences are spread inside different sectors.

To collect, to generalize and to make usable many of these information inside an informatic support system for the education, a transfer operation has been conduct extracting knowledge from different fields:

1) from *industry*. The industrial sectors (in particular petrolchimic, aeronautical and military), for their needs of availability of the devices and of safety, economy, efficiency of the processes, have been researching for over thirty years on the theme of planned maintenance in order to control, to predict and to reduce the distribution of downtimes, the Mean Time To Repair and the Mean Time Between Failure.

Concepts like reliability, durability and maintainability have been developed inside industrial and militar sectors and than tranferred to the building sector. In particular the military sector, owing to its mission, has developed important metodology to establish design concept for high maintenability systems.

A transfer work has been conduct from some Military Standards Handbooks (MIL-STD 470 *Maintainability Management of DOD systems*; MIL-STD 471 *Maintainability Demonstration*; MIL-STD 472 *Maintainability Prediction Handbook*; MIL-STD 470 *Maintainability Terms and Definitions*) extracting, semplifying and organizing information useful for architectural designers, such as the minimum dimensions of elements and spaces for maintenance operations, assembly and disassembly sequences and the relations and connections between elements and parts of the systems;

2) from *regulations*. The instructions related to minimum dimensions are extracted also from standards dealing with mechanical and eletrrical sectors (such as Afnor, British Standars, CEI standards);

3) from *tertiary building sector*. Many typological and technological solutions adopted inside complex tertiary buildings for easy and rapid maintenance activities (external and internal spaces for the maintenance activities, accessibility and inspection of systems, dimensions of maintenance equipment, and so on) are assumed in their basic concepts to extract general instructions useful also for other building sectors (for instance the residential);

4) from *case-studies*. The same transfer operation has been carried on buildings in which the maintenance problems had been treated with particular attention.

The information extracted from these fields have been transfered and organized as reported in fig.1.

## **The hypertextual didactic tool structure**

All the information collected in the hypertextual didactic tool structure are extracted and consulted through a principal matrix (fig.2) that connects columns reporting the subsystems (which form the building) and rows reporting the subrequirements (which constitute the

maintainability requirement) and that represents the entry to the hypertextual navigation (fig.3).

At each intersection of columns and rows it is possible to come to a deeper layer of selection in which at first to select technological units (for instance vertical envelope, horizontal superior envelope, horizontal inferior envelope) and secondly to choose between dry assembled and not dry assembled systems and components (this double option is due to the two different maintenance behaviours).

At this point the navigation inside the informative network takes place.

The user can extract information on the base of three different categories of knowledge, and at the same time can realize his path going cross these three categories by key-words that connect texts and images.

- 1) Regulations (fig.4). It is possible to obtain the references of regulation and standards concerning maintainability and maintenance operations either from building sector or from industry sector. Through key-words it is possible either to read abstracts of the specific standards or to visualize operating schemes and images of typological or technological configurations;
- 2) Maintainability instructions (fig.5). Instructions are sintetized to give check-list regarding the aspects that have to be considered. Through key-words it is possible either to reach more detailed explanations, or to visualize schemes, dimensional instructions and images (fig.6), or to read regulations titles and abstracts;
- 3) Examples. Typological (fig.7) and technological (fig.8) instructions can be visualized looking at photographs and drawings of buildings and components. Each of these images are completed by description in which the maintainability solutions are described. Through key-words it is possible to enter the other information categories.

## Conclusions

The hypertextual didactic tool is nowadays completed and after a test phase it will be available for the students of some Construction Laboratories of the Faculty of Architecture of Milan.

In this moment the Faculty of Architecture of Milan is experimenting a new studies organization in which architecture project has assumed a fundamental role as means for the transmission of knowledge. An intense debate is nowadays carried on about innovative didactic models and the most appropriate methodologies and tools for the teaching of technological knowledge inside the design training courses.

The aim is to create an articulate environment of informatic tools; each tool can regard a particular aspect of design knowledge. The student can set his personal and complex scenery of design problems, look for solutions and for evaluations by connecting the different tools and extracting specific information.

The tool that we have presented can be an example of these tools through which the students can act auto-reflexive processes: the design activity becomes not only the occasion to realize a project, but also to learn and to reflect about the design method.

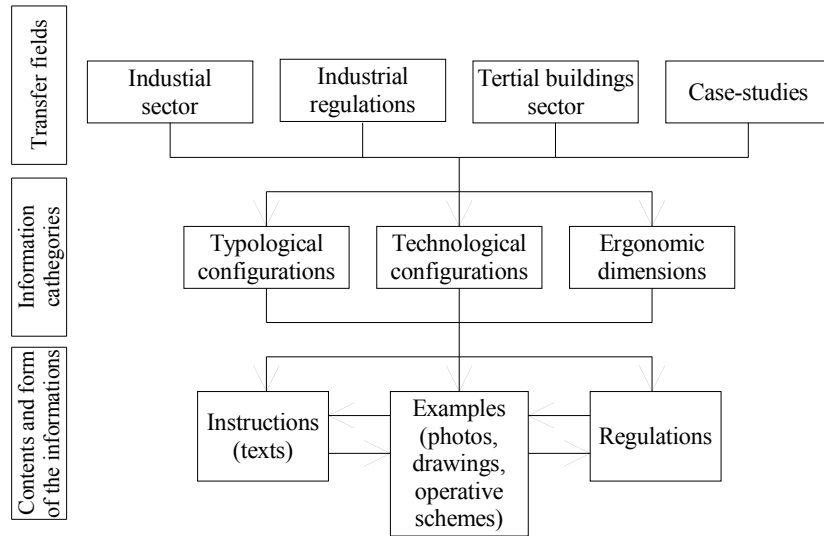


Fig. 1. The transfer process

|                          | Structure | Envelope | External partitions | Internal partitions | Internal equipment | Installations |
|--------------------------|-----------|----------|---------------------|---------------------|--------------------|---------------|
| Accessibility            |           |          |                     |                     |                    |               |
| Diagnosticability        |           |          |                     |                     |                    |               |
| Modularity               |           |          |                     |                     |                    |               |
| Aptitude to Inter-change |           |          |                     |                     |                    |               |
| Standardization          |           |          |                     |                     |                    |               |
| Aptitude to Replace      |           |          |                     |                     |                    |               |
| Aptitude to disassembly  |           |          |                     |                     |                    |               |
| Aptitude to assembly     |           |          |                     |                     |                    |               |
| Isolability              |           |          |                     |                     |                    |               |

Fig. 2. The principal matrix

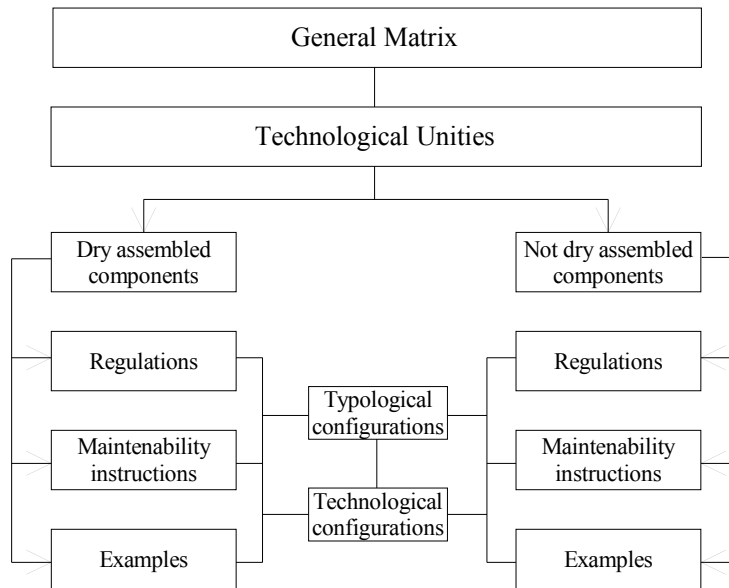


Fig.3. The hypertextual didactic tool structure

Figure 4. Example of the regulations references that it is possible to consult through the hypertextual tool.

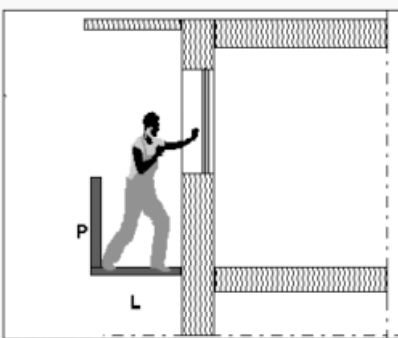
The highlighted words are key-words that allow to go either to the regulations texts or to other information cathegories and sections in which the same themes are treated.



LA MANUTENIBILITA'

---

CHIUSURA VERTICALE / ACCESSIBILITA'



|                       | L      | P      |
|-----------------------|--------|--------|
| 1 Persona             | 60 cm  | 100 cm |
| 2 Persone + Materiale | 120 cm | 100 cm |

**Passerelle**

**Caratteristiche tecniche**

- Materiale : Cemento Armato, Metallo, Laterizio ecc..
- Larghezza L, in funzione dell'uso previsto:
  - a) una sola persona
  - b) due persone
  - c) trasporto materiale
  - d) **appoggio piattaforme**( L= Ingombro piattaforma)
- Ad un'altezza superiore a 1,50 m deve essere provvista di un **parapetto** di protezione.

**Edificio**

Indietro

Matrice

UNI

Normativa

P.Manutenibilità

Riferimenti

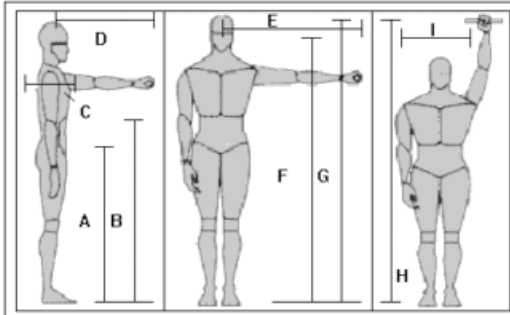
Figure 5. Example of instructions and schemes regarding typological and dimensional aspects. Through key-words it is possible to reach more detailed explanations (fig.6) or examples of buildings (fig.7) in which the described solutions are present.

LA MANUTENIBILITA'

---

CHIUSURA VERTICALE / ACCESSIBILITA'

Assemblati a secco



|  |  |
|--|--|
| <p>A = 68,1 - 91,9 CM</p> <p>B = 98 - 120 CM</p> <p>C = 33 CM [ MED ]</p> <p>D = 67,6 - 75,9 CM</p> <p>E = 68,6 CM [ MED ]</p> <p>F = 143 - 174 CM</p> | <p>G = 195 CM [ MAX ]</p> <p>H = 185 - 230 CM</p> <p>I = 57,9 CM [ MAX ]</p> <p>Peso = 44,9 - 101,2 Kg</p> |
|--|--|

**Dimensioni corpo in piedi in posizione di lavoro**

In questo caso oltre all'ingombro stesso della persona **ferma** bisogna considerare quelle dimensioni derivanti dai movimenti compiuti durante il lavoro; sono misure da considerare sempre nella progettazione dell'edificio, dei suoi sub sistemi, e dei tipi di accesso se si intende agevolare l'accessibilità degli

Indietro

Matrice

UNI

Normativa

P.Manutenibilità

Riferimenti

Figure 6. Example of ergonomic informations useful for the configuration and the dimentioning of typological and technological solutions.

LA MANUTENIBILITA'

---

CHIUSURA VERTICALE / ACCESSIBILITA'

Indietro

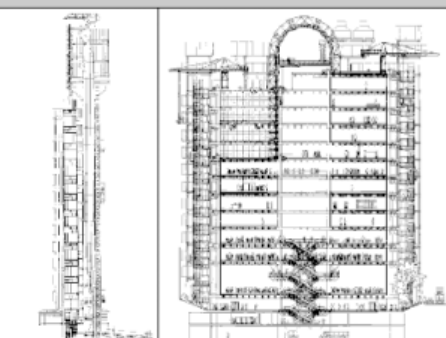
Matrice

UNI

Normativa

P.Manutenibilità

Riferimenti



*Richard Rogers, Lloyd's of London, Londra, 1985. Richard Rogers Partnership, "Lloyd's of London", Edizioni Tecno, 1985.*

Edificio adibito a centro di lavoro ed attività correlate al servizio assicurativo.

**Soluzioni previste :**  
*Dispositivi meccanici di sollevamento :*  
 - gru a torre fisse con braccia estensibili, posizionate sulla copertura piana, alle quali sono agganciati, mediante funi, appositi carrelli.  
**Sistemi fissi :**  
 - scale fisse a gradini, esterne;  
 - piani di sosta a livello di copertura previsti come zone di appoggio per lavori di manutenzione.

Figure 7. Example of architectures in which are presents some typological solutions relating to the analyzed subrequirement and subsystem. Through key-words it is possible either to have more detailed informations about the architecture or to enter the other information cathegories.

LA MANUTENIBILITA'

---

CHIUSURA VERTICALE / SMONTABILITA'

Indietro

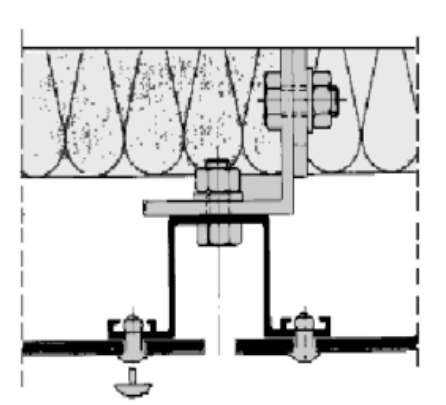
Matrice

UNI

Normativa

P.Manutenibilità

Riferimenti



*Sezione orizzontale sistema con rivetti.*

Rivestimento per architetture realizzato con pannelli (Alucobond) composti costituiti da due lamiere in alluminio accoppiate ad un nucleo in polietilene estruso. Applicazione del rivestimento di facciata : fissaggio con rivetti.

**Componenti:**  
 - baraccatura e regolazione tridimensionale per la realizzazione di un corretto piano di appoggio;  
 - sottostruttura verticale costituita da

Figure 8. Example of components in which are presents some technological solutions relating to the analyzed subrequirement and subsystem. Through key-words it is possible either to have more detailed informations about the component elements or to enter the other information cathegories.



**CAD  
As Interaction Instrument  
Between Planning  
Partners**

**Gernot Pittioni**

Ingenieurbüro für Bauwesen Pittioni  
Germany

*CAD has been developing rapidly to a widely used and widely spread instrument equally in architectural studios as well as in most offices of the engineering planning partners. This paper tries to submit an impression of difficulties and advantages by introducing CAD as interaction tool. An outlook on future aspects will be given.*



# **CAD**

## **As Interaction Instrument**

### **Between Planning Partners**

#### **1. Introduction**

CAAD has brought a new dimension into working methods. Into working methods not only within the architectural studios themselves but also within the multiple interchange between different planning partners.

Planning partners are surrounding the somehow central position of the architects and submit the more technical aspects to the planning process. Statics and building services - meaning heating and cooling, water and waste water, energy and air conditioning - surveying and site supervising, to mention only the most important.

The engineering partners of the architects mostly were handling CAD long before architects entered the computer-stage. Interacting by CAD-interfaces made things easier on the one hand, on the other hand architects are driven into new difficulties by the enforcement of certain disciplines.

#### **2. Historical review**

Only short historical remarks should be given here:

In the sixties CAD started to get introduced - first in the engineering area, later and very rarely in the architectural studios. A lot of research was going on in the universities, mainly in the US and in the UK.

In the seventies CAD succeeded to get a certain acceptance in the planning process. Engineers seized the tool and tried to persuade themselves that they are working more efficiently - and more and more they actually did. The user surface did not range as important item within the very exclusive system-developers. Nobody could even think about data transfer - as there were nearly no planning partners with CAD-assistance. CAD in those days was not so much CAD but rather CID: Computer Impeded Design.

The eighties brought the big success to a number of software-houses dealing with CAD-systems. A hot discussion between developers

came up, which operating system could best handle the huge requests of CAD-programs und CAD-users: UNIX, DOS or did the APPLE-world fit best. The efficiency of the programs was widely improved, the user-friendly-surface moved towards a much more central importance. Interfaces between CAD-systems were discussed, DXF and IGES were created.

Presently we have a widespread acceptance of CAD-systems, not only in the engineering area but also in the studios of architecture. The development of hard- and software made possible, that the normal users generally are not really interested which operating system is on duty. We watch the development of a number of different CAD-systems and we deplore the lack of intelligence within the interfaces, which is due to the early point of introduction. The developers are mainly relieved that most of the graphic information can be moved from one system to the other, without too much loss of information.

### **3. Interchange between planning partners**

Since CAD was introduced, a multiple interest built up to take advantage of the data produced in the course of the planning process. There is a variety of planners with widely varying activities:

#### **3.1 Interchanging planning partners**

Here are given the most important ones:

*Architects*

*Civil Engineers*

*Building Service Engineers*

*Surveyors*

*Site Supervisors*

*Administration (Public Authorities ~)*

*Administration (Customer ~)*

#### **3.2 Interfaces**

Since there is a huge variety of different CAD-systems, we are going to need interfaces to export and import CAD-data. There are efforts



made to improve the intelligence of those interfaces, but most of the intelligence is left to the users, which is not a very lucky solution, speaking of the average.

The mainly introduced interfaces are the following:

#### *DXF*

This interface was created by AutoDESK providing a very simple interchanging script. There were millions of implications of AutoCAD worldwide and the business-heads were rather certain that other system would ever come close. So the other systems were forced to take over the AutoDESK-dictated standard to get a chance. Nevertheless we do have DXF in our days and interchange is possible, the low level of the standard is a fact we have to live with.

#### *IGES*

This interface was created for more powerful systems, but it is lacking common usage. Very few CAD-systems offer IGES. And an interface is only of some value if we can assume that all planning partners are able to interchange, whatever system they are using.

### **3.3 Quality defects caused by interfaces**

CAAD nowadays is drawing advantage of a certain intelligence within the systems. The user mostly is not involved into decisions whether there should be made a change of layers while working on different aspects of data. So the system is forcing a number of decisions, producing results nearly without logic mistakes - as long as the systems are left alone.

Data transfer to other systems implies the use of interfaces. Speaking of DXF as the mainly used tool, data transfer is working mostly without mistakes between numerous systems - but on a very low level.

Most of the intelligent features do not arrive at the other system by data-transfer, as:

#### *Measurements*

These data are transformed to lines and characters without being linked to the geometric data. Users introducing DXF-information into their systems and wanting to use measures intelligently associated to geographical data, are forced to create the measures once again.

### *Linetypes*

Different thicknesses and line types can be altered with some luck, if there is a certain connection held up between the exchanging partners and if they are fairly well familiar with their software. Anyway, without any further input the transferred result is arriving with the default line-type.

### *Character sets*

It seems that this will never work out really satisfying, so we should be aware of a certain amount of „post-processing“ or we should remove the text-layers as a whole.

### *Hatching*

Here it is of some importance to remove the layer carrying the hatching information, because the system importing the DXF data is not able to recognize hatching as it is. We get an incredible amount of line information, which is blowing up the data volume to a large extent.

## **3.4 Quality defects caused by users**

As there were beginners' difficulties within nearly all user areas introducing CAD, there are now similar difficulties entering the interchanging stage. We should agree that all or most of the interchanging partners have closed up to some professionalism using their system.

If there still are left basic handling troubles with geometric accuracy, or there are handling troubles while using for instance the layer administration, the information arriving at the partners might end up in a condition which - in the worst case - makes further use literally impossible. We have to strictly distinguish between trouble caused by the lack of intelligence within the interface or the trouble caused by „low-sofistic“ user-handling. The latter may be fatal.

## **4. Interchanging media**

The interface is producing data inevitably much larger than the original source. This is of some importance when it comes to data transfer.

### *Floppy disks*

This data-exchanging media is the oldest, commonly used and widely spread. But since there are only 1.44 Megabytes of storage available, trouble is coming up. A good floor plan of a larger building with average information comes to about 1 Megabyte of CAD-data. Transformed to DXF this is enlarging to somewhat about 3 to 4 Megabytes and thus exceeding the capacity of a floppy disk. You can choose between playing disc jockey or handling compression routines. The latter is much better.

