Staging the space of mixed reality - reconsidering the concept of a multi user environment

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ABSTRACT

This paper presents our work and research findings on developing the concept of a multi-user shared environment for culture, performance, art and entertainment. It introduces artistic concepts of multi-user spaces focusing on the notion of virtual space as a stage setting and on the behaviours and interactions of people within it. The VRML based demonstrator "Murmuring Fields" presents a mixed reality shared environment installation for several users based on a decentralised network architecture and supporting external participation across internet and in shared physical space.

The notion of user representation is replaced by the notion of user enactment, treating the concept of avatar as an extended body of communication. "Murmuring Fields" presents a prototype of an information space where real space becomes the interface to the virtual enabled by an invisible and intuitive full-body interface environment.

Following our goals for user embodiment and group interaction, connecting real and virtual environments as a mixed reality, we have developed the e-MUSE system (electronic multi user stage environment). Derived from an artistic point of departure, the installation "Murmuring Fields", e-MUSE is the underlying platform for networked communication, interface, rendering and display organisation. It uses VRML to implement mixed-reality environments in which visitors' exploration and experience of virtual space are connected to real space as well as other participants' experiences.

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Additional keywords: Internet, VRML, World Wide Web, interaction

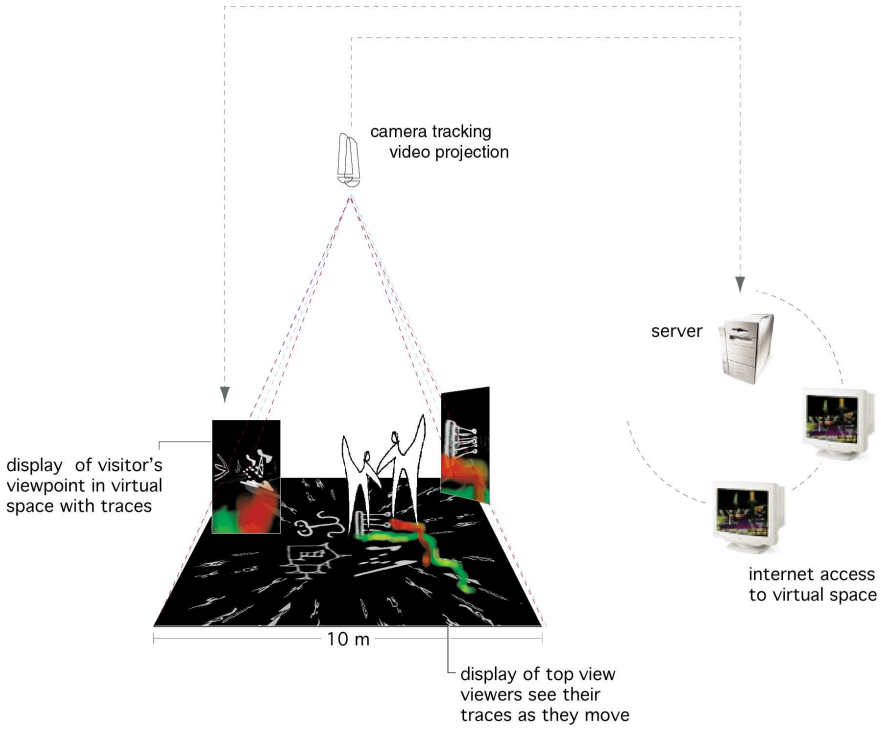

Fig. 1: Diagram of "Murmuring Fields

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1. INTRODUCTION

Most common approaches to multi-user virtual environments focus on representation and interaction purely within the virtual space. “Murmuring Fields” focuses on presence and interaction of multiple participants in the intersection between real and virtual space.

1.1. Description of the “Murmuring Fields” environment

“Murmuring Fields” is a black and white murmuring sound space reacting on the movements of the visitors’ bodies. Movements trigger sounds located in the virtual space of “Murmuring Fields” which in turn are transmitted back into the real space. The sounds are structured as a field of density inhabited by statements of the philosophers and thinkers: Paul Virilio, Villem Flusser, Marvin Minsky and Joseph Weizenbaum [3]. In the centre these statements overlap creating a collage of noise. Space is dense and filled. As one moves outwards the statements are broken first into words and then into single phonemes.