Anyway, floppy disks turn out to be rather solid and cheap, but they are not the solution the world is waiting for. And when it comes to long distances floppies tend to be awfully slow.

### *Modem-Transmission*

A much better method of data-transfer takes advantage of a transmission-media, that is available all over the world: the telephone network. There is no delay by using the post office and there is no limitation of data-volume. The only drawback may be seen in the costs of transmission.

The equipment needed is very confined: We need a modem- a nice transmission rate of 14400 or 28800 baud turns out to be useful - and we have to connect it with the telephone switchbox on the one end and the PC on the other. Modems differ largely in their features and price, a specialist should give advice. If available an ISDN-connection turns down the transmission times considerably. Thus 1 Megabyte of data-transfer are a matter of less than one minute.

If there is ISDN available we can do without the modem, an ISDN-board tucked into the PC is handling all problems. But: Problems come up, if your partner is not holding an ISDN end in his office, but only a modem. Therefore the modem is the allround solution, at least for the time being.

This is, seen from the present situation in Germany, state of the art. There is a considerable number of engineering offices capable of data transmission by modem, studios of architecture at present are clinging to floppy disks.

### *Internet*

As there are only few modems in studios of architecture, there are only few networkers in engineering offices.

Seen from the equipment there again is a modem or an ISDN-board. But the transmission is done differently, we need a network-provider. One does not place a phone call to the planning partner and send - or receive - the CAD-data. There is a phone call to a net provider, done by the net communication software you have to install in your PC. There your data hit a gateway leading to the powerful and fast network of the provider. Your partner finally picks up his data by another gateway passing again over a telephone and a modem. This use of the net provider and the gateways produces costs on either side of the transmission.

This seems to get importance in future because of the power and speed of the networks. But costs presently are preventing more frequent use.

## **5. From Interchange to Interaction - some Features**

All present means of transmission are very badly operating, if it is really interaction, what is wanted. It is a sometimes not very satisfying way of interchange and reminds us awfully of the punched cards, we fed the large computers in former days - and hours later we received the response in the form of a pile of paper. Real interaction with the computer began to come up with the workstation, where you sent your message and could receive the response in due time on your screen - hopefully.

To perform a similar process with the planning partners it is inevitable to interact with them directly by means of your PC-screen. Today software-houses are developing systems, where you can talk with your partner over micros and tiny TV-sets fixed to the computer screens. The screen may offer several windows, both participants have access to. And one or more of the windows may contain CAD-drawings, the partners both can work on and afterwards send - or receive - over the telephone-net.

Mostly this is an optional module of the CAD-software with the CAD-software being the business part of the deal. On computer fairs we can watch an engineer talking to his supervisor on a far away site and providing him with drawings after having the site supervisor change several details of the construction. To pep things up there is another window containing a digital site-photo of the detail regarded. After all the capacity of the telephone net will confine your fervour to transmit a whole video sequence.

So, there is a point to start with. In the first step we should be happy if we could have a phone-call by using micros to avoid nervous hacking on keyboards. Most of us would agree to cancel the TV-set, because it seems to be enough, if you receive the grunting voice of

your site-supervisor, you need not have as well his sweating face in front of you. And if finally both participants agree on transferring some CAD-data in whatever direction, this will mean a lot of progress.

And this is not a science fiction vision but can be realized without greater difficulties. The goal seems to be the independent from a certain CAD-system and to provide interactive access to CAD-data. By hopefully soon cheaper digital cameras we may come up with picture transmission as well. Zooming in these pictures without losing too much of the resolution would be great.

## **6. Conclusion**

Starting with the simple data transfer between different CAD-systems and discussing means of transfer I tried to leave the area of mere interchange and proceed to real interaction.

Today we are operating the data transfer on a rather low and unsophisticated level. I did not claim to discuss ways to improve the intelligence of interfaces. This is discussed for many years and will not be very promising as long as intelligent transfer is again confined to a small group of CAD-systems, if ever.

Interaction based on CAD-data will save time and money. The future use of networks with high capacities will further improve the connection and interaction activities between planning partners.



**Objectware :  
from C++ towards CAD++**

**Zenon Rychter**

Technical University of Bialystok  
Poland

*Objectware is software supporting the object-oriented paradigm. Object orientation controls complexity through thinking in natural terms. The approach unifies all stages of complex system development: analysis, design, and programming. It applies to software design, from operating systems to CAD packages, as well as all fields of engineering design, CAD based or not. The paper discusses what next generation CAD, object-oriented CAD or CAD++ will be like by studying the philosophy behind the C++ object-oriented programming language, which most CAD++ software developers use.*





## **Objectware: from C++ towards CAD++**

### **Object revolution**

We are witnessing a software revolution. The name is object-orientation. Software turns to objectware. Object-oriented programming languages are mushrooming, see Coad(1991a, 1991b, 1993), Goldberg(1985), Jamsa(1996), Keene(1989), Perry(1994), Stroustrup(1991). Good old procedural languages convert to object-orientation. The C language has grown into C++, the two plusses meaning the added value of being object-oriented. Along a parallel path C has become Objective-C. The Pascal language has evolved into Object Pascal. Even Basic has acquired some object feel. And those not lured so far perhaps will find more visual appeal in: Visual C++ or Visual Basic. Languages such as Smalltalk and Eiffel are object-oriented from the outset, with no pre-object-oriented parents.

Language, human or programming, is important: it decides what and how we can think. It provides building blocks and construction rules for modeling reality. Equally important, it enables communication: human to human, application to application, human to application, and application to human. Finally, it provides long-term storage of knowledge. But unhandy language obstructs construction or even makes it impossible. And communication may stuck in a bottleneck, suffer from noise, or even break down.

### **The past: from machine code to C**

The evolution of human and programming languages followed different paths, sometimes running in opposite directions. Humans initially used pictorial hieroglyphics, which represented things in a visual, direct, self-explanatory way. In computer parlance, it was an iconic, WYSIWYG, What You See Is What You Get, approach, the ultimate stage of modern Graphical User Interfaces (GUIs) and visual programming. Hieroglyphs (icons) are visually attractive to the novice, but are troublesome in more demanding tasks. Since each icon is (supposed to be, not necessarily in reality) meaningful, a new icon must be designed (and there are no standards here) whenever a new name is needed. In a rapidly growing world, this must end in an iconic explosion. A meaningful, individual icon cannot be used as an anonymous, standard, universal, atomic building block in larger, hierarchical constructs. Its considerable size leads to storage overload when it comes to huge collections of data. Humanity (with the notable exceptions of China, Japan, and Korea) solved those problems by the introduction of small, fixed, meaningless, abstract alphabets. So characters replaced hieroglyphs in human languages. By contrast, character-mode interaction with computers (through keyboards and typewriter-like printers) was the original approach, now generally regarded obsolete, not user-friendly.

The earliest programming languages were totally unlike the primitive human languages. They were direct manipulators of computer memory, organized in an array of two-state (zero-one = bit) switching devices. Quite rightly their name was machine languages, or rather codes, something not to be read by humans. The gap between end users (speaking plain prose) and programmers (bit shifters) was at its widest.

To ease the pain of programming in a machine language, assembler languages were introduced, see Duntemann(1993). Symbolic names such INC (for increase) or JPM (for jump) could now be used by programmers to replace sheer numbers understood by computers. To end users the advance was microscopic. The tool was not for them at all.

The introduction of the FORTRAN (formula translator) language initiated the epoch of procedural programming. Now actions could be represented by functions. But the functions operated on rather raw data: arrays of numbers were the limit of sophistication. Number-crunching has become easy. Those interested in conceptual, creative models of complex realities had still to wait for something else.

Necessity is the mother of invention. Computers themselves became complex systems involving many different components (processors, random access memory, permanent storage, input devices, displays, printers) communicating with each other. Modeling (thinking about) computers in terms of numbers just was no longer feasible. System programming was required and the C language was developed as the standard for writing operating systems (OS), see Kernighan(1988). C is a small, portable (machine independent) general purpose language. With C you have almost absolute control over the computer, down to the granularity of an individual bit of memory. At the same time, you can form hierarchical constructs of any complexity, representing any conceivable data structure from any application domain: numbers, arrays, arrays of arrays (of arrays, etc. if necessary), vectors, lists, queues, graphs, trees, records, files, sets, enumerations, characters, strings, sentences, paragraphs, books, dictionaries, geometrical entities. In short: objects. Real life objects. Objects for all. No wonder the C language has become the work-horse tool of professional software developers in all areas: compilers of programming languages, graphical user interfaces (GUIs), text processors, data bases, spreadsheets, calculators, symbol manipulators, simulators, games, and computer aided design (CAD) systems. Third-party developers of add-on extensions to CAD packages also resorted to C when performance and seamless integration with the core CAD system were at stake. There is no secret to that: C is the true engine of CAD and an open CAD's application programming interface (API) is most naturally a version of C, perhaps wrapped up in domain specific naming. So whoever you are, and whatever you need to model, C can do the job.

### **The present: from C to C++**

Yet people solving real life problems, including designers using CAD, have not turned to C as a general conceptual framework, thinking tool,

and communication standard. Even C programmers were looking for something that would make their work easier. Life with C was exciting but risky and error prone: full control and full responsibility for what you are doing. This was good for one person, solving a simple problem in a short time. It was painfully inadequate in a complex task, requiring the concerted effort of many people with different fields of expertise, spanning a long period of time, going iteratively and backtracking through phases as diverse as making an initial rough concept and implementing it in full detail, prototyping, testing, fine tuning. Here complexity and change rule. Reliance on a human coordinator who understands all, remembers everything, keeps track of all changes and sees all their effects and side effects would lead to disaster. The answer is organization enforced by a language. The language would have to formal because computers do not accept informal partners. On the other hand, the language should be natural and flexible enough to reflect the human way of thinking, so that everybody involved in a complex project could use it.

And so the C++ language was born, an object-oriented extension of C. It is discussed here because it is the most widely used object-oriented language. Importantly, the author uses it. And the design principles behind C++ are profoundly expounded by the language originator, Stroustrup(1991). Finally, the transition from C to C++ suggests the name CAD++ for an object-oriented, next generation CAD. But what counts here is not one language or another, but the underlying object oriented philosophy, shared by all languages of the class. A philosophy of interest to all: CAD software developers, third-party developers, and common designers using CAD, see Grabowski(1995).

While C++ expands C and accepts all of the C-language constructs, the changes it brings are revolutionary. It is not that an application developed using C++ will necessarily differ from one developed by means of C. It is the whole uphill way from an initial vague idea of an application to its final production version that has been dramatically changed. C++ addresses several fundamental issues: complexity, reuse (multiple use), expansion, maintenance, flexibility, error sensitivity reduction, change sensitivity localization, concurrent, distributed development at different levels, meaningful and natural cross-level communication, access control, the economy of the whole software development process.

On the surface, the main thing is an object, as the name object-orientation suggests. Objects represent non-volatile granules from the world around us. Object should be as natural and obvious as possible, and should be given self-explanatory names (e.g. a room). And what is natural is decided by the end user, CAD user, not the programmer. The end user selects objects of interest in his domain and he names them as he likes. Hence object-orientation is end-user orientation. That's a revolution. It not only pleases end users, but promotes stability, since domain specific knowledge will probably change little compared to changes in information technology.

Useful objects come in packs, types, where otherwise different individuals have something important in common. In C++ types are

called classes, and thinking in terms of classes is the true solid foundation of the object-oriented approach. A class is a type (or prototype), a template for object (real thing) construction, destruction, and behavior. A class is a fully automated object factory, with customized output. For a one-time design task a hand-made object will suffice. But you will not reuse it: not a car but the car factory is reusable if you need another car. A class abstracts structure from objects. An object is an instantiation of its class. Abstraction takes extra effort, and deeper knowledge, but pays off abundantly in the long run. A well designed and carefully tested class supports reuse. You do not have to start from scratch but construct from safe, standard, customizable components.

A class is a self-contained, all-in-one module. It encapsulates data (attributes, properties) and functions operating on the data. This makes for intelligent objects, objects that "know" how to behave depending on circumstances. For example, a room object knows that it cannot overlap other rooms and that its proportions must respect practical limits.

As much as possible, a class is a black box. A good example is a TV set. It is operated by a simple user interface (GUI in fact), but the details of construction (termed implementation in programming parlance) are hidden. It only takes one push of a button to turn your TV on and see its default behavior. Whenever needed, the behavior can be adjusted. When you create an object of a class, you turn it on. Objects also have default behavior, so you do not have to know much to let objects fly. If you learn about them more, your control will increase.

The distinction between class interface and implementation is of fundamental importance for all: CAD systems manufacturers, third-party developers of add-ons, power users, and ordinary end users. The ordinary end user will only have to do with what is called public interface. Functions that compose this interface are just object manipulators for everyday use. For example, windows, dialog boxes, menus, toolboxes are all objects operated via public, graphical interface. The public interface of a well designed class is the most durable part of a system. A public function *rotate(angle, angle, angle)* rotating an object in three dimensions about three axes will never change, because its logic is fixed. In C++ you may use functions with the same name for rotations about two or one axis, by just writing *rotate(angle, angle)* or *rotate(angle)*, respectively. Even more, if you want to incrementally rotate by a fixed angle about a fixed axis, you can just write *rotate()*, and the system will know what to do. So functions in C++ are also intelligent: under one name you group akin but not identical operations, and depending on circumstances (e.g. number of supplied angles of rotation) the system will call the right version of operation. In human communication context-sensitive naming is commonplace. Now programming languages are following suit.

Users operate objects via public interface functions, which, by design, are as close as possible to the user natural mode of communication. When existing objects need to be refined, or new objects are required, it is the end user who starts the process by specifying her/his needs in terms of public interface: functions, their names, their arguments, the values they

return (if any). This wish-list is then transferred for implementation to developers literate in programming, but the process of implementation will not change the interface functions look and behavior. So end users and programmers speak, where feasible, the same language, the end user language. Communication is direct, no technical lingo breaks it. Everybody can concentrate on his job. Programmers may continually improve on implementation according to advances in computer technology (new processors, parallel processing, etc.) without disturbing end users living a stable life among their public interface functions.

A class constructs similar objects, carrying the same level of detail. If there is not enough information to construct objects of a class, the class is called virtual. For example, a class *polygon* may have *area()* among its public functions, but it may not be clear how to calculate the area of a general polygon. Still a lot of useful information can be placed in that class (vertices, edges), and only the area calculation must be postponed until later. A virtual class is always a base class or parent for derived or child classes. A child inherits everything from its parent, defines the virtual (undefined) parts of its parent, and adds extra data and functionality. For example, *rectangle* may be derived from *polygon*. The *area()* function for a rectangle can be easily defined. *Rectangle* can also have a *diagonal()* public function, not present in the base class *polygon*, where it does not make sense. A child can be a parent of another class, and so on. A child can have, one, two, or more parents, and inherit from all of them (multiple inheritance). So classes provide a powerful tool for the modeling of hierarchical relationships, having the form of directed acyclic graphs or trees. Cyclic relationships are also accounted for through friend classes. A friend of a class must be declared within the class and has full access to all of its contents.

The concept of base and derived classes is fundamental to class reuse, expansion, and maintenance. You do not have to start from scratch, but search an available class library for closest match to your needs. For example, if you have a *rectangle* class and want to develop a *room* class, you may derive *room* from *rectangle* and inherit all geometrical data and functionality ready-made in *rectangle*. You only have to add what is specific to *room* and not present in *rectangle*. This approach saves a lot of effort. The future of CAD will definitely look that way. CAD software manufacturers provide the core CAD engine and base classes. Third-party developers derive from base classes and supply specialized child class libraries. Power users customize and expand functionality using class-based APIs. Ordinary end users just use objects in their daily work, but when not satisfied they send complaints and wish-lists, specifying expected changes to public interface functions, secure in the knowledge that in a class-oriented environment their dreams may promptly come true.

While ordinary users will use only the public interface, developers of derived classes (who as everybody else have access to the public part of a class) have also their own, protected interface. The protected components of a class are hidden from the general public. But they are visible and can be used in derived classes.

At the deepest level of protection in a class are its private data and functions. These are the innermost details of class construction, its internal organs. Ordinary mortals would respect privacy and stay away from the private and even protected class members. If they are to change private data, they have to do so through public interface. For example, you change the contrast of your display by turning a knob, not manipulating the internal wiring. This public/protected/private organization keeps everything and everybody in order. Without it everybody could change everything at any moment without the knowledge of her/his partners. In a serious project this would lead to disaster.

In real life we see wholes and their parts. C++ accounts for this through members (parts) of a class (whole). The members can be objects of other classes or they may be classes themselves. The nesting of classes can be as deep as we wish, a framework flexible enough for any problem area. Also recurrent membership is possible, of unlimited depth. So a class can contain objects of the same class, and those objects can also be composed of same class objects, etc. It is like a TV displaying another TV, in which one sees another TV. Fractal images also have such self-similar, self-repeating at different scales structure. In CAD, complex (whole, parts, parts of parts), evolving, branching, recurrent, dynamically growing and shrinking structures are commonplace. C++ handles them all.

A class is a template for objects. But classes themselves may be derived from class templates, providing common functionality for a parametric family of classes with different members having only different types. This is specifically possible for container classes (sets, lists, vectors, queues, dictionaries). C++ provides parametric containers as a library. If you need a class of vectors of a particular type, you take the library template class and simply specify the type of your objects. By a similar mechanism, C++ supports function templates, that is functions which do the same job, sorting for example, on different type objects. The beauty of this is that one has to remember only one name for all possible uses of a function in different contexts.

Objects communicate with each other through the mechanism of messages. The mechanism is particularly important in interactive, multithreaded, multitasking, multi-user environments. For example, a mouse click is turned to a message send to the window on which the mouse cursor was located at the moment of click. The window may handle the message (e.g. repaint itself) or pass it elsewhere. Messages are placed in message queues of particular processes or threads where they wait for handling. Each process has its message loop describing which messages to handle and how. A message-driven environment is ideal for concurrent, distributed CAD.

### **The future: from CAD to CAD++ or Object Oriented CAD**

The future undoubtedly belongs to the object-oriented paradigm. The paradigm really says: think in your professional domain as you think in everyday life. There can be nothing simpler than that. Everybody can

easily convert to this faith. Programmers were the first to do so. Object-oriented programming dominates the 90s. This is the more so that, on top of raw object-oriented programming languages, we have a growing offer of visual programming environments where powerful, full-featured GUI applications are constructed graphically onscreen, by drag-and-drop operations. Windows-based operating systems are not only perfect examples of objects in action, but underneath are complete object-oriented programming environments with ready to use GUI classes. And since far more than 50% of code of an application goes into the GUI department, the increase in speed of software construction is amazing. CAD software developers, where user interaction is the core functionality, are in the same category as GUIs. There is no longer need to reinvent windows, dialog boxes, and the like - those are built-in parts of a windowing system. Even three-dimensional graphics and rendering classes, such as Open GL, are already there. A good taste and feel for the user needs becomes more important in developing a good CAD package than the mysterious skill of coding. So far CAD users and third-party developers could only use objects of predefined classes. They were condemned to the same non-object-oriented C language as the original CAD manufacturer. New generation, object oriented CAD or CAD++ is written in object-oriented C++, so creating new classes (user defined types) becomes an equally easy task for the CAD++ creator, third-party developer of library components, and end user. In such an open object-oriented environment, ready made libraries of all sorts of domain-specific classes will appear at the speed of a chain reaction. And common users will have to do with a myriad of intelligent objects, knowing the rules of geometry, placement, dimensioning, acoustics, lighting, even esthetics, and knowing at what stage of the design process what part of their built-in intelligence to show, from conceptual design, to production drawings, and specification writing. With CAD++ the design process will no longer be as we know it.

## References

- Coad P., Yourdon E.(1991a), Object-Oriented Analysis, 2nd Ed. Englewood Cliffs, N.J., Prentice Hall.
- Coad P., Yourdon E.(1991b), Object-Oriented Design. Englewood Cliffs, N.J., Prentice Hall.
- Coad P., Nicola J.(1993), Object-Oriented Programming. Englewood Cliffs, N.J., Prentice Hall.
- Duntemann J.(1993), Assembly Language Step-by-Step. New York, N.Y., Wiley.
- Goldberg A.(1985), Smalltalk-80: The Interactive Programming Environment. Reading, Mass., Addison-Wesley.
- Grabowski R.(1995), Objective MicroStation v6.0. MicroStation User Europe, May/June, 16-17.
- Jamsa K.(1996), JAVA Now, Jamsa Press.

Keene S.E.(1989), Object-Oriented Programming in Common LISP. Reading, Mass., Addison-Wesley.

Kernighan B.W., Ritchie D.M.(1988), The C Programming Language. Englewood Cliffs, N.J., Prentice-Hall.

Perry P., Corry C., Cullens C., Davidson M., McKean R.W., Tackett J.(1994), Using Visual C++ 2. Que Corporation.

Stroustrup B.(1991), The C++ Programming Language, 2nd Ed. Reading, Mass., Addison-Wesley.



# Pattern Grammar within the Language of Architecture

**Sevil Sariyildiz**  
**Sanja Durmisevic**  
**Jasmina Ploco**  
TU Delft  
The Netherlands

*Technology plays an important role in the design and designing process, influencing the architectural expressions and giving an impulse to new developments of architectural language. It has been always the stimulating push for the generation of new concepts, spaces and technics in architectural design. Especially the developments in the field of material technology and construction industry. Lately, Information and Communication Technology (ICT) pledge to have an important impact on designing practice as well as a part of the technological developments.*

*In order to widen the application of CAAD in designers realm, it is necessary to interpose new design tools and methods. This means introducing CAAD more as a "designing tool" and making its employment feasible from the very first stages of design process - during the conceptual phase.*

*Pattern Grammars, which we will introduce in this paper is such a method that provides support to designers, architects and urban planners. These patterns, based on complex 3D spatial geometrical polyhedra and polytopes, when generated, have form and structure at the same time. Parallel with geometry creation, aspects such as accessibility, functionality and integrity of a building should be taken in consideration as well.*

*Working with pattern grammar within CAAD environment, enables faster generating of concepts and examination of spatial qualities, offering at the same time higher standards of design flexibility and enormous variety. It also introduces new design approaches to stimulate the innovative ideas concerning the design. This, altogether, represents an added value of CAAD.*

**Key words:** CAAD tools, pattern grammar, substitution method



# **Pattern Grammar In Architectural Language Within A CAAD-Environment**

## **INTRODUCTION**

The application of Computer science in the 60's started to creep into architects life as a drawing tool, which replaced pencil, ruler, drawing table, but still used in mixture with traditional tools. It was then called CAD. In the 70's this word was replaced by "Building Informatics" which included the use of Information technology in the design process. Nowadays we use the term "Information and Communication technology" (ICT) for the whole building process. In designers realm it is still mainly used as a drawing tool and partially for the information processing. But is it all what we can expect from this very rapid developing technology? Prof. Gerhard Schmitt once stated:

*" It is more than a tool, it is a new medium for architects and designers" [RSDC96].*

This paper gives an overview about the influence of ICT on architectural design process and focuses on the development and application of a pattern grammar for the conceptual phase of a creative architectural design. It also describes different steps of substitution method that enables architects to comprehend consequences of his/her design decisions.

### **1. THE ROLE OF ICT IN ARCHITECTURAL LANGUAGE**

ICT has a great chance to provoke expansion of new ideas that will support the designing process. In the first place, the ongoing developments of Internet and its possibilities, will surely have an influence on global architecture. Secondly, the developments of virtual reality will bring the architects to new ideas and concepts.

We are already so far that a communication between a living neurone and a chip is established. This extraordinary success to connect living and non-living material will surely open new perspectives and shed a new light on further scientific research in that direction [EOSM96]. Having this in mind, we can expect in the future that the designer will have direct communication with computer without obstacles such as screen and keyboard. It might be even possible that the designer will not only have an optical communication with computer but also tangible communication within computer, where he/she can simulate ideas

directly on a screen. Those are all possible directions we might be heading towards, but where do we stand at this moment and what does it all mean for architecture?

When we look at the developments in architecture during the 20th century, we can state that the innovation in architecture was very high, compared with last few centuries. This has 2 main reasons. Developments in the field of building materials and techniques, on one hand and the developments of computer sciences on the other hand. Result of these developments was that they stimulated exploration of new design concepts and the growing complexity of the buildings and built environment.

In the future, the ICT could have an influence on the designers both during the conceptual phase and the materialisation process (in very first and very last step of design process). Apart from that it can also provide a support during decision making process (consequences of different structure systems regarding costs and time-planning for their executions, or by introducing function-connectivity pattern a number of variations could be created in much shorter time).

One of the methods that could support architects in the phase of conceptual design, is the usage of pattern grammars to explore spatial design concepts. These patterns are based on complex 3D spatial geometrical polyhedra and polytopes. After generating the pattern for their use as an underlayer for the design, next step is to translate the pattern to material components, giving certain properties and attributes to point, lines or surfaces of patterns. This could be possible by using substitution method.

Further in this text, we will discuss the pattern grammar and later on we will come to the subject of the substitution method.

## **2. PATTERN GRAMMAR IN ARCHITECTURAL LANGUAGE**

As it was mentioned before, pattern grammar is for use during the conceptual phase of language creation, but one should not forget other element groups that shape the language as well such as function, connectivity, accessibility etc.

### **Patterns and main reasons for using pattern grammar as a language generator**

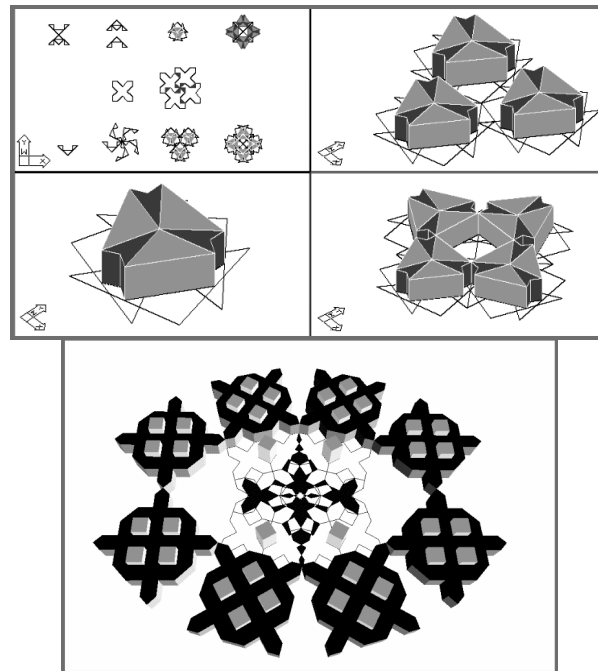
The origin of patterns occurs in nature. Their applications in architecture is not new. They were present in every period of architecture and art and in various scales. Think of the cities we live in! The cities are based on a certain pattern. Sometimes it is an organic form that grows into a landscape, sometimes it was enclosed in a very strong geometrical shape (like it was done in the earlier cities), and even today we build our cities

based on a pattern, very simplified but still a pattern - a grid system. [Sari91]

To support their orientation, human beings - by nature - need a certain system of ordering things and hierarchy of importance within that system which brings harmony in design. Within the pattern grammar nothing happens in isolation. One thing leads to the other. Breaks in or between patterns creates other rules which makes observer an active one and gives a sense of orientation. Exactly on these break points concentration of activities can take place. That is where tension is created. For example, in a grid system one element becomes larger and more dominant in the area and its spatial characteristics are different. This not expected change in the patterns keeps an observer awake and it draws attention. [Lync60].

In every human society the application of patterns could be traced. In certain cultures it was more explored and exploited than in others. The most complex patterns can be found in Islamic cultures, because in Islam it is forbidden to draw figures and faces or place the human sculptures in religious buildings. Artists and architects have therefore looked for another solutions. Their answer was ... patterns and with them they have expressed their artistic capabilities up till now. Patterns were applied on the walls, floors and ceilings, lattices for doors and windows, on a textile and carpets but also as a structure of a part of a building. [Sari95]

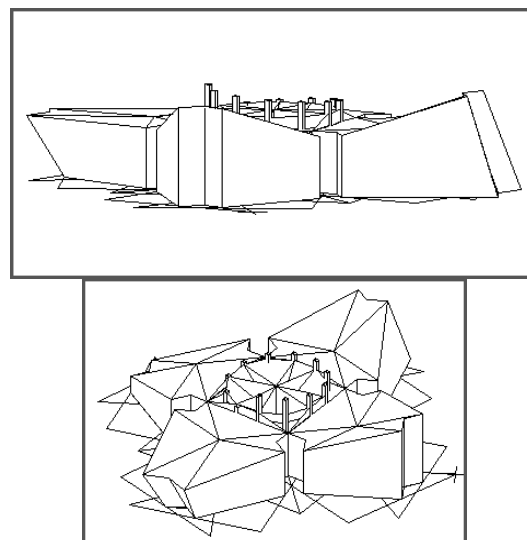
Regular polygons were used for generating these patterns such as triangle, square, circle etc. in 2-D surfaces. Our starting point for the generation of patterns are the 3-Dimensional polyhedra and polytopes. The irregular patterns were not much used in the history. Probably the main reason for that was, in the past, that it was too complex to generate and manipulate these shapes. All drawings were made by hand and that was time consuming. Nowadays, the computer sciences enables us to use time more efficiently. We can manipulate these shapes extremely fast so that the path from the idea till the realisation becomes shorter and shorter. Using combination of shapes, new shapes can be fabricated. Possibilities to assemble new shapes are endless and with computers, in a very short time it is possible to generate the most amazing spatial structures which go beyond human imagination, as shown in *figure 1*.



*Figure 1: examples of pattern creation*

One may think that the usage of pattern grammar might restrict the flexibility of a design.

Other may find it too structuralistic. We should take in mind that the patterns are only a design aid. Once a pattern is generated it can be used as an underlayer to determine further the free shapes. It doesn't need to be structuralistic and regular. By geometrical manipulations (transformation, dilatation, rotation, reflection) one can easy generate irregular patterns by means of CAAD tools. Once being acquainted with the logic of patterns, one realises that possibilities of having different variations are endless. Think about what this infinite number of forms and rules could mean for the architectural language!



*Figure 2 : creation of an irregular pattern based on the same pattern as in figure 1*

Christopher Alexander wrote about patterns:

*“Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice” [Chri77].*

A key word in this discussion for building construction is “prefabrication”. In order to decrease activities on the building sites and to faster “deliver the product” it is impossible to have prefabrication taken out of a building’s vocabulary. The main advantage of using regular patterns in architecture lies in repetition and continuation of the rules, which leads us directly to prefabrication of the buildings.

Secondly, main characteristic of pattern is the absence of scale or measurement of the fragments. The grammar of patterns can be used on a different levels of detailing: in regional planning, city-planning, as underlayer for architectural design, till the last details. Architects can choose themselves on which level of detailing they are going to work. As soon as the geometry is created, it has **form** and **structure** at the same time which also brings harmony in design [Sari91]. In that way it is a structure within a structure. Patterns, because of their repetition, have simplicity within complexity which means that applied to architecture this could open possibilities of working with different levels of complexity.

### **3. THE SUBSTITUTION METHOD IN DIFFERENT STEPS OF LANGUAGE CREATION**

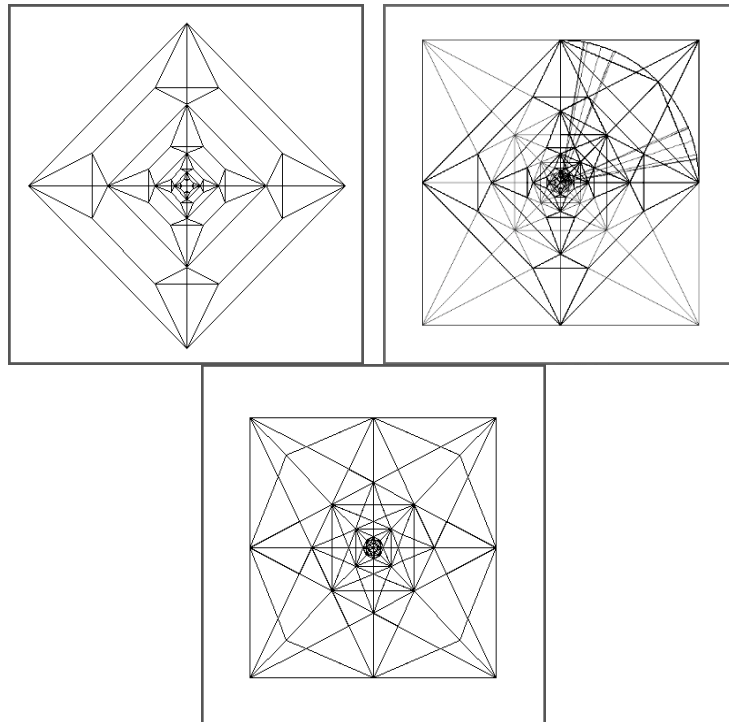
Providing a suitable support, it can be possible to design from concept till detail within CAAD environment. Substitution method can be a key to such support. We will describe this method for both phases with an accent on conceptual phase. This method will be illustrated on an example of roof constructions (cupolas).

In substitution method we introduce two “streams” of actions that one may choose to follow. One involves a 2D and the other a 3D working environment. This, we find necessary, for it is not possible to strictly define the design process. Each architect goes differently through the designing process. Some work more confident with 3D models, finding it an important aspect of architectural design. In that way they can easily establish what in their opinion are the spatial qualities and feebleness of design. Other architects have 2D oriented designing deeply anchored in their work, and only if necessary they create 3D model.

We strongly believe that many misdeeds could be prevented during materialisation process and construction of a building if architects would work in 3D from the very beginning of their design process, or at least somewhere on the line before the detailing and the specification of building materials takes place. Regardless of which path the architect

chooses, very soon the two models can reach same level of complexity before they enter a detailing process (global materialisation), that will say, before the model reaches the stage of materialisation it has to become a 3D spatial model.

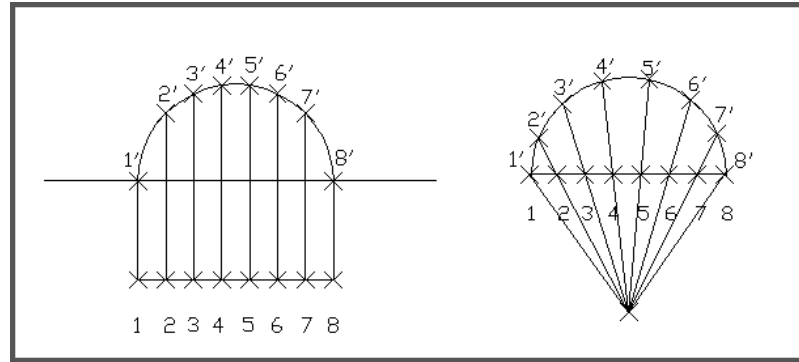
One or more basic elements are combined and manipulated by means of translation, rotation and dilatation. Depending on number of manipulations a pattern has a higher or lower level of complexity. But even if a pattern seems very complex it is feasible to reduce it to more simple one, merely by creating the priority of the constructing lines. Different patterns can also be generated by choosing different rotation centres. Some pattern creation is given in *figure 3*.



**Figure 3:** examples of pattern creation

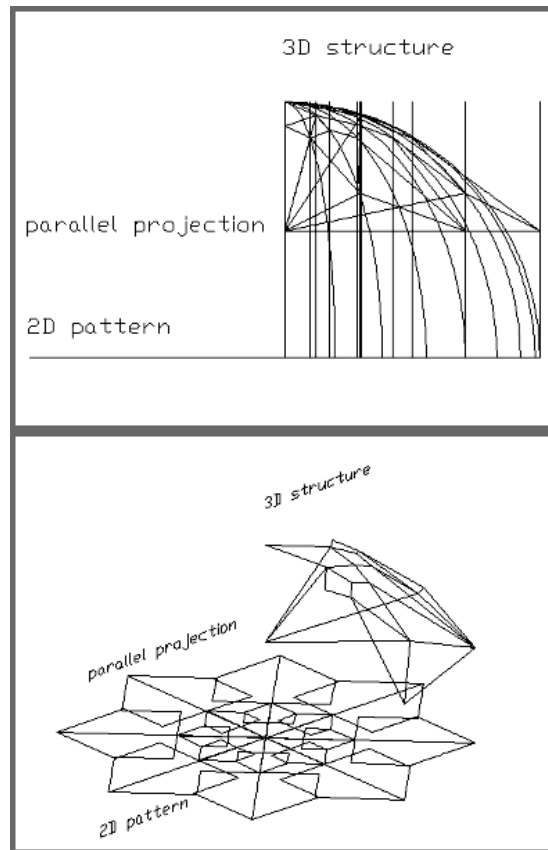
As the architect becomes more familiar with this method he/she will favour to begin their work following the 3D stream. In that way the necessary step of translating 2D drawing into a 3D model can be avoided. For cupolas we have developed our own software (within Auto CAD) where it is possible to have gravitational or parallel projection of a 2D pattern on a 1/2 globe surface or on its segment. Basic principal of both projection is shown below in *figure 4*.



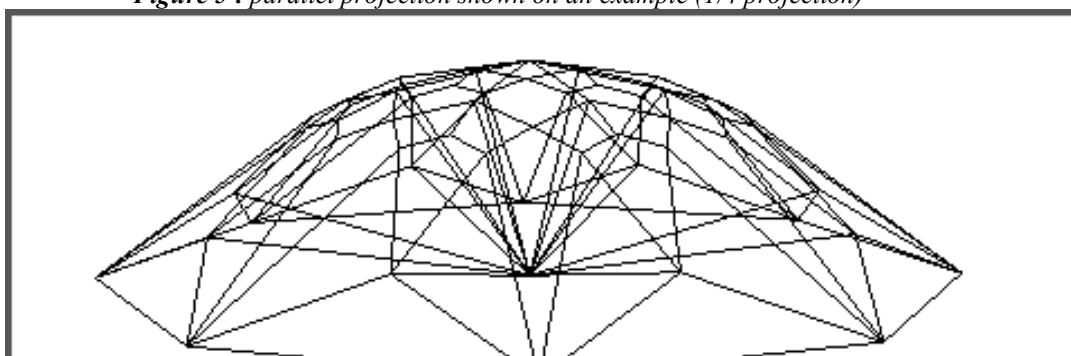


**Figure 4 :** Principle of parallel and gravitational projection of a 2D pattern

Application of this method is shown in *figure 5*, where on a basis of 2D pattern parallel projection is applied. Projection is shown on only 1/4 of a globe (to make it more clear) and in a *figure 6* the result of whole projection is given.