The movement of the user triggers the sound files creating sound experiences. Travelling from the centre outwards is a voyage from density to silence. Movement causes the coding and de-coding, arranging and rearranging of content. Philosophical navigation incites discovery and produces polyphone sound-scapes. As visitors move around they develop a spatial relation between their memory and the virtual space.

1.2. Imagine a room furnished with data

“Murmuring Fields” is a physical interaction space filled with data. Here the visitor can rely on the scale of the body and space while at the same time navigating through the "furniture" of data. Data is organised spatially and revealed as the visitor navigates the space. As a mixed reality environment the visitor's exploration of virtual space is connected to real space as well as other participants experiences.

“Murmuring Fields” relies on the development of invisible and intuitive interfaces facilitating full-body interaction. Using real-time video tracking the visitor’s intuitive exploration of real space is transferred to the virtual environment. The real space - a room of 10 by 10 meters - is mapped on to the virtual space. As the visitors’ awareness of the mixed reality increases, the body interaction within one spatial environment, is influenced by the other**.**

The visitors’ body movements are represented as traces in virtual space. Treated as an extended body of communication

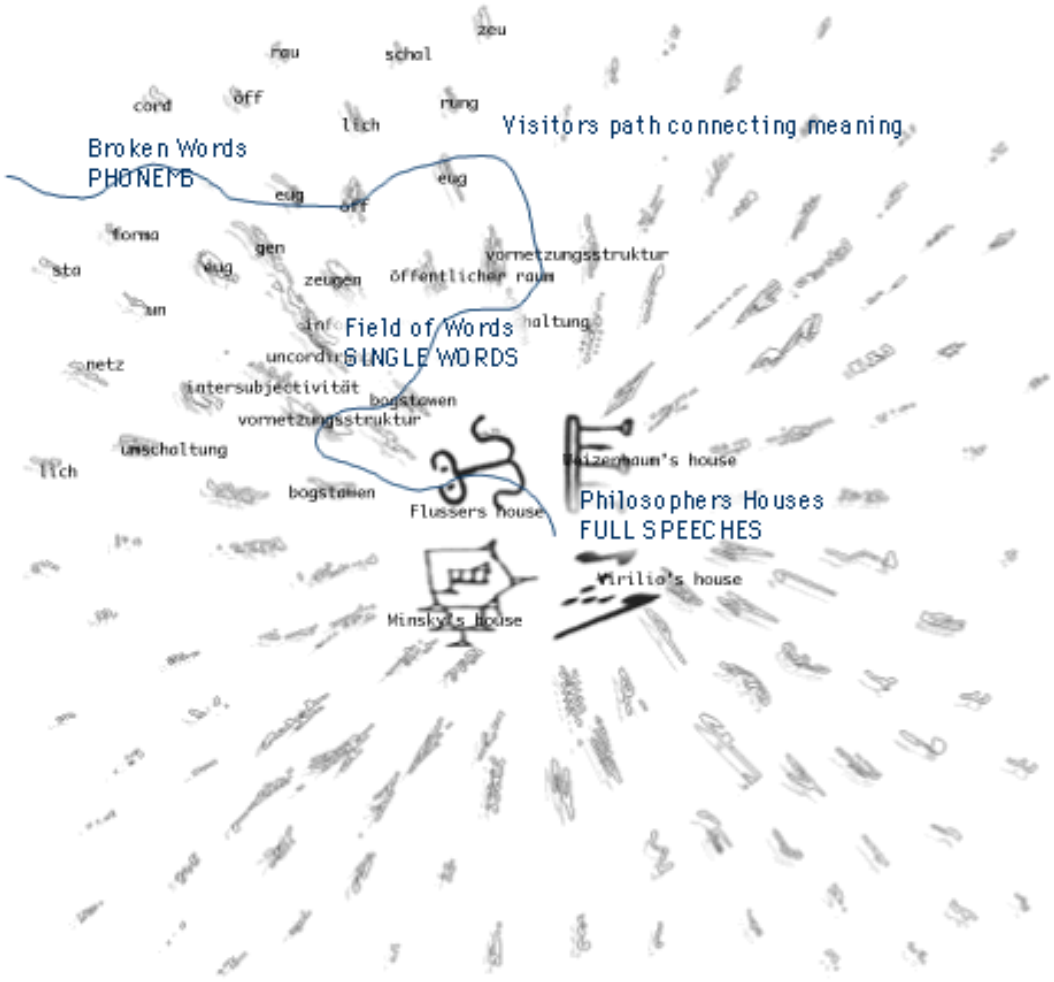

Fig. 2: Sound-scape of “Murmuring Fields”

user representation is replaced with the notion of user enactment. The TRACE-avatar embodies movement and gesture as channels of communication. Guiding aspects are the abstraction of visual appearance and the procedural creation of traces connected to body movement in real time.