**Figure 5 :** parallel projection shown on an example (1/4 projection)

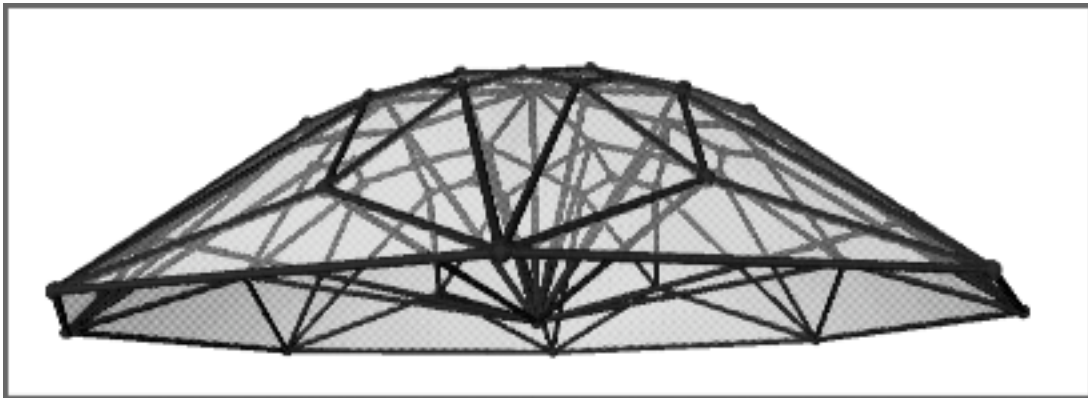


*Figure 6 : result of parallel projection*

Once a spatial geometrical model is created, in the next step it should be globally materialised. This is where substitution method is applied. Point, line and surfaces have different attributes on different application levels (because detail is build-up on two systems - “MERO” system and second level Al-profiles and glass):

Level one:

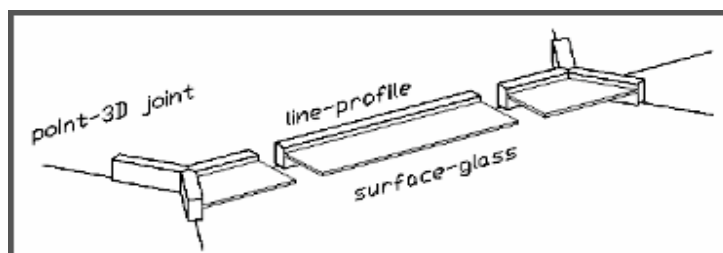
- Point is replaced by a globe, line by beams and surfaces are introduced on a second level



*Figure 7 : global materialisation on first level*

Level two:

- Point is replaced by 3D Al-profile joint, line becomes Al-profile that connects two joints and surface becomes glass.



*Figure 8 : global materialisation on second level*

Summary of pattern creation and substitution method is given in *figure 9*.

*Figure 9 : substitution method applied on a pattern grammar*

## CONCLUSION

It is possible to develop the substitution method for all architecture areas, so that it can be applicable in domains of urban planning, designing, building technology, interior design etc. In this paper we have concentrated more at developing the substitution method to support the conceptual design and building technology.

Introducing the pattern grammar and the substitution method we can influence the average designers by offering them a new method and medium. Therefore, it can increase the quality of their design and the efficiency of the design process. It is very difficult to introduce new tool for the top-designers and their way of designing, but even they might find the pattern geometry challenging and inspirational for their own designs. Think about one of the greatest architects from the US, Frank L. Wright, who based almost all his designs on pattern geometry!

New concepts and ideas can emerge and refresh the language of architecture just by looking around us and discovering over and again what world of nature and the hands of man have created so far. In that process, the ICT and its further developments can and will play an important role. Using computer science as an extension of our own intelligence, we can explore spatial qualities of our designs more accurate and faster than ever before out of which new shapes can emerge and mistakes could be reduced to a minimum.

The boundary of architecture and its language changes with every society and new technologies that accompany it, but the origin of architecture will never change, for it has always been conceived in the human brain and consciousness.

## References:

- [RSDC96] Opening Conference of RSDC at TU Delft, October 1996  
Prof. Gerhard Schmitt, Faculty of Architecture, ETH Zürich  
Lecture: "Non-physical architecture-a new approach to material form"
- [EOSM96] Wetenschap en Technologie voor Mens, November 1996  
Grafton M. - Title of the article: "Een Kleine Stap Naar Echte Cyborgs"  
p. 50-51
- [Lync60] Lynch K. "The Image of The City" 1960

Massachusetts Institute of Technology

- [Sari95] Sariyildiz S. “X-Dimension in Building”  
Inagural Speech, TU Delft, Faculty of Architecture, 1994
- [Chri77] Christopher A. “A Pattern Language” 1977
- [Sari91] Sariyildiz S. “Conceptual Design by Means of Islamic-  
Geometric-Patterns within a CAAD-Environment”  
PhD-thesis, TU Delft, Faculty of Architecture, 1991

**Tools of an Integrated  
Software Environment for the  
Architectural Design Process  
- Concepts, Technologies and Added  
Value**

**Sevil Sariyildiz  
Mathias Schwenck**  
TU Delft  
The Netherlands

*The technological developments in every field of science have an influence on the society and therefore on the design and design process itself. We are forced by the rapid developments in the field of ICT (Information and Communication Technology) to think fundamentally about changes in existing design process as consequence of the influence of this new technology. What will be the way and the method to integrate the new tools in a design process to increase its efficiency and to reach better design results?*

*In this paper we will focus on the three main aspects of using computer tools in an architectural design process. By means of examples we will illustrate our vision concerning the future tools for design developments and their integration into integrated design support systems. We will provide a survey of related problems of the design process and deal with aspects of related disciplines that have to be integrated into the design process.*

**Key words:** *ICT design tools, architectural design, materialisation, tool integration, integrated design support systems*



# **TOOLS OF AN INTEGRATED SOFTWARE ENVIRONMENT FOR ARCHITECTURAL DESIGN**

## **INTRODUCTION**

If we look at the history, every technical invention and development has resulted in advantages and disadvantages for the well-being and prosperity of mankind. In the building sector and built environment, the discovery of new materials and techniques has always led to fresh challenges and changes. Developments in other fields of science, such as mathematics, materials science, mechanical and aerospace engineering have always influenced building and architecture. Buildings like the Eiffel Tower, skyscrapers as well as the Munich Olympic Stadium could never be built without the development of the new techniques.

In our time, besides the inventions on the field of CAAD, AI techniques and other multi-media tools for engineers and architects, the communication technology plays an important role. If we look at the middle ages, the monasteries were the central point of the scientific developments and practice. By the discovery of the book print technology by J.Gutenberg in 1455, the scientists found each other and could communicate with each other even if it was very limited. Now with the ongoing developments of internet technology the world is getting smaller and smaller.

This technology will have influences and bring innovations and changes for the building sector. The way how we handle the design and its process and the use of tools will be different than the traditional ones. The exchange of knowledge by means of this technology will bring new stream of world architecture and inventions in the field of building technology.

Independent from the communication technology, whatever it will be, the developments concerning the building design will focus on these three main subjects. Therefore it is necessary to prepare tools for these areas in an integrated way [SaSc96]. As illustrated in figure 1 these tools are basically:

- architectural design related tools
- building techniques related tools
- building process related tools.

In this paper we will focus on these points and will give some examples of our developments.

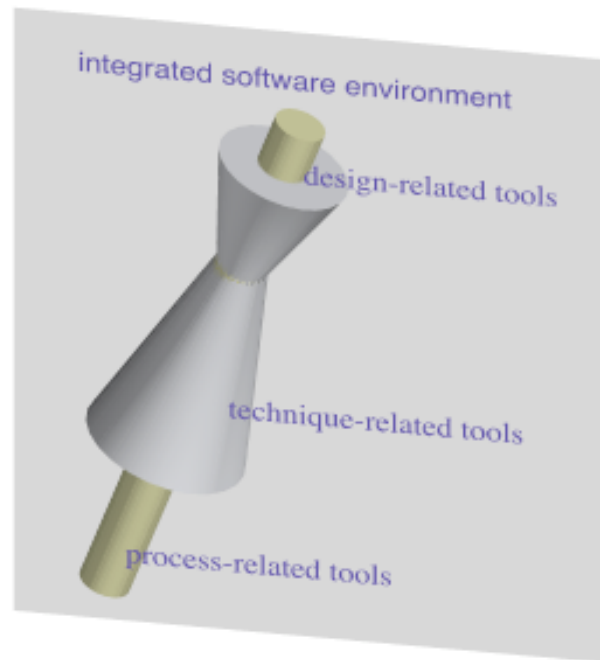


Figure 1

## ARCHITECTURAL DESIGN RELATED TOOLS

It is very hard to define exactly what a design is and how architects design, because every single design is as unique as the designer himself. There are no general, unanimous rules applicable to each process and each designer. The starting point is always different, although there are certain questions every designer will have to face.

Irrespective of whether it is a bridge, part of a machine or a building, every design will start with a programme of requirements, after which a concept is developed. After this phase the various design processes will divert.

A part of a machine will mainly be designed with a view to its functional and financial requirements. A bridge or a toaster, however, should also have other qualities. In this case different added values will be expected, in particular those regarding quality of form.

From a design of an architect people will expect additional value, namely the perception of space. Not only should a new building look attractive, but people should also feel at home inside the building and in its immediate surroundings. In this respect there is a fundamental distinction between architectural design and the designs in most other disciplines.

Architecture is a science which is a mixture of an exact science and the art. The combination of these two important items makes architecture a difficult but a challenging task. An architect has to combine these primary elements in the design and at the same time while expressing the feeling of art, must take very good care of many other factors which play an important role in the building and design environment. The technical aspects on one hand, the aesthetic and social aspects on the other hand.



Initially, the addition of both these qualities, form and perception of the environment, takes place conceptually. In the eventual realisation of a design various disciplines will play a role, and in the completed design, function, technique and form should be expressed as integral parts. Subsequently, these concepts are also materialised.

The architect has to evaluate his design and communicate with the others concerning the design, and therefore he has to make variants from which to choose the best. The best way of evaluating the quality of a design and to communicate with others is to simulate its future reality. The optical qualities of an object can be illustrated much more efficiently with a computer, and can be changed far more easily than in scale models and drawings. So far, only haptic (bodily tactile) qualities cannot yet be simulated.

Design engineers who make use of computers basically work with a man-machine-system, in which the machine is deployed as a means to render ideas directly into concrete forms, but the qualities are not visible they only exist in man's conscience. The question is now, how computer science can help the designer in this (initial) phase of the design process?

We do not believe in that the computers can guide the designer during the process of finding forms and concepts. It can only support the designer by offering this new medium. That is why we do not believe in the developments of artificial intelligence that the design full automatically done by computer. It can never replace the human experience and creativity. But it can support the designer where it is confronted with the exact criteria and knowledge which can be converted to a computer model.

The computer can only work on a pre-program, in accordance with the programs man has taught it, whereas man works on the basis of his education and upbringing, as well as from his imagination and creativity. In this phase one can think about knowledge-based systems or Decision Support System in order to support the architect in this phase.

Starting with this way of thinking, we develop a *pattern grammar* to use them as an underlayer during the creating of spatial forms. In the development of this grammar, patterns are treated as three-dimensional polytopes and polyhedrons so as to use them as an underlayer in the different phases of the architectural and the urban design process. Some aspects of this research are described in [SaDP97], [Sari91] and [Sari95]. On the next two pages (figure 2-13) we show an example of a design with pattern worked out by Christian Müller [TO&I94].

## **BUILDING TECHNIQUES RELATED TOOLS**

A design starts with a functional analysis, resulting in a well-defined programme. The concepts of quality of form and perception of the environment are then added.

Once the concept is ready and determined, after the testing of possible variants with the aid of advanced visualisation tools, this design has to be materialised. That means that the model has to be transformed into components and materials.

Many architects have seen this materialisation as a purely top-down occurrence, others consider it a bottom-up process. In reality it is a mixture of both, with a purely top-down procedure in some fields, and an absolutely bottom-up development in others. Contains a number of steps, wherein some elements on a relatively low geometrical level but bearing a lot of symbolic value, are placed by geometrical more defined elements that contain less symbolic value. Besides, these two processes never have the same starting point. Throughout the design process dozens of sub-processes constantly intermingle.

Thus; the architectural design process is a process which is the mixture of deductive and inductive processes. It is an iterative process which works the various steps across.

It is impossible to define a specific course in advance. The one and only design process with a unique development does not exist. Not one design process has ever been like the other. However, on the other hand it is certainly possible to define each step in the process of materialisation.

To date, materialisation has been achieved through a time-consuming procedure, according to traditional methods, which often fails in effectiveness and consistency and does not offer all the possibilities from which to select. The development of methods by which three-dimensional materialisation can be supported by means of computer science technology is largely unexplored territory.

It is common knowledge that a computer is very appropriate to check exact criteria, but in the conceptual phase of the design process there are hardly any exact data. In the consecutive phase, the materialisation, however, data become more and more exact.

In the phase of materialisation the question arises to determine which material, element, or detail will best satisfy all the requirements regarding costs, aesthetics, physics of construction, applied mechanics, installations, dimensions of load-bearing structures and details. This we call the building techniques aspects of the architectural design or materialisation phase of a design

In this process there is a great need for applied knowledge such as mathematics, geometry in particular, applied mechanics, material science, building physics, knowledge about calculation of constructions in general and calculation of dimensions in particular.

Before the developments of information technology, this has been done merely based on our own experience and knowledge. Within the developments of this technology, many software has been written for specific problems - purely ad-hoc such as cost calculations or for building physics aspects, calculation of constructions. But still there is no software available which can integrate these various disciplines of design in one system to support the designer while taking decisions.

The greater part of the knowledge required to take these decisions is expert knowledge which can be stored and made accessible by means of an expert system.

The system which has to be developed should integrate the various disciplines of design during the design process and should give continuous feedback to the graphic part within an advanced environment of visualisation. That means that the various expert system tools should also integrate in this environment besides the CAAD tools. For instance, in a climatic partition wall in a building it is not its insulation value at a certain section that is of great importance, but rather the successive layers and their connection with the angles, also at the point where three walls will meet. And so, it goes beyond mere computerisation of check calculations and the results should be as graphical information.

**Figure 2 - 7**

**figure 8 - 13**

## **BUILDING PROCESS RELATED TOOLS**

A major area in which computer science may support the architect is exchanging and processing data. This requires building up a reliable data model. Not only will such a data model of a building be of good use in the design process, but these data are also of vital importance in the life-span of a building.

Nowadays building has become much more complex. Not only in their functionality, but also in the way they are put together: infrastructure, building with support and external covering, technical equipment, communication techniques etc. Many partners are involved in the process, and a major part of the activities during building consists of collecting, processing and transferring data among the various participants, such as the architect, the engineer, the contractor, the electrician, the physician, the constructor, government institutions, and the users.

This data will have to be ordered and processed very efficiently, but the problem is how to order this data so that it can be easily processed.

The data concerning a building of relative importance are so extensive that one single person cannot possibly know and control all this information. It is absolutely necessary to order this information, so that any person involved will be able to obtain the information he needs.

This type of ordering in fact consists of a hierarchic built-up of the information. Re-ordering actually implies restoring the hierarchy.

In this hierarchic structure it is desirable for an architect to have insight in some fields, discernment in others, and in the first place an overall picture. This hierarchy must be not only vertical and horizontal hierarchy but a three-dimensional hierarchy.

That means that each part of the technical information which is put together like the electricity, plumbing etc. and imagine that when the electrician wants to know everything that pertains him in relation to the rest of the building, he must be able to call only that part of the object on scale, for instance, 1/200. He must be then able to receive the plan with, for instance, all the supply and safety installations on a scale of lets say 1/20. He will be able to see where all the lamps and interrupters are situated as well as their relationship to the rest of the building's layout.

The information must be selected according to the questioner. The architect and the building engineer do not need the same information about the details. The building engineer does not need the information about furniture for example. He needs the information about the structure of the building.

While this information is selected, it also must be usable so that when it is returned back to an architect from the building engineer, the architect should not have to draw all over everything again. The changes must be easily processed. Therefore it is necessary to built up an object in different levels in horizontal and vertical hierarchy.

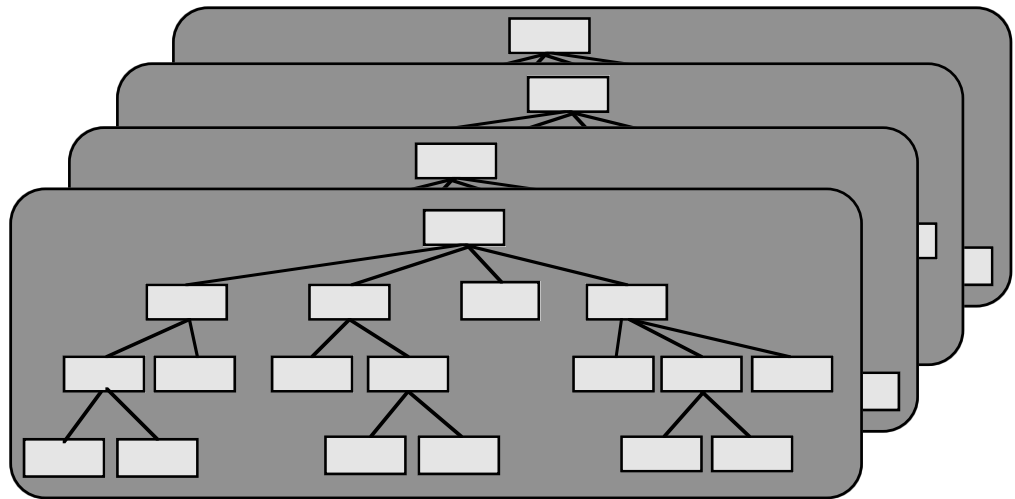


Figure 14: The three dimensional ordering of the information as object-oriented data

Each design is part of a process, and consequently part of the building process. In process technology one of the primary rules is that each step must be clearly related to the final goal, and must be tested and evaluated to this purpose.

In any process each next step further elaborates the results of the previous one. This further elaboration includes more than just assuming geometrical data developed at an earlier stage. It also concerns decisions on actions, information flow, quality etc.

It is very important to consider designing as an essential part of the building process. In current building practice, however, the architectural design frequently is no part of the building process in the sense described above. The architect restricts himself to supplying forms, after which the building contractor starts the whole process all over again. With the current state of affairs the architectural design is too far removed from the process-technology of building.

## Integrated Software Environments

In addition to the problems mentioned so far, the current state of available design software is characterised by a lack of integration of different tools. The different tools have to be integrated in an open, modular, distributed, user friendly and efficient environment. Situations where limitations occur because of incompatible file formats, incompatible communication protocols or because of user interfaces that are not suited for the people working in the field of architectural design have to be avoided. Integrated design environments can provide this by realising integration in the following three dimensions [ScBr93]:

- Data (Information)
- Control (Communication)
- User Interface (Presentation).

The *data integration* aspect of tools determines the degree to which data generated by one tool is made accessible and is understood by other tools.

The *control integration* aspect of a tool determines its communicational ability, i.e. the degree to which it communicates its findings and actions to other tools and the degree to which it provides means to other tools to communicate with it.

The *user interface integration* aspect is the degree to which different tools present a similar external look-and-feel and behave in a similar way in similar situations.

Instead of only developing design tools, integrated systems are also addressing the problem of the operating environment of these tools. This can be considered the principal advantage of integrated design systems and provide the added value. [Wolf93] concludes that the additional effort that has to be taken to realise an integrated support environment will be more than compensated by the advantages of these solutions.

In figure 15 on the next page we illustrate the three mentioned categories of tools to be integrated. For each of them one example is given, such as database of building components within the category “building process related tools”. During the materialisation process, expert knowledge of various fields has to be integrated. For example, expert knowledge of detailing can be implemented by means of an expert system. Such tools belong to the category “building technique related tools”.

Generic functions for data and design management are not implemented in a specific tool, but in a framework offering general services for the tools.



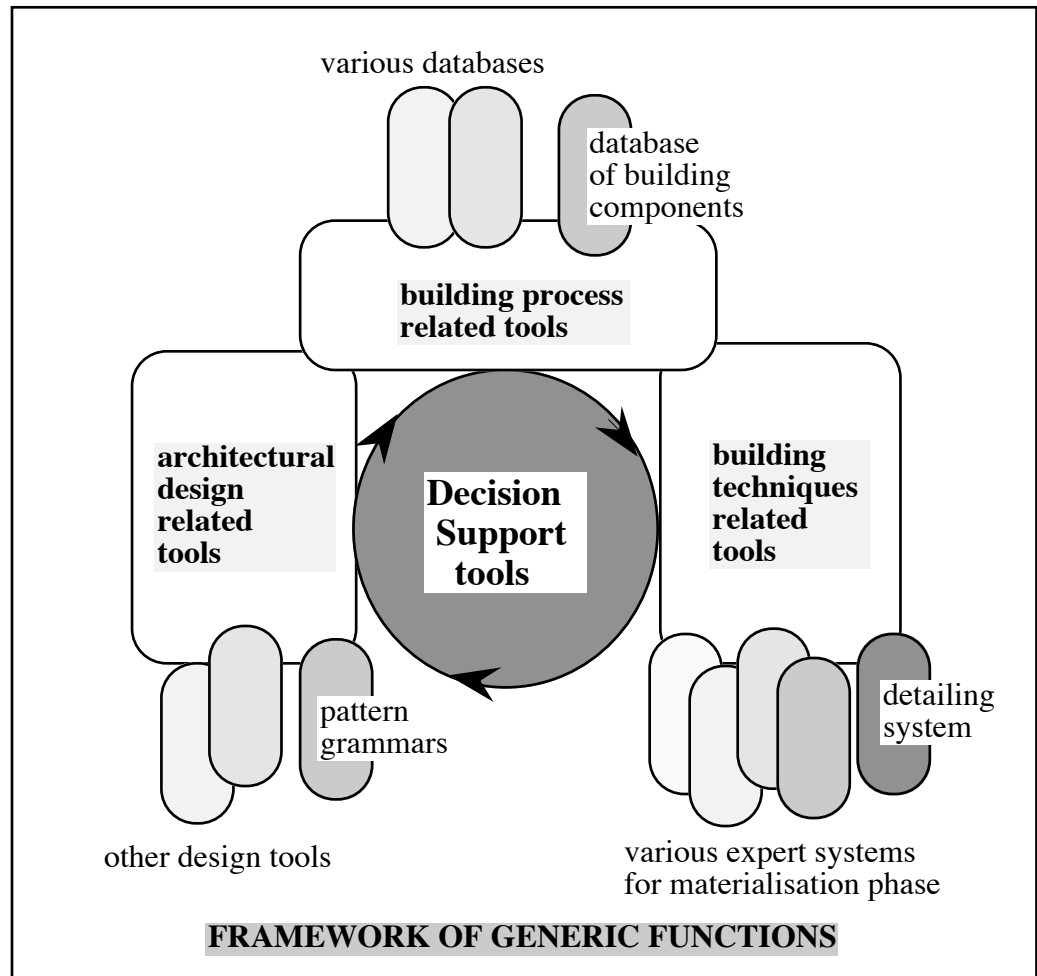


Figure 15: An integrated software environment

## Consequences for the Architectural Design Process

Which changes occur in the architectural design process if we apply the new tools within an integrated software environment ?[ScVö96]

- Conceptual design and materialisation are inseparable because it is impossible to erect a building without materialisation. Knowledge about the limits and possibilities of several materials and structures as well as their combinations is available by means of software. Because of the possibility to start with a research of the “final limits” the reality of the design process will be excellent.
- The possibilities to combine materials and structures lead to a wider variation of designs. It is now possible to explore them already during the conceptual design phase.
- 3D views are vital to explore the human space limits and qualities within the materialisation limits.
- The conceptual design should be extended significantly in order to use the new possibilities. It becomes more time-consuming. The effort taken can be easily compensated by quality improvements as well as by less time demands in later phases.

- Because of the integrated way of designing it will be possible to inform the principal, the authority and the consultants on a “digital way”. The value of the calculations is as excellent as the design process.
- The documents can be generated earlier and much more complete so that every member in the design process is informed with the same quality and with the same possibilities of the building. This can take more time but the value of every document is extremely high because the tuning has been done. The definitive design needs significantly less time to be generated.

Additionally the whole design process tends to demand less time. We will illustrate this by a comparison in figure 16:

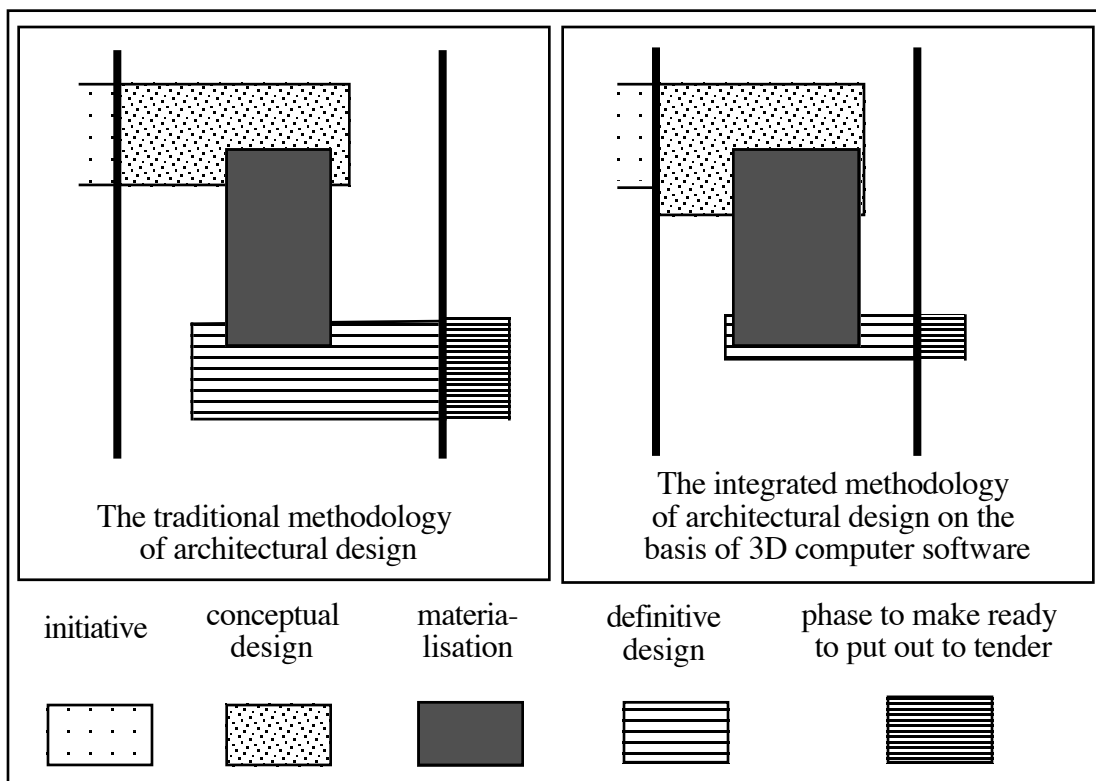


Figure 16: Expected Changes in the Architectural Design Process

## SUMMARY AND CONCLUSIONS

It is almost impossible to keep pace with the incredibly rapid developments in the field of computer science. Computers are becoming cheaper and increasingly powerful. The Internet will make the world smaller and smaller, bringing scientists in very close contact with each other. Networks will enable them to communicate night and day. In the United States efforts are being made to build Electronic Super Highways and much faster internet possibilities. Today these networks, combined with fast computers, make it possible to simply exchange graphic data (drawings, photographs, films, etc.). Now, researchers may execute simulations by remote control, or hold a conference by video with

colleagues abroad. In the future we will even not need a software at our disposal in our own machine but via the internet we can have access to any specific needed software on internet. The communication between the building partners will also take place by means of video conferencing that even the travel time to have meetings will bring more time to do more creative and efficient work. The emergence of new technologies will also affect our subject area, our way of living, our habits and our cities and this will create fresh challenges, fresh concepts, and new buildings in the 21st century.

The application of these new techniques, methods and tools in the building sector is a very complex problem. Contributions can be made by developing tools in the three categories that have been considered in this paper as well as by dealing with their integration.

If they are applied in such a way, these ICT developments can have significant impact on the building sector and therefore in the society. Some advantages are:

- efficient and better design and construction process
- contribution in the industrialisation of the building sector
- robotising of the construction process
- developing assembly techniques
- flexibility in the architectural design
- more variety in the architectural design
- high quality in the building and cheaper buildings
- contribution in the solving of environmental problems
- globalisation of the architecture
- because of the better communication techniques, upgrading of the knowledge of the building sector concerning the new building technology
- better communication between the partners involved in the building process.

## References

- [SaDP97] Sariyildiz S., Durmisevic S., Ploco J., "Pattern Grammar In Architectural Language Within A CAAD-Environment" Proceedings of the 1st AVOCAAD-Conference "Added Value of Computer Aided Architectural Design", Brussels, Belgium, 1997
- [Sari91] Sariyildiz S. "Conceptual Design by Means of Islamic-Geometric-Patterns within a CAAD-Environment" PhD-thesis, TU Delft, Faculty of Architecture, 1991
- [Sari95] Sariyildiz S. "X-Dimension in Building" Inaugural Speech, TU Delft, Faculty of Architecture, 1995
- [SaSc96] Sariyildiz S., Schwenck M., "Integrated Support Systems for Architectural Design"

Proceedings of the 3rd Conference on “Design and Decision Support Systems in Architecture and Urban Planning”, Spa, Belgium, August 1996

- [ScBr93] Schefström D., Broek G. van den, “Tool Integration - Environments and Frameworks”  
John Wiley & Sons, Chichester, 1993
- [ScVö96] Schwenck M., Völker H., “Modelling the Architectural Design Process - Analysis of Traditional Methodology and Approaches to the Future”  
Report, TU Delft, Faculty of Architecture, 1996
- [TO&I94] “Report On Research Activities”  
Internal Report, Chair “TO&I”, TU Delft, Faculty of Architecture, 1994
- [Wolf93] Wolf P. van der, “Architecture of an Open and Efficient CAD Framework”  
PhD-thesis, TU Delft, Faculty of Electrical Engineering, 1993

# The CIAD-System - Multimedia Teachware as a Driving Force for CAAD

**Sevil Sariyildiz**  
**Mathias Schwenck**  
TU Delft  
The Netherlands

*Software systems for educational purposes have been developed and used in many application areas. In this paper we will describe a development in the field of architecture and building science. CIAD is a teachware system directed to be used in the education of students of architecture as well as a tool that gives a survey to architects and engineers in the practice. In the first place it provides information about the use of computer science technologies in the building design process. Furthermore, information about the architectural design process itself is included.*

*CIAD is a modular system which can be extended and updated easily. After giving an overview about the system, a module dealing with the detailing of a building design will be explained in-depth. By means of different examples the user gets information about the process. In animation sequences made from different renderings of example designs the process is explained. After that the user is requested to re-execute the different steps.*

*By means of this teachware we create an environment where the user learns more efficiently by working with examples that are made by various CAAD-programs. Additionally to the primary purpose to give an overview concerning the use of information and communication technology (ICT) for architectural design, the user will be motivated to use ICT as a medium for future work.*

**Key Words:** *Computer Aided Architectural Design, Teachware, Multimedia Techniques*



# **The CIAD-System - Multimedia Teachware as a Driving Force for CAAD**

## **INTRODUCTION**

The application of computer programs for teaching purposes has been a field of interest since the 1960-ies. At the beginning there was an estimation that computers, called “teaching machines”, should be able to take over more than 50 % of every kind of education in a very short time. The development so far includes many projects resulting in inappropriate computer aided learning systems. It has shown that this expectation was significantly wrong. Furthermore, the overrating of the possibilities in computer aided learning or teaching has caused many reservations with respect to the use of computers for educational purposes [Wolf92].

In the last years the situation has changed because of new technologies like multimedia. Their common use has been enabled by the significant increase of hardware performances and other developments in the field of computer science. Another reason is that people in general are used to audio visual presentations, e.g. television, computer games, etc. and tend to pay more attention to this kind of presentations than conventional ones.

About the role of computers in learning processes [Parn92] stated that computers are powerful tools for education people. The main reason is the fact that the people are fascinated by the interactivity of the computer. In this way computers are very good means to provide motivation for learning.

Comparing the statement by Parnas with the problems mentioned above the contradiction seems to be obvious. [Maye92] has also taken into account this problem and presented the conclusion that the approach of computer aided learning did not fail because it does not work. Computers were even very effective for learning *given the right context and the right support*.

Therefore, we conclude that general problems that have to be taken into consideration in the development process are:

- Is the context in which we want to use teachware suited for computer aided learning?
- Which kind of support is needed to provide an effective way of learning?

- How can we avoid known disadvantages of traditional teachware?

These questions are discussed in the context of the CIAD-project in [SaSJ95]. There has been given a positive answer to the first question. Furthermore, the realisation concept for the development of the project is described. That includes the concepts that have been applied to solve the other two problems mentioned.

## **THE CIAD-SYSTEM**

CIAD (Computers In Architectural Design) is a teachware system developed for two general purposes:

- (1) to provide information about computer science technology applied in the architectural design process
- (2) to provide information about the architectural design process using these computer applications.

CIAD is a teachware system directed to be used in the education of students of architecture as well as a tool that gives a survey to architects and engineers in the practice. It has been developed in the context of a European COMETT project financed by the European Community for 3 years. The main aim of the project was to give support to the people who are working in the building industry about the newest developments in the field of computer science, but also to make this information available for students of architecture.

One of the starting points for the teachware was the general life cycle of a building consisting of several phases as shown in figure 1:



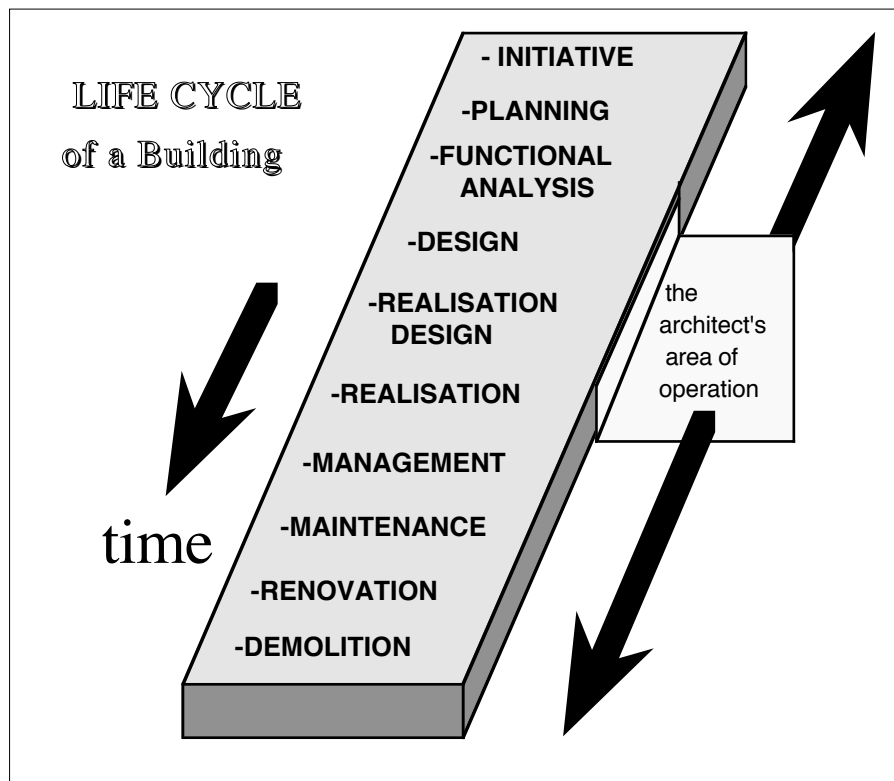


Figure 1: The life-cycle of a building

The developed teachware program deals with the Conceptual Design and the Materialisation as two parts of the life cycle of a building. In addition, a general overview is given about the application of information and communication technology (ICT) in the building sector.

So, there are three main subjects which are taken into account, namely:

1. an overview about ICT for the building sector in general
2. design aids for the conceptual phase of design
3. existing and also to be developed tools for the materialisation phase of design.

While doing this, we built up the software in such a way that the trainee has the possibility to get information about these subjects, to look at the examples and also to practice this knowledge by means of the software. Existing hardware and software for building technicians and architects as well as new research in the field are considered.

The teachware is programmed in a Macintosh environment with the "Authorware Professional" program by Macromedia, Inc. This program can be considered a high level programming language for multimedia applications. It is very suited to make visual interactive displays for learning purposes.

CIAD is a modular system consisting of various modules. In general, the modules could be divided into two categories:

*(1) Primary Modules*

All modules directed to impart knowledge about computer aided architectural design.

*(2) Secondary Modules*

This category contains all modules related to general topics such as the use of computers in the building sector or to fundamentals.

The classification does not imply an order of importance. It is only based on the fact, that the primary modules are directly related to the subject. In contrast, secondary modules are dealing with the context in order to impart basic knowledge.

The primary modules can be classified depending on the kind of learning mode. We support three modes:

- *“Theory”*

This modules are directed to impart theoretical knowledge about the subject discussed. The main goal is to extent the knowledge of the user about the concerning field.

- *“Practice”*

In this modules the knowledge already imparted will be illustrated by means of examples. Practical aspects are discussed.

- *“Exercises”*

The user get the possibility to make exercises or is requested to make some tests.

These problems are discussed in-depth in [SaSJ96]. In the next chapter we will focus on a specific module dealing with a detailing exercise.

## **AN EXERCISE MODULE FOR THE DETAILING PHASE**

In the teachware we try to give examples that show the possibilities and impossibilities of information technology for the building sector. Furthermore, the teachware is practice-oriented. “Real-world”-problems in building design are simulated including the way in which the computer may help to solve them.

For the teachware a design of a small building was developed. This design was made in several variations of materials, building elements and building techniques. Each step is simulated within the teachware

environment. The user is able to (re-)build the design within the computer. In this way, the design is used as an example to let people practice with the teachware and, at the same time, they learn something about the detailing procedures. So, the user learns while working.

In this section we will describe a primary module dealing with an exercise related to the detailing of a small building. This module is mainly directed to be used in the education of students. By means of different examples the user gets information about the detailing process. After that he is requested to re-execute the different steps in the correct order.

To realise a scoring system which records and checks the work of the student the user is requested to answer some questions regarding his identification. Features that are stored for every user are data for user identification (name and study number), information about the parts of the module finished including the achieved results and the overall result. A side effect of the recording facility is the possibility to individualise the communication with the user by individual comments including his name.

The figure 2 - 17 on the next four pages give an impression of a part of this module. It covers the construction of a simple wooden building as shown in figure 2. The house consists of different sub-elements which have to be composed in the right sequence.

In general the exercise can be divided into two parts:

*(1) Demonstration of the Process*

In an animation sequence made from different renderings of the example design the composition process is explained (figures 3 - 9).

*(2) Re-execution of the Process*

The user is requested to compose the different elements in the correct order as demonstrated in the first step. After selection an element the system checks the correctness of the selection and gives explanations. If the selection is correct as shown in figure 10, the user gets some information about the element he composed in the right way and is requested to go further. Otherwise the error is explained and he gets a second chance to select the correct element (figure 11). If he fails again, the element is placed automatically with an extended explanation. The figures 12 - 17 give some further snapshots from the process. At every time the user is able to get general information about the materials the house consists of by clicking on a specific button.

More detailed information can be found in [SaSJ95].

Figure 2 - 3

figure 4 - 9

figure 10-11

figure 12-17

## SUMMARY AND CONCLUSIONS

1. There is a need to develop such teachware for self-learning, because teaching in the concerning field is a time-consuming and expensive happening if it is done with traditional methods.
2. A general concept has to be developed which handles the various specific themes.
3. While developing teachware, there is a need for a teamwork with various specialists like architects, building technicians, computer scientist and even students to test it.
4. Developing teachware is time-consuming, but if you have it, teaching time is very short or even nothing.

In order to answer the question what the added value of such teachware is, we have to take into account the following three features:

- Because of the dynamic by using movies, videos and especially the spatial 3D visualisations within the teachware, there is a faster learning and understanding of the things compared with the traditional way of teaching.
- Teaching time is much shorter.
- The human being is visual oriented, so using teachware is a natural way of learning. The enthusiasm to learn things increases significantly.