"Murmuring Fields" demonstrates a framework for an extended performance, overcoming the split between acting and observing. It moves away from the isolated actor, connecting him with a multi-sensorial reality joined by other participants.

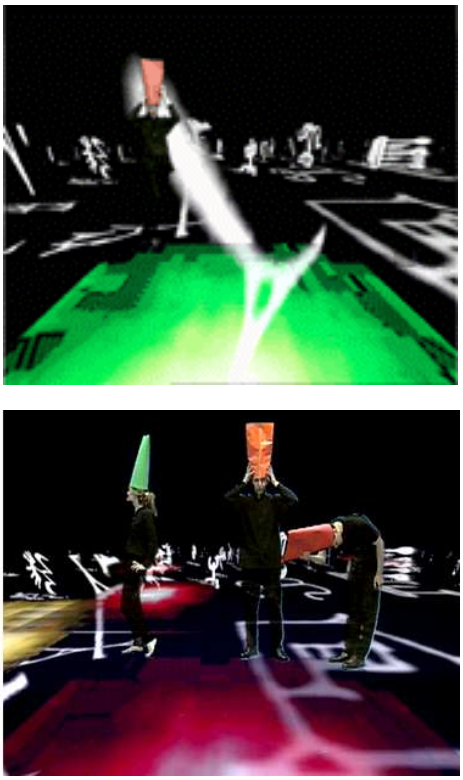

Fig. 3: Developing a vocabulary of body language

1.2 The making of "Murmuring Fields" - developing e-MUSE

Mixed-reality signifies the interconnection of the real and virtual producing a new framework for communication and interaction possibilities. The augmentation of real and virtual space and the ability to be present in both spaces at the same time, is amplified through the notion of a shared environment: a situation in which participants discover their interdependence in exploring, perceiving and creating the „world". As part of our research and experiments on new patterns of communication in such environments, we have developed the "Murmuring Fields" installation and the e-MUSE system supporting its realisation.

"Murmuring Fields" is an interactive communication space. e-MUSE is the underlying platform for networked communication, interface, rendering and display organisation. It is a VRML based multi-user system. By implementing VRML as a networked multi-user application we have opened the otherwise closed system of VRML. Splitting browser and interface provides independent levels of control and implementation for rendering and displaying the virtual world, for multiple user support and for support of non-standard input devices well as interaction and communication concepts for shared mixed-reality environments.

Fig. 4: Setting up the virtual stage

Because of the ease and flexibility of the underlying architecture, e-MUSE can be seen as an experimental platform for prototyping and trying out new spatial configurations as well as interaction and communication concepts for shared mixed-reality environments.

2. THE PROBLEM OF USER REPRESENTATION - AVATARS AS USER ENACTMENT

The notion of user enactment reflects the recognition that user presence in multi user virtual environments is not only the question of "representation" but that of providing mechanisms for interaction and communication with other participants. In order to stress these guiding issues, we have replaced the notion of "representation" by the notion of "enactment". We have therefor formulated following guidelines for avatar concepts: 1) abstracting the visual form, 2) connecting production of the avatar form to user's body movement, 3) providing existance in time, - the metaphor of the durational "trace".

2.1. TRACE-avatars

The TRACE-avatar solution emphasises the focus on movement and gesture as two basic channels of presence and communication. Like a shadow, a trace is a sign of presence and movement in time. Metaphorically, participant's movement is understood as a timeline of thought which can be used as a choreographic notation of space-time events. The trace's simple and dynamic visual form provides the necessary information needed for localisation in space and time. As it triggers sounds in the virtual space (also emitted in the real space) it turns into an audio-visual trace of presence. Being dynamically connected to the participant's body movement and gesture, it supports the feeling of presence and interaction through senses other than the visual.

The fundamental connection between presence in the real and virtual space of "Murmuring Fields" functions as a circuit where participants' body movement in real space creates and moves