## References

- [Maye92] Mayes J.T., "The 'M-Word': Multimedia Interfaces and Their Role in Interactive Learning Systems"  
In: Edwards A.D.N., Holland S. (eds.), "Multimedia Interface Design in Education"  
Springer-Verlag, Berlin, 1992
- [Parn92] Parnas D.L., "Software - Allheilmittel und Rauschgift"  
In: Dette K., Pahl P.J. (eds.), "Multimedia, Vernetzung und Software für die Lehre"  
Springer-Verlag, Berlin, 1992
- [SaSJ95] Sariyildiz S., Schwenck M., Jander E., "CIAD - A Multimedia Teachware - System for the Field of Architectural Design"  
Report, TU Delft, Faculty of Architecture, 1995
- [SaSJ96] Sariyildiz S., Schwenck M., Jander E., "Multimedia Teachware in the Field of Architectural Design"  
Proceedings of the 3rd Conference on "Design and Decision Support Systems in Architecture and Urban Planning", Spa, Belgium, August 1996



- [Wolf92] Wolff M.R., "Computerunterstütztes Lernen in der wirtschaftswissenschaftlichen Hochschulausbildung - Status und Anforderungen"  
In: Dette K., Pahl P.J. (eds.), "Multimedia, Vernetzung und Software für die Lehre"  
Springer-Verlag, Berlin, 1992



## Space Syntax, an Inspiring Design-Tool

**Guido Stegen**

Architectenbureau Stegen - Remy  
Belgium

*The space syntax system which is presented in this paper has been developed to help the designer to evaluate and to define the form of complex spatial environments, especially the urban structures. The system has a double nature. On the one hand, it is a way to consider those environments. On the other hand, it includes an computerized model which calculates, on the basis of morphological properties of the spatial environment, several output-variables which represent measure, in which certain urban phenomena are spatially distributed. Instances of urban phenomena are: circulation, framing, functions, population... These correlations oblige the designer to take into account those urban facets at every stage of the project. The disciplinary fragmentation is then made very difficult for him. Besides, the contradictions or incompatibilities from local-global interests become an integral part of the urbanity. Those correlations re-open also a track which seemed to be abandoned - the one of the functionality of the urban and architectural structures - and, therefore, force the designers to confront their social responsibilities. All this has been made possible thanks to a categorical revision of what is essentially the city. According to the theoretical framework of Space Syntax, environments are above all considered as a distributive system of spaces and less of buildings.*



## SPACE SYNTAX, an Inspiring Design-Tool.

### Introduction

Paul KLEE used to say that ‘art not represent what visible is, but makes visible’. It makes conscious of realities who are hidden behind other signs, concepts, images, biases. “Models are a matter of inspiration, not deduction ...” (B.De Moor,1994) suggests that the same conceptual dimension can be given to models. Then we use them more like metaphors, who help us oversee complex situations in a non-analytic way, without reduction. This definition stands far away from what we usually expect from models. Generally one prefers models with a high prediction-capacity. But experiences with predictionmodels has shown that theoretical scientists and practitioners have different images of the ideal model, due to what engineers call the existence of a ‘trade-off’ between robustness and performance: the more precise a model can predict a situation, the more he’s sensitive to small deviations. In some applications the use of computertechnology and the integration of feedback-control can reduce this effect into acceptable proportions. Even then, models work as long as the systems they are trying to simulate, are highly consistent.

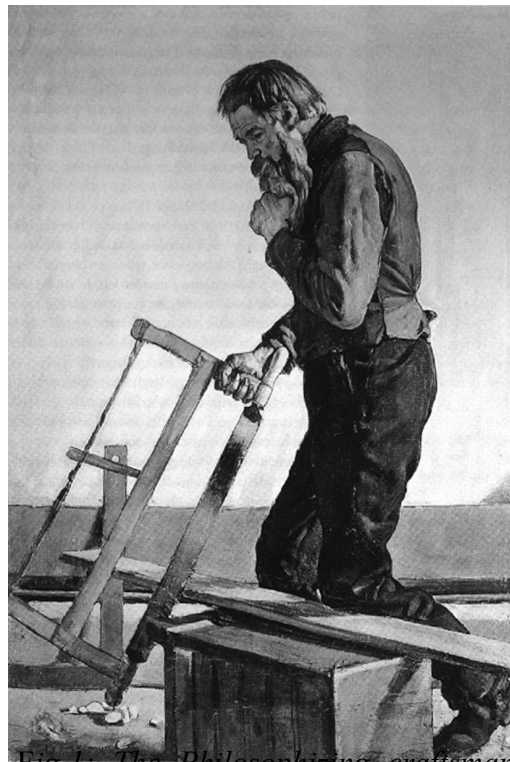


Fig.1. *The Philosophizing craftsman* by Ferdinand HODLER (1884)

What can we allow a computer to do when he’s confronted with non-consistency and contradictions? This is still one of the fundamental questions in the development of artificial intelligence. Do we ask him to be statistically relevant, or random, reasonable or maybe brilliant? Some scientists hope that in the future a quantum-computer-technology will be able to deal with contradictions by generating parallel procedures and using suspended decisions, the possibilities. However, once these possibilities fall down into irreversible positions, somewhere between probability and a smart accident. The fall of the contradiction is a question of time. The practitioner in environmental design experiences that many contradictions occur in the legal, historical, technical, sociological, economical, cultural context of his projects. Cities are known as the most complex artifacts, containing complex processes,

caused by a more and more complex population. By then, deductive or inductive methods lead to highly arbitrary decisions.

The model I'm invited to present here, is a successful compromise between 'the matter of inspiration' and the predictionmodel. 'Space Syntax© is a set of techniques usually, but not always, involving computers for the analysis of spatial configurations of all kinds, especially where spatial configuration seems to be a significant aspect of human affairs as it is in buildings and cities. Originally conceived by Professor Bill Hillier and his colleagues in the Bartlett School of architecture and Planning at University College London in the 1970's as a tool to help architects simulate the likely effects of their designs, it has since then grown to become a tool used around the world in a variety of research fields and applications. It has been extensively applied in architecture and urban design, and more recently has been used for researching problems specific to the planning, transportation and interior design fields. Over the past decade, Space Syntax techniques have also been used for research in fields as diverse as archaeology, information technology, urban and human geography, and anthropology'<sup>1</sup>. Books and articles published on this theme are mentioned in the appended references.

For the UCL-developpers, the combination of inspiration- and predictioncapabilities was an essential part of the underlying scientific approach, close to the Popperian vision. This claims that, when the research-object is complex and full of internal contradictions, an hypothesis or proposition is scientifically acceptable only if falsification is possible. In such a pragmatic scientific approach, the mechanisms behind the correlation between the observation and the outputvariables, are not the major points of interest. Put into practice, the propositions are first used as 'problematic regulative ideas'. Further, the falsification needs also output-variables, produced by the model, proving significant correlations with observed facts. The Space Syntax system has this double nature and that opens a field where the several disciplines, concerned in urban and building design, can find common points of impact.

## **The functionality of the environmental design**

If we examine the utility of the CAD, we inevitably arrive at the question of the task of the designer. Since the belief in the functionality of architectural and urban structures has strongly diminished, the tendency exists to consider the means utilized in the design from an auto-referent point of view, that is, to see in which measure the means are allowed to express themselves better. On the other hand, the configurational modelling finds its interest above all in the stages which precede the presentation and the expression. Because of its 'hard-ware'-character, architecture cannot set aside the question of the general interest in time and space. Indeed, "*First we shape our buildings and then they shape*

---

<sup>1</sup> Mentioned on the brochure for the International Space Syntax symposium on the 16-18/04/97.

us"<sup>1</sup>. The criteria used to define the quality of a proposition are far from being universal. Nevertheless, it seems to me obvious that projects which concern a large heterogeneous population will have to answer to utility and interest criteria vastly different from those which are reserved for individuals. The criteria of general interest reach us by way of democratic, scientific institutions, but remain highly abstract. The risk of paternalist behaviour from the environmental designer is in this case real. This trap can be avoided by questioning the functionality of the project. What is the problem? Is this really a problem? For whom is this a problem? Is my proposition an answer to this problem? If the answer is no, the proposition is paternalistic and it has an interest only for a reduced population. The would-be interest must be the result of the interest of the majority.

I conclude from it that the urban project must be functional. But which functionality can still be credible? Designers reject more and more this idea because of the "skid" which has taken place in the past. The origin of the defeat and at the same time a new hope are summarized by the following dialogue: "*Une maison est une machine à habiter*"(Le Corbusier, 1923). "*But I thought that all this functionalist stuff had been refuted. Buildings aren't machines*"(Student). "*You haven't understood. The building isn't the machine. Space is the machine*" (Nick Dalton, Computerprogrammer at UCL)<sup>2</sup>. The pertinence of this answer is defensible on the basis of the Space Syntax system.

## Which functionality of the form?

The modernist functionalism used to be very mechanical. It tried to realize a functionality between the form and the singular fact. This implies a specialization on behalf of certain possibilities but to the disadvantage of many other possibilities. Instead of a functionalism of possibility, appears a functionalism of impossibility which culminates in "zoning". This system of rules puts the responsibility on the individual who must manage to organize as best he can, the imposed function. Zoning is the summit of the functionalism of the non-possibilities or of non-functionality of the built environment. This defeat has led to an anti-functionalism which is translated in "Where there is nothing, everything is possible..." (R.Koolhaas, 1996). In the light of this statement, we can ask ourselves if at the end "...everything must be possible everywhere?"

The mechanistic functionalism as well as the anti-functionalism are aspects of a functionalism of possibilities. The functionalism which is here defended, and for which this model can be useful for us, is a

<sup>1</sup> This statement is been attributed to Schweitzer, Bakeme, Emmerson, but mostly to Churchill.

<sup>2</sup> Extracted from Space is the machine p.VII, Bill HILLIER.

functionalism of probability. It is a functionalism which is not pointed at the singular fact, but based, in a statistical way, on deterministic and spontaneous evolutions. *"The view of self-organization takes into account the 'collective' dimension of individual actions, and emphasizes that individuals acting according to their own particular criteria may find that the resulting evolution of the system may carry them in an entirely unexpected direction, ...and this results from the fact that for non-linear systems, the whole is not given trivially by the sum of the parts."* (ALLEN P.M., 1981). If the management of the environment is helped by such a determinism, it can limit itself to the possible correction of the excesses and not, like in the case of the non-functionalism, to see itself constrained to interfere with each singularity. Because of their formal complexity and their population, cities are the ideal frame for this functionalism of probabilities. Maybe, we should restate what used to be said between the thirteenth and the nineteenth century: *"city-air makes free"*.

The big divergences that we have to accept in this approach between singularity and globality imply a redefinition of both responsibility and the task of the environmental design. The acceptance of their unavoidable character should lead to the management of the social and lawful contradictions to which we have referred at the beginning of this text. *"The contradiction between particular and general interest receives very few attention in the decisionmaking. However appears a great disparity between 'who wins, who loses and who pays'"* (J.KORMIT). This discomfort affects particularly the authors of projects. More and more, they have to notice contradictions between what they considered and their propositions or between their propositions on the global scale and those on a local scale. In order to have access to possible solutions, it is therefore high time to recognize this problem. In the presence of those divergences and of this recovered functionality, the task of an environmental designer in a society ought to be to propose and to inform the society of the spatial conditions which are necessary for the desired development. The sense or nonsense of the configurational modelling, informatized or not, depends principally on its ability to help designers in this mission.

### **Which determinism for a functionalism of probabilities?**

We have pretended before that the morphology of space has an influence on the development in a deterministic way. This implies the two following questions: 'What are the conditions for a determinism to exist?', and 'Do those conditions already exist in space?'. For the theoretical<sup>1</sup> bases of the hypothesis of this subject, I have to be quite dogmatic and to refer the reader to other publications. On the basis of what one accepts about what happens in complex processes in different fields, we can suppose that two conditions are necessary.

The first one concerns the environment in which the process takes place: *"For open systems, where energy and matter can and do flow through the*

<sup>1</sup> Of psychological, phenomenological and philosophical kind



*boundaries, then the system can exhibit spontaneous self-organization". (P.M.ALLEN, M.SANGLIER, G.ENGELEN, F.BOON, 1985. "Dissipative structures apparently go in the opposite direction to the law of entropy and are able to diminish locally the entropy and can create order out of chaos". (H.VAN BELLE). The dissipative spatial environment is above all the public space. It is the urban space and it generates the developments. Compared to this first condition for deterministic and durable developments, we can note that the actual tendency to fragmentation and specialization of spaces, leads us in a wrong direction.*

The second condition is related to the influence of the human substance on the transformation of places. It has been previously claimed that the global effect cannot be obtained by addition, deduction or induction of the composing parts. The condition is the existence of what used to be called occasionally an attractor. This is an unchanging fact, even small and implicit, in the majority of the dynamic substance in the system. In the urban system this is the human behaviour. This attractor will necessarily appear through the interaction between the environment and the human behaviour.

- The interaction includes three processes which influence each other and resupply themselves by feedback. Environments are transformed according to the effective use that we make of them. By this, we mean material and social environments and concerning the use, we mean the physical use. Places must be physically accessible.
- The second process concerns mental accessibility: humans use environments if and like they know them.
- People know an environment through perception. For the spatial behavior, it's the view which plays a predominant role, because it informs us in a very precise way about our position and movements.

A space undergoes then transformations if it is perceived (PER), known or conceptualized (CON), and if it is accessible or available (AV). For those reasons, we see a complex spatial system as a system of elementary spatial relations PER/CON/AV, linked together. Therefore, such a network is often called a topological network. It can be considered like a "mental map" but without objects. The most exclusive or fragile link in the feedback mechanism of the PER/CON/AV system is the CON stage. As soon as we forget a place, we lose any intention directed towards this place. Moreover, even though we have an image of a place, but if the spatial relation with this place, the path, is not known by us, the place becomes de facto inaccessible. It is in this weak link (CON) that we will look for the determinism because it has a critical position in the survival of purposive acts. It is in the conceptualization phase of the environment that differences of accessibility should appear and that our spatial behavior will be differentiated in a deterministic way. Complexity seems there, like in many other domains, to be the determinative and differentiating factor. Complexity is "more object", disorder, unintelligible and inaccessible. Confronted with complexity we become "more subject", dependent and unfree. For spatial behaviour it is the complexity of the path, also called the topologic depth, that is probably the determinative factor of accessibility of a place. If this hypothesis is

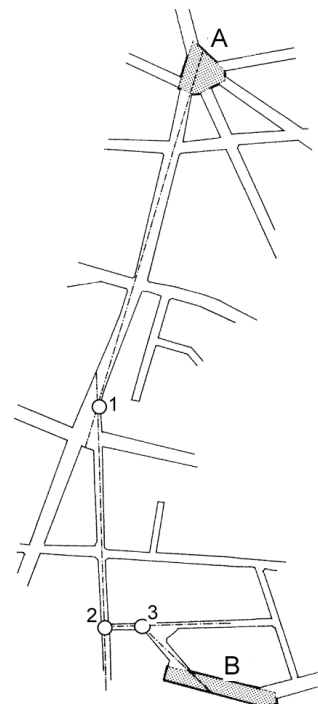
correct, complexity joins the economical criteria accepted as decisive for the choice of the pathways, for instance the metric distance, duration, the costs, etc... This hypothesis will appear so obvious that the economical criteria become often accessories. Complexity takes a lot of our mental reserves. It is yet to be demonstrated whether these hypotheses can be falsified.

### **Necessary variables for falsification and prediction**

*"To be is a value of a variable"* (W. Van Orman Quine, 1939). How are we to attribute variables that express the degree of accessibility of places and whose correlation with reality can be checked? How can we formalize a spatial elementary element (called PER/CON/AV) and from there formalize the complexity of a pathway? I propose to see such elements in an instrumental way (cf. J. Dewey). That means that components of knowledge are models or concepts generated outside the reality. Those elements don't have a reality which precedes this process of knowledge. They are not reductions but abstractions of the reality. Because of that, transformation into abstract elements is an interpretation of the reality. In the application of the Space Syntax model, the transformation such as I will explain hereafter is only the general rule which is often re-examined according to the principle, already explained, of the tendency towards simplicity in the conceptualization of our surrounding world.

#### **Input-variables**

Reality has been taken into account as follows for the input of the model. The example taken is the example of the public urban space since this is the most accessible and the most dissipative one.



1. Within the outlines of this space, we draw the way between couples of places by means of a minimum of interconnected straight lines.(see figure 2). These lines represent the elementary spaces, the components of the model (PER/CON/AV).
2. Further, the obtained network is revised until he contains a minimum of lines. The first condition is always respected.

This network is the input for the computer program Axman, which is part of the Space Syntax system. On the basis of this network, the program gives a variable to each line.

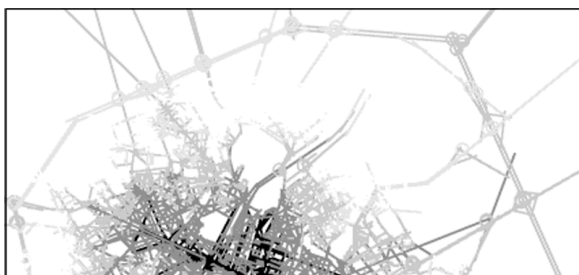
**the Relative Depth (RD)**-value of one space in relation to another is the topological inter-distance. This value corresponds to the number of folds and knots on the way between the two spaces. On the figure 2, the RD between A and B is 3. Figure 3-a and 3-b show two different depth patterns in the Brussels Region.

**the Mean Depth (MD)**-value of a space is the average value of the RD in relation with the other spaces of the spatial system concerned. The spaces with a low MD-value are called swallow spaces. They are mainly responsible for the coherence within their environment. The program doesn't always take into account all the spaces of the network. The operator (programmer) can ask the MD-value of a space for a set of lines, limited to a specific depth from that space (MD3, MD4,...). When all the lines of a network are taken into account, the symbol is MDn.

**the Connectivity (Conn)**-value of a space, or a line, indicates the number of other lines to which a line is connected.

**the Integration (int or R)**-value: of a line is the reciprocal of his relativised mean depth value. Then a swallower or more integrated line acquires a greater value than a deeper and more segregated one. Like for MD, the integration value can be asked for a local or global environment. Here too, the symbols comprise the depth which is taken into account. For example, R3 is the integration value of a line, taking into account an environment limited to a depth of 3. All the sizes of the environment are possible as far as the total network. In this last case, the symbol is Rn, similar to MDn. Thus, a distinction is made between the more local integration values (R3, R4,...) and the more global integration values (R8, R9,...Rn). As, shown on the figures 3-c and 3-d, global and local integration patterns may be very different. The differences signify that the spatial coherence is not understood in the same way by local people and by people living outside the area (district). When global and local integration patterns are quit different, the local and global users behave differently and they seems unpredictable for each other.

*Figure 3-a*



*figure 3-b*

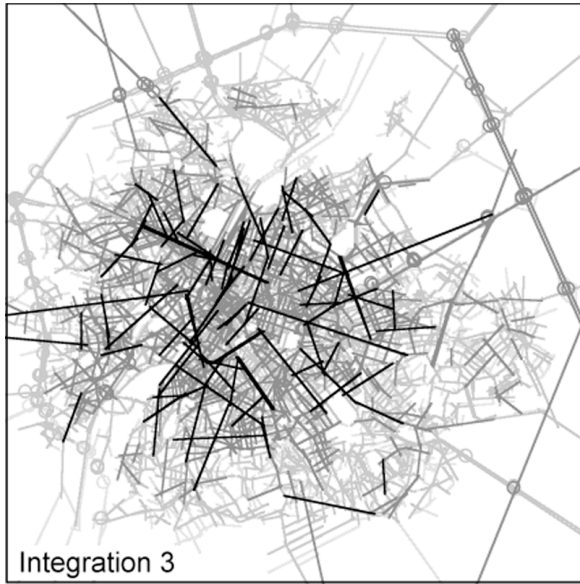


figure 3-c

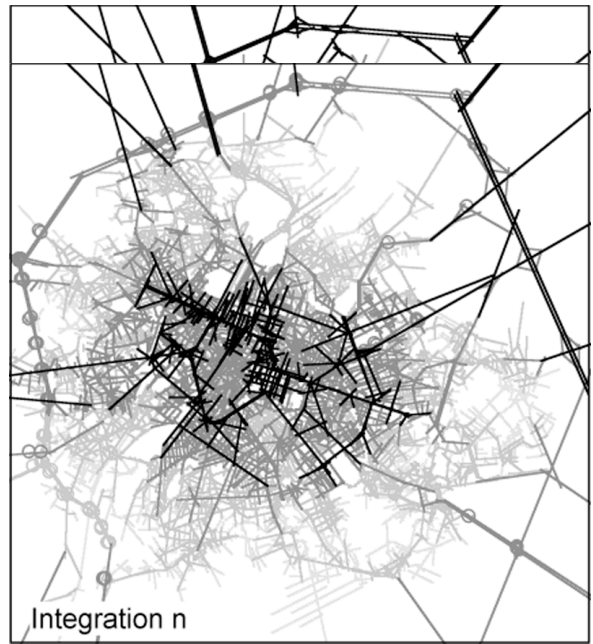


figure 3-d

### Correlations between variables and reality, falsification and prediction

Correlations between observations and modelvariables indicate that mental accessibility, mathematically defined in the variables, plays a decisive part in urban determinism. Of all the possible spatial behaviour, presence is of course the most elementary. Because of the nature of the supposed attractor in the determinism, by the mental accessibility, the observed movements and the spatial integration should above all be related. That seems to be the case.

Figure 4 shows the correlation between pedestrian movement (men, 8->10a.m.) and a combination of local integration and building density in the historical center of Antwerp. The two black dots represent the Meir, the major shopping street. Generally, shopping streets overact because of the so called amplifier-effect. Without this space, the correlation  $r=0.81$  becomes  $r=0.93$ .

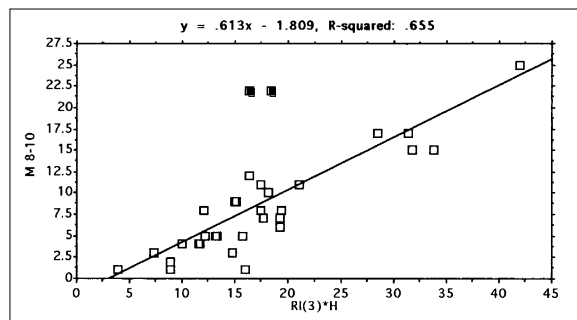


fig.4

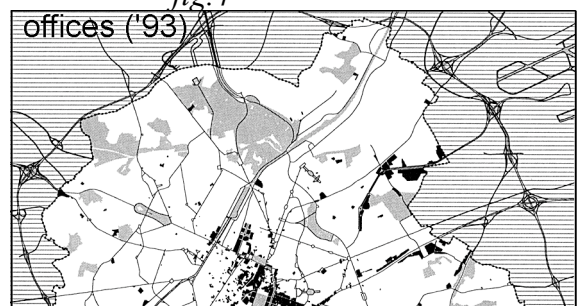




fig.5

fig.6

Figure 5 shows the degree of road-saturation by motorised traffic in Brussels, correlating most with a global integration pattern (Rn) represented under fig. 3-d. Also the distribution of land use and built density follows the morphological characteristics of the streetgrid. Figure 6 shows that office buildings and areas are mostly located where global integration (3-d) is high and topologically close to the highest

integrated space (3-a).

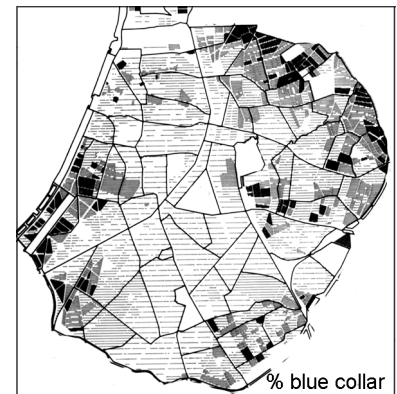
fig.7-a



fig.7-b



fig.7-c



That land- and building-values and also environmental quality often correlate with spatial integration is probably responsible for the correlation we can see in figure 7: that a population with a higher income generally lives in more integrated spaces.

All those simple relations between facts and the values of the variables are visible on the scattergrams and on maps. But, the available maps based on statistical sectors falsify the image of the phenomena because they lack a homogeneous repartition of these phenomena within the zones. Therefore, we tend to attribute the data on the PER/CON/AV-elements, i.c. the Space Syntaxlines, either than to zones. Used this way, The Space Syntax model becomes an aid for perception (Computer Aided Perception) even before being an aid for design (CAD).

## The local-global interface

One may come to the conclusion that the model is good, when its output variables correspond with the observations. But, this is by no means a quality criterion of the environment. The high or low values of the variables may not automatically be considered as indications for the spatial quality<sup>1</sup>. Nevertheless, also the spatial quality can be measured by means of the model. It is the so called local-global interface or the degree of synergy. The arbitrary aspect of the correlations between the phenomena and the variables can be wiped out by using double correlations or double proportions. In this case, the relations between the variables of the model indicate the quality. Up till now, the observations confirm the following hypothesis: that the patterns of the different variables must be interlinked. For example :

- a good correlation between the local and the global integration creates a state of synergy, favourable for development and stability.
- as the previous one, a good inverse relation between the integration values and the values of the relative depths from generators of presence like stations, motorways exits, shopping malls, office clusters, ...)
- a good correlation between the integration values and the connectivity enables the spatial structure to be intelligible and therefore more accessible.

The state of synergy makes that the urban scales do not contradict each other and pays its contribution to a spontaneous non-conventional social synchronization. Implicitly, the individual feels then confirmed by the spatial behaviour of his social environment. *“These local to global correlations between spatial properties are exactly what allow the parts of cities to come together to form a global whole, and more importantly, they are what makes the urban network intelligible to us - whether we are pedestrians or drivers. Essentially, intelligible space allows individuals to behave in a rational way as they move around the city and so to gain autonomy. At the same time, the consistent relations between local and global movement patterns are what allows us to work, sell or live. It is the effects of the configuration of urban space that allows individuals to behave rationally which would seem to be precondition for the social function of the city and so for the civilization of new techno-logical innovations such as the motor car ...”* (Penn A., Hillier B., Banister D., Xu j. - 1993).

The need for synergy is applicable to an entire network as well as to a local part of a network, as for instance a neighbourhood. It is on the basis of these characteristics that areas are defined in the Space Syntax system. That is to say: looking for an area, a locality, means looking for a

---

<sup>1</sup> It is tempting to associate disquality to segregated space, because of occurring correlations, like for example: land- and building value, decay of the environment, socio-economical characteristics of the population, etc. This should not be done since those phenomena are of social interest and they are acceptable if kept within certain limits. Moreover, it is possible that the correlation will become the reverse if the price of the mobility continues to raise.

set of spaces where the variables are the most correlative. Mostly, the spaces of those clusters have developed in the same period and under the same morpho-sociological circumstances. It has not been proved yet that the recognition of the areas has any importance for the environmental policy, but it has been clearly established that, the correlations between the movement observations and the model variables are much better if areas are defined as described above. Figure 8 shows how the local-global interface can be visualised by scattergrams. The gray dots are all the public spaces of the Brussels Region. The black dots are the spaces making two different areas. The Leopold-area, a business district, shapes a local scatter, close to the local regression line. The Marollen, a more marginalized cluster, has a layered scatter; this is an indication that the local/global-interface is broken.

fig.8

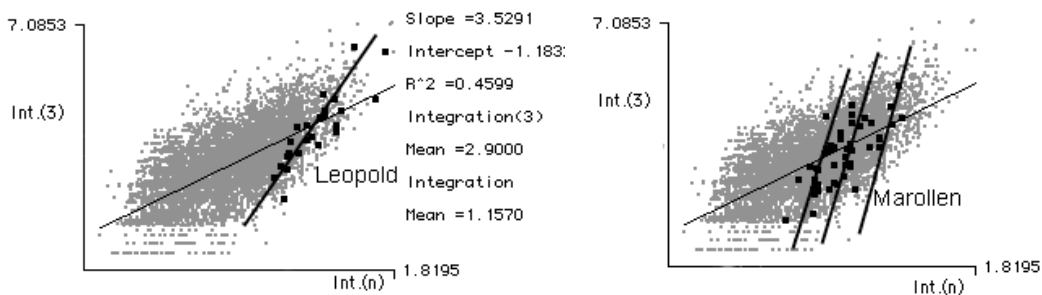


Figure 9 shows that entire towns (here Brussels and Antwerp) can be seen as mega-clusters and that even on that scale the local/global-interface is still a qualitative description of space. The table indicates by several numerical characteristics that the spatial coherence and harmony are better in Brussels. This is confirmed by the graphs which shows that insecurity is lower in Brussels. This correlations between insecurity and the local/global-interface exists have also been seen by examination of smaller areas in towns.

|                      | **  | Brussels | Antwerp |
|----------------------|-----|----------|---------|
| mean depth*          | (-) | 7.548    | 8.673   |
| mean Connect.        | (+) | 5.796    | 4.874   |
| mean R3              | (+) | 2.900    | 2.630   |
| mean Rn              | (+) | 1.157    | 0.941   |
| corr.coëf. depth*/Rn | (+) | 0.781    | 0.744   |
| corr.coëf. Conn/Rn   | (+) | 0.256    | 0.184   |
| corr.coëf. R3/Rn     | (+) | 0.460    | 0.304   |

\* = depth from the most integrated space  
 \*\* : (-)= a low value is better / (+)= a high value is better

Fig.9-a

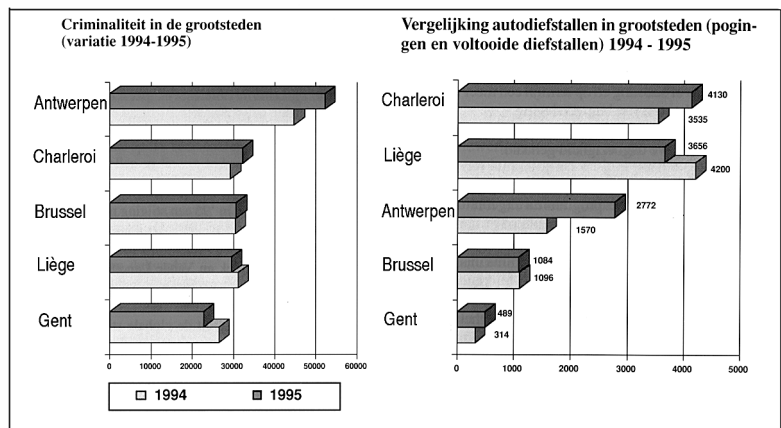


fig.9-b

## Space Syntax as a design tool

All the examples given so far, show that the model is able to give us a reliable image of spatial potentials. But the essential aim of configurational modelling is to help with the elaboration of projects and to conduct and guide developments. Because of the good correlations between the movement and the model variables of centrality, it is obvious that Space Syntax can be used for the configuration of urban movement networks. It has been established that “*the configuration of the street grid, the capacity of the street segment, the distribution of land uses, the distribution of development density.*” (A.PENN, 1993, p.12) influence differently the intensities of vehicles and pedestrians. By modulating these morphological and functional factors, the townplanner can arrive to a better controlled relationship between “speeds”. Those factors, each one in its own way, have also an influence on what is called the global-local interface. They can correct morphological disharmony. Nevertheless, since their evolutions are deterministically linked to each other, their correction-capacities are restricted.

In a concrete project, the model is a mean of supervision and control. This is due to his non-metrical character. Once an architectural and structural proposal has been metrically elaborated (forms, densities, programs,...), his topology can be verified and checked by means of the model. Shortcomings can be corrected by changing the configuration of the street grid, the building density or the land use. The most difficult, but certainly the most rewarding utilization of the model consists in its use as a means of evaluation of an existing urban structure in order to define the simplest morphological adjustments, necessary to remedy of community problems. It is in this kind of application that the model is stressed since there is no other way to deal with this complex reality. Examples of the application by LaSE and G.Stegen&F.Remy-arch.(Brussels), of these techniques, resulting in instruments for the daily routine of the environmental policy are:

- The development plan for the central station-area in Antwerp (august 1995). Commissioned by the Belgian Railway Company (NMBS-SNCB) / Eurostation n.v.. This study had a triple interest. First: discover the origins of the decline of the large area around the central station. Second: evaluate the effect of the raising with 100% of the existing capacity of the station. Third: propose a development plan which discontinues the assessed urban disharmonies
- Particular lay-out plans (PPAS-BBP) in the area around the boulevard Leopold-II (1991-1993), one of the most integrated spaces in Brussels. Commissioned by the local authorities of the Commune of Molenbeek in the Brussels region.

In these documents the formal definitions of the buildings are limited to what's relevant for the urban potentials. Architectural details are absent. The land use requirements are allocated to space by using a matrix, filled by conditions which are linked with the potentials of spatial morphology, given by the Space Syntax model. This technique admit a certain flexibility of land use. Such instruments are different from masterplans, which are a different concept of the urban management.



## Behind the variables

From these surprising correlations, we can draw the conclusion that the morphology of the environment has undeniable repercussions on various urban phenomena. Of course, besides the field where the model is consistent, there are fields where it is not. This is inherent in the model which is one of spatial potentialities. In any case, systems like Space Syntax prove that it is possible to create instruments enabling the environmental designer to verify the functionality of his proposals. Continuous research with this model will increase its performances and sharpen the interpretation of variables. At the same time, its limits will become clearer. In view of the heterarchical character of the phenomena in the real world, it would seem necessary to adopt the means to this situation. Each model will take into account his sector of favourite pertinence. In the Bartlett School of Architecture and Planning-UCL, other computerized models are being developed of those who worked out Space Syntax. LaSE, the research cell of the architects bureau G.Stegen&F.Remy, in Brussels, made a model, called 'Sequence-2', which simulate and explain the variance in development within an elementary space. Combined with Space Syntax, it should enable a better understanding of the intelligibility of spatial environments. These researches require a systematic observation of the effects of the morphology of the space on events and therefore on its functionality. On the other hand, these models require of the users to take into account the laws governing space and the available margins.

When space, as the main subject of the project, gains its own rights, the quibbling over styles and façades will fade. The incompatibilities between global and local interest, between price and architectural quality, between the space and the object will disappear. This way of thinking allows the designer to work on a global and local scale at the same time. The global/local-interface makes contradictions relevant either than problematic. The inclusive thinking becomes an attitude due to the complexity of the model variables. Interdisciplinary contradictions will be diminished, or they will be accepted. It will be admitted that the morphology has correlation with various sector that are part of the architecture and the urban planning. A particular difficulty in the generalization of this approach seems to be the acceptance of determinisms in human spatial behaviour. Nevertheless, there is nothing "blasphemous" on making physical environments which consider human mind. It is surely not the case if it makes people feel free and in harmony with their social environment.

## Text-references

DE MOOR Bart (1994), Cirkelen om de wereld-Werelbeelden, wetenschap en technologie, p.127, Pelckmans, Kapellen.

HILLIER Bill (1996), Space is the machine : A configurational theory of architecture, Cambridge University Press.

KOOLHAAS Rem. (1996), S, M, L, XL, p.199

KORSMIT Jan. (1994), Stilstaan bij mobiliteit - Mobiliteit, een tweesnijdend zwaard, p.77 - Garant, Leuven.

ALLEN P.M. (1981), SANGLIER M., Urban Evolution, Self-organisation and Decisionmaking - Environment and Planning, volume 13, p.167-183.

ALLEN P.M. (1985), SANGLIER M., ENGELEN G., BOON F. - Toward a new synthesis in the modeling of Evolving Complex Systems - Environment and Planning B, Vol. 12, p.65.

VAN BELLE Hubert (1994), Cirkelen om de wereld - Het denkkader van de systeemtheorie, p.162, Pelckmans, Kapellen.

PENN Alan (1993), HILLIER B., BANISTER D., XU J. - Configurational modelling of Urban Movement networks - Bartlett Research, UCL, London.

## Figure-references

Figure 1: Filosoferende Handwerksman, painting by Ferdinand HODLER (1884)

Figure 2: LaSE and G.Stegen&F.Remy-arch., Brussels

Figure 3 and 7: Space Syntax model of the Brussels Region, made in 1996 with the Wizzy Axman-software (version 1.6.1) of the Space Syntax-system. Authors: LaSE and G.Stegen&F.Remy-architects, Brussels.

Figure 4: Observations made in Antwerp for the Belgian Railway Company (NMBS-SNCB) and Eurostation n.v., The development plan for the central station-area.(august 1995). Authors: LaSE and G.Stegen&F.Remy-arch. - Brussels

Figure 5-a: Ministerie van het Brusselse Hoofdstedelijke Gewest, 1993 - published in B.I.M.-rapport nr.9, (1994) by Brussels Instituut voor milieubeheer (BIM-IBGE).

Figure 5-b: represents Parcels destined for offices or office-projects - state 1/7/1993. Source: BRAT; production: COOPARCH-R.U. with BRUSSELS Urbis ®©-1.0.2. Published in the R.R.D. - GEWOP for the Brussels Region (3/3/1995) as fig.4.1.

Figure 6-a and -b: maps 25 and 31 in Kansarmoede in de Grootstad Antwerpen - Deel II published by the Koning Boudewijnstichting and the Universitaire Instelling Antwerpen (UIA). Authors: R. MARIJNISSEN, E. POPPE, Th. JACOBS, E. VAN HOVE.

Figure 6-c: Space Syntax model of Great-Antwerp, made in 1995, with the Wizzy Axman-software (version 1.6.1) of the Space Syntax-system. Authors: LaSE and G.Stegen&F.Remy-arch., Brussels.

Figure 8: Criminaliteitsstatistieken 1995, Kristien DESMET in Pretekst nr.11 - july 1996, p.10-11. - ed. Kluwer.

## Space Syntax-references

**Contacts:** Space Syntax Laboratory

The Bartlett School of Graduate Studies, (1-19 Torrington Place),

University College London, Gowerstreet London WC1E 6 BT  
Tel. +44 (0) 171 813 4364 - Fax +44 (0) 171 916 1887

**Personnel** : Prof. Bill Hillier <b.hillier@ucl.ac.uk>, Tim Stonor <t.stonor@ucl.ac.uk>, Alan Penn, Dr. Julienne Hanson.

**International Space Syntax Symposium:** 16-18th April 1997.

Symposium organiser: mark.major@ucl.ac.uk)

**Publications :**

Space Syntax, a different urban perspective, B. Hillier, J.Hanson, J.Hudson, R.Burdett - in The Architects Journal, 30/11/1983.

The Social logic of Space B.Hillier & J. Hanson / Cambridge University Press / 1984

The axis as symbol and as instrument B.Hillier / B.S.A. & P - UCL.

Against enclosure B.Hillier / Mai 1987

Configurational modelling of urban movement networks. A.Penn, B.Hillier, D.Banister, J.Xu /1993.

Natural Movement: or configuration and attraction in urban pedestrian movement B.Hillier, A.Penn, J.Hanson, T.Grajewski, J.Xu / 1993 / Pion London.

Space as a material B.Hillier / Association Internationale de Semmiotique de l'Espace / Conference at Berkeley / June 1994.

The Architecture of Society : stochastic simulations of urban pedestrian movement in SIMULATING SOCIETIES, in N.Gilbert & J.Doran (eds), ch.5, UCL Press London, 1994.

Space is the machine Bill Hillier / 1996 / Cambridge University Press.



**Drawing with Pencil, Pen  
and Mouse**

**Rob van Helvoort**  
Hogeschool West-Vlaanderen  
Belgium



## **Drawing with pencil, pen and mouse**

### **Using pencil and pen**

Only twenty years ago the traditional architect office often was a place where the architect designed with a soft pencil from behind his drawing board. In those days our school was a place where students graduated as secretaries. As many ended up in an architect office the idea was launched to create an educational profile which specially trained students for work in the architect's office; the Architect-Assistant was born. In those early days training focused on secretarial tasks with basic elements of drawing and construction.

Twenty years ago drawing by computer was an adventure which was started by picking up your pen, writing a computer program, typing the program code onto punching-cards, feeding the cards into a mainframe computer and, with a little luck, getting the result you wanted on thermal paper.

In the early eighties, the first CAD program on a personal computer made its debut. This program was able to perform with the same power as a minicomputer but only at a fraction of the cost. Besides, you no longer had to be a programmer to use it. This breakthrough made CAD an alternative for the drawing board. However, in the early days CAD was not exactly popular in the architect office. Drawings had been made by pencil for ages, the only investments needed being paper, pens and a drawing board so why change to a costly computer. A computer which also asked for a huge time investment in order to get to know the drawing functions of the CAD program. In the early days the personal computer was mainly introduced into the architects' office for the benefit of making up construction specifications and other documents by word processor or spreadsheet.

During these years students at our school were trained how to use a word processor and discover the advantages of a database.

### **The mouse comes in**

At the time of the rise of the personal computer the educational profile of training courses at school once more was redefined. Former secretarial subjects like accountancy and languages were dropped and training was focused mainly on the architectural and building world with subjects like strength analysis, properties of materials and Computer Aided Design. Being an Architect-Assistant, the actual design of a building project is no part of the training programme as the assistant starts to work from the rough sketches of the architect. Skipping the design process made CAD the perfect tool to offer to students in order to develop their drawing skills.

That is why, in the early nineties, the CAD program Robocad was

introduced at our school. The reason for choosing this particular program was mainly political as the manufacturer had excellent references from one of the highest education authorities and was able to offer the computer program at very competitive rates.

Although the program itself was all right to use and specific for architectural applications it soon turned out that nobody else in the professional world was using it. After extensive research amongst architectural offices and the building industry our school, in 1993, switched to AutoCAD, a general CAD program. Next to a widespread use, AutoCAD also has the advantage of a very open structure which enables the user to add anything to this program, from a customised menu item to a purpose written routine.

1996 saw the first draft of CAD trained students to leave our school. They graduated with extensive skills in drawing by computer. We were perfectly able to judge this during the training program as they had to use CAD in their own work. Next to drawing, the students were also able to fine-tune the CAD program in order to be more effective, a quality which made these students even more competitive to the industry.

However, we didn't get to that result just by teaching our courses. We learned that we have to keep students' feet firmly on the ground as drawing by computer should not become a target in itself. The fact that one draws by computer doesn't make one a better draughtsman. It is a general fact that a CAD drawing might look a lot better than a drawing on the board as, for instance, text always will be placed as neatly as can be. Drawing by computer comes in very handy when you have to repeat identical elements, tedious hatching suddenly becomes a pleasure but still you have to know what you are doing. Drawing by computer doesn't mean you can stop thinking.

## **Making CAD CAAD**

So far we only talked about CAD drawing; using the computer to improve what you previously did by using a pencil and a pen. It is beyond any discussion that Computer Aided Design has advantages compared to the traditional way of drawing. These advantages are not specific for the architectural world, anybody who used to draw by using a pencil and a pen can benefit. For the Architect-Assistant the next step was to get from Computer Aided Design to Computer Aided Architectural Design. We found this step was most likely to be taken in the field of 3D-drawing.

Next to the regular 2D-drawing training we also provide extensive courses on 3D-drawing. In principle you can start the 3D course with a basic knowledge of 2D-drawing. You learn to think 3D, by far the hardest part, after which you start drawing various 3D models, from wireframes and 3D-faces to solid models. Generating a perspective view, applying materials to surfaces and perform a walk through a building are some of the next steps. This is where CAD becomes CAAD.



Try to imagine how much time it used to take to make a perspective drawing, not to mention the time it took to make it into a decent presentation drawing. Whenever you had to change the height of the eye in the basepoint of the same perspective drawing this would keep you occupied for the next twelve hours. Nowadays, with the help of Computer Aided Architectural Design, generating a completely different perspective view is just a matter of pushing a few buttons with a result as impeccable as it was the first time.

## Exploring the Internet

During the last couple of years the personal computer, next to word processing, spreadsheet and CAD, has got a new reason for use in the architect office: Internet.

Using access to Internet will provide you with a large database of information on almost any subject you want. As before with the introduction of the computer, you now once more have to invest time in order to get to know the possibilities of the World Wide Web. But once you have got in touch it becomes a very powerful tool.

A tool which is under constant change as technology on the Net goes fast. Just take a simple drawing. It's no problem at all to put a picture of any drawing on a Website, the problem is whether you can obtain much information from an image the size of a stamp. In order to solve this problem the .DWF file format was developed. This latest technology in viewing drawings on the Web reduces any drawing, 2D or 3D, to 2D vector data. By means of a 'plug-in' or 'add-on' to your favourite Internet browser you are not only able to look at the drawing as it is, you have also got extra 'pan' and 'zoom' functions which allow you to view the drawing in further detail.

It is good to know technology can help in a convenient way but what is the use of putting a drawing on a website? First of all it is a way to promote yourself or the ideas you stand for. Searching for a place to follow a practical training course in a foreign country we extensively used our website to show what our school stood for with examples of the projects students are working on.<sup>1</sup> Secondly you can put courses on the Net and have students studying wherever and whenever they like. A year ago we experimented with CAD courses from the University of New South Wales in Australia. The course was taken from the Net while the assignments had to be handed in at our school. There was a storm of enthusiasm not only from students but also from staff.

A completely different aspect of the use of Internet is Email. Using Email you can send information to anyone anywhere at the cost of a local phonecall. It's not only a note you type on your word processor, you also can attach complete documents, spreadsheets, databases, drawings, anything you want. The possibility of Email also makes life easier for students at our school. Just before the exams staff are very likely to find

---

<sup>1</sup> You can visit us on the World Wide Web at <http://www.innet.net/~pub00308>

mail with some last minute questions, sometimes even with a drawing attached. Maybe, in the future, this will be the only way to teach. For the time being it is a very convenient way of helping the students.

### **What's next**

Whenever you have a look at the employment opportunities for the Architect-Assistant you will find that nowadays you have to be capable to use CAD. Just being able to draw by the board doesn't work any longer. Moreover the architectural and building world have told us that they are really satisfied with the training courses we offer.

However, a recent trip to architectural offices in various European countries has made clear that the market is now eager to find persons who not only have a firm knowledge of CAD but also are into CAAD and computer presentation techniques.

At school this should result in offering more training in those presentation techniques using various computer programs ranging from a simple render of a 3D object to extensive 3D animation. However, the limited budget and the software which continuously demands more powerful computers, restrict our possibilities.

But that is another story.

**Approaching a New Methodology:**

**Integrated Architectural Design  
on the Basis of 3D Computer  
Models**

**Harry Völker  
Mathias Schwenck**

TU Delft

The Netherlands

*The traditional way of architectural design leads to some shortcomings with respect to the quality of the design and the efficiency of the design process. Therefore possibilities for improvements have to be considered. In order to come to fundamental improvements the application of advanced computer technology in the field of architecture has to be co-ordinated with improvements in the area of design methodologies.*

*In this paper we suggest a new methodology for architectural design. It is based on an integrated manner of designing. Despite some early design steps the whole design process is executed on the basis of a 3D model which is handled by means of computers. The central data objects in the design process are the different types of models. The models contain all relevant information generated in the design process. A comparison of our approach with the traditional way of designing illustrates the potential of the new methodology.*

**Key Words:** *Computer Aided Architectural Design, Design Methodologies, Integrated Design Systems, Computer Support*



# **Approaching a New Methodology: Integrated Architectural Design on the Basis of 3D Computer Models**

## **INTRODUCTION**

Many architectural design processes have been successfully performed. Different methodologies have been applied, that are characterised by working without computer tools or by applying them only in a very limited role. In general these methodologies, that we will refer to as “traditional methodologies”, can be considered a suited way of designing. On the other hand there are some inherent problems like for example:

- problems to combine different drawings in order to check the possibilities and to tune the various technological solutions
- impossibility to take into account the distinguished alternatives immediately during the discussions between architect, principal, consultants or authorities
- fast and simple exchange of information between architect and the other partners is almost impossible (at least very limited)
- architect has to take over the tasks of a co-ordinator and therefore less time available for his creative tasks because of the effort needed for the management of the design process
- calculations during the modelling phase require much effort to be taken, but the results remain relatively rough and insecure.

A more detailed description is given in [ScVö96]. These problems and shortcomings may lead to significant quality and efficiency problems. Therefore we have to look for improvements to overcome these limitations. The fast development of science and technology offers some solutions. In order to use information technology for architectural design effectively in an integrated way we will approach a new design methodologies in this paper.

After describing basic concepts and major phases of the methodology we will take into account its advantages and disadvantages. In [VöSA97] a case study is described where this methodology is applied and extensions with respect to integrated architectural and urban design are discussed.

## **INTEGRATED DESIGN ON THE BASIS OF 3D COMPUTER MODELS**

In this paper we suggest a new methodology for architectural design. “Integrated Architectural Design on the Basis of 3D Computer Models” is characterised by the following basic concepts:

- The process is based on an integrated manner of designing. Decisions are made as a result of discussions in a design team, where possible alternatives have been carefully evaluated.
- The whole design process is executed on the basis of a 3D model which is handled by means of computers.
- The availability of support software corresponding to the needs of the architect is one of the key features determining the success of the idea.
- In the design process there are different types of models. These models contain all relevant information generated in the design process. This includes the possibility to deal with several alternatives. Because of their availability at later stages of the design process, definitive decisions can be made “better” and highly qualified.

Generally an architectural design process, following this methodology, can be described with the following model consisting of six major phases.

#### *Phase 1 “Conceptual Studies”*

This phase is dominated by the initial communication between principal and architect. It also includes an analysis of the feasibility of the project. The result is an initial model defining the project only with respect to general aspects.

#### *Phase 2 “Generation of a Semidefinite Model”*

During this phase the level of completeness of the model has to be increased in order to enable its input into the computer.

#### *Phase 3 “Generation of a Computer Model”*

The semidefinite model created in phase 2 is placed into the computer in order to generate a 3D computer model to research and to develop the total concept with respect to its spatial characteristics. In this phase it is possible to design the optimum of 3D consequences.

#### *Phase 4 “Round Table”*

The architect co-operates with different consultants to extend the semidefinite model. After receiving the needed information from the architect the different consultants prepare separately their recommendations, that will be “performed” during a “round table”. This offers the advantage that all design decisions could be made based on a direct communication between all members of the “design team”.

#### *Phase 5 “Developing the Model”*

The architect extends the model to complete it. This includes communication with the principal as well as work to get permissions etc. from administrative authorities. At the end of this phase the model is definitive, but not yet completely checked.

#### Phase 6 “Final Check”

The predefinitive model is checked against all demands relevant for the design project.

Figure 1 on the next page describes the major phases and illustrates the input and output information of each phase. Generally there is no linear order of the six major phases during the design process. It is actually an iterative process including different cycles. The most important one is the cycle between the phases 4, 5 and 6. “Round Table” and “Developing the Model”-phases alternate few times till a definitive model is reached. Afterwards, invalid results at the final check may cause further steps to go back to earlier phases.

The different models occurring in the process could be described as follows:

#### “Initial Model”

The initial model defines the project with respect to general aspects. The model contains the results of conceptual studies. It also includes the results of the feasibility study.

#### “Semidefinitive Model”

The semidefinitive model is an extended version of the initial model. It is defined more precisely. The semidefinitive state is reached if the generation of a computer model is enabled.

#### “Semidefinitive 3D Computer Model”

The semidefinitive 3D computer model can be partly considered a computerised version of the semidefinitive model. However there are significant differences with respect to the level of completeness. By means of generating a 3D representation the architect can research and develop the model with respect to its spatial characteristics.

#### “Predefinitive 3D Computer Model”

Through different processes the semidefinitive model has been completed. It is definitive, but not yet finally checked.

#### “Definitive 3D Computer Model”

If the final check shows the validity of the suggested definitive 3D computer model it reaches the state “definitive”.

### **Phase 1: Conceptual Studies**

- communication between principal and architect
- analysis of feasibility

Differences between the models occur with respect to computerisation, level of completeness and level of checking. The non-computerised models represent ideas, the computerised models represent “real” documents. Therefore non-computerised models could be mostly found in early phases. During the different phases the level of completeness of different documents increases because of the introduction of new results. These “evolutionary” processes may not change the other characteristics of the model at all e.g. the development of the semidefinitive model during phase 5. An example of different levels of checking shows the relation between predefinitive and definitive model. They may contain the same information but the latter has already passed the final checking of principal and architect.

[ScVö96] gives a more detailed description of the different phases. The different partners taking part in the building process are also considered there.

## **EVALUATION OF THE NEW METHODOLOGY**

The use of computers, in order to realise a design process on the basis of three-dimensional computer models, offers many new possibilities for quality improvements and time savings. The most significant are:

- The availability of a 3D representation of the design allows the architect a better evaluation of the spatial qualities.
- All relevant information about the design project is available in an integrated way in different models. The information handling significantly improves.
- A fast and simple exchange of information between the architect and other partners becomes possible. The models can be distributed digitally, so it costs less time and money. Data processing and exchange over a long distance is possible in a very short time.
- This methodology provides a basis for the integration of design, construction and calculation process because it offers possibilities for efficient communication and information exchange.
- The position of the architect changes. Once being a co-ordinator, responsible for all separate communication processes, he now becomes a kind of a director. He needs less time for management tasks and has therefore more time available for creative design work e.g. generation and evaluation of alternatives.
- Separate communication processes could be replaced by “round table”-discussions of all members involved in the design process. Because the information can be changed easily it is possible to introduce the modifications immediately into the model. The advisors as well as the

*Figure 1: The major phases including their input and output information*  
architect get direct feedbacks regarding the consequences of modifications. They are able to check the possibilities, to recognise new problems and to tune the various technological solutions during the discussion.



- In general design steps could be executed with a higher quality without efficiency decrease.

- The principal could recognise the influence of administrative authorities or consultants directly on the screen. This offers a possibility to overcome causes for confidence problems, like for example if the principal may think that the architect tries to realise his own wishes by saying that they are based on requirements of the administration or advises from consultants.

- Calculating and modelling are integrated activities, so the truth-value will be excellent.

The following table summarises some significant advantages and disadvantages.

| Traditional Methodology for Architectural Design   | Integrated Architectural Design on the Basis of a 3D Computer Model   |
|--|---|
| <ul style="list-style-type: none"> <li>• much experience is available</li> <li>• dominates in current building processes</li> <li>• basis for current education of building specialists</li> <li>• communication problems are a significant limitation</li> <li>• information exchange very complicated and inefficient</li> <li>• the architect has to deal with many management tasks limiting his creative possibilities</li> <li>• integration of design and construction processes is strongly limited</li> </ul> | <ul style="list-style-type: none"> <li>• based on the application of software as a supporting tool</li> <li>• existence of information in an integrated form decreases the complexity of communication</li> <li>• improved co-operation between the different partners</li> <li>• the role of the architect changes to a “director”, i.e. he has more possibilities to work on the design</li> <li>• 3D presentation improves the analysis of the spatial quality of the design</li> <li>• suited for the integration of building and construction processes</li> </ul> |

*Table 1: A comparison between design methodologies*

Taking into account the comparison we can conclude that the new methodology of integrated design based on a 3D model supported by means of 3D software offers great potential for improvements in architectural design. It seems not useful to try to develop architectural software for the traditional way of designing because of the inherent shortcomings of this methodology. In order to come to fundamental improvements the application of advanced computer technology in the field of architecture has to be co-ordinated with improvements in the area of design methodologies.

Which changes occur if we apply the new methodology?

- The possibilities to combine materials and structures lead to a wider variation of designs. It is now possible to explore them already during the conceptual design phase.
- The conceptual design should be extended significantly in order to use the new possibilities. It becomes more time-consuming. The effort taken can be easily compensated by quality improvements as well as by less time demands in later phases.
- Because of the integrated way of designing it will be possible to inform the principal, the authority and the consultants on a “digital way”. The value of the calculations is as excellent as the design process.
- The documents can be generated earlier and much more complete so that every member in the design process is informed with the same quality and with the same possibilities of the building. This can take more time but the value of every document is extremely high because the tuning has been done. The definitive design needs significantly less time to be generated.

Additionally the whole design process tends to demand less time. We will illustrate this by a comparison where figure on the right-hand side represents the methodology of integrated design by means of 3D computer software and the left one represents the traditional way:

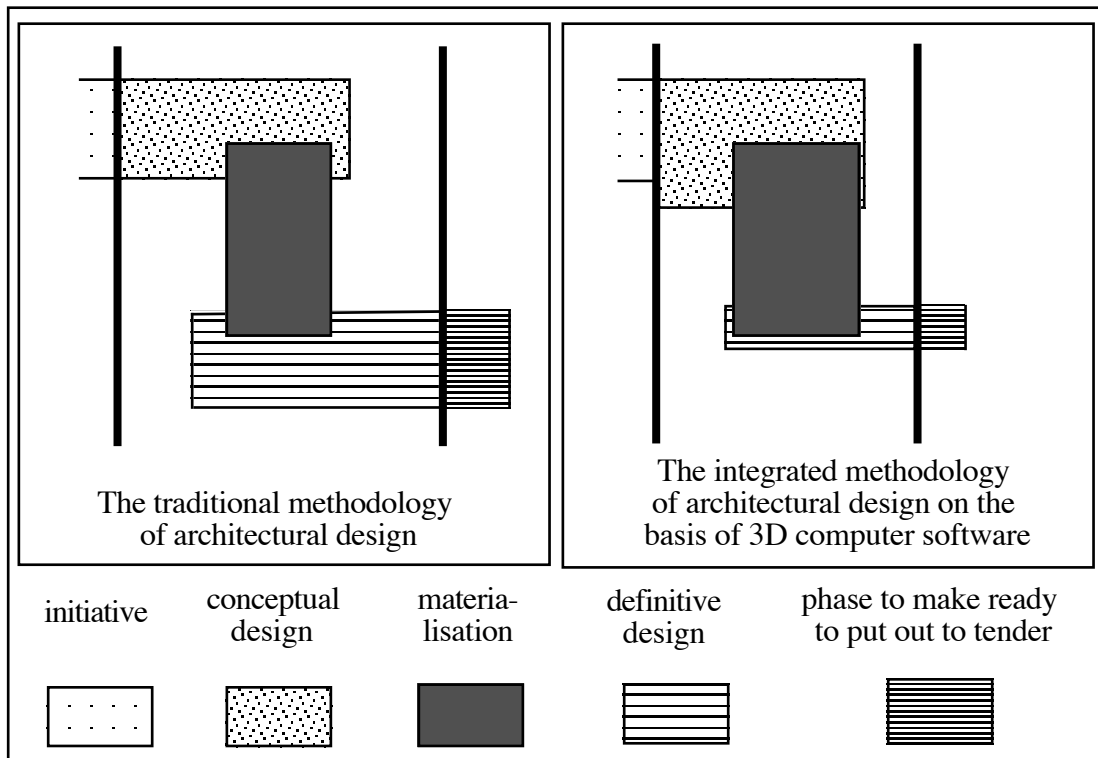


Figure 2: The influence of the applied methodology on the design process

## SUMMARY AND CONCLUSIONS

In this paper we have approached a new design methodologies offering significant advantages. The most important differences occur with respect to the quality improvements. Integrated design leads for example to time savings and significant improvements in the communication processes between architect, principal, consultants and administrative authorities. By working with integrated 3D representations it is possible to improve the quality and the security for the principal as well as for the architect and his consultants.

The methodologies is based on the existence of support software that at least partly is non-existent until now. Future work will thus include the application of the results in the development of integrated support software for the architectural design process.

Furthermore, some additional features like the participation of a contractor in the design activities and issues related to the management of the process have to be taken into account more detailed.

## References

- [SaSc96] Sariyildiz S., Schwenck M., "Integrated Support Systems for Architectural Design"  
Proceedings of the 3rd Conference on "Design and Decision Support Systems in Architecture and Urban Planning", Spa, Belgium, August 1996
  
- [ScVö96] Schwenck M., Völker H., "Modelling the Architectural Design Process - Analysis of Traditional Methodology and Approaches to the Future"  
Report, TU Delft, Faculty of Architecture, 1996
  
- [VöSA97] Völker H., Schwenck M., Amin A., "Integrated Architectural and Urban Design with 3D Computer Tools - Application of a new Methodology"  
Report, TU Delft, Faculty of Architecture, 1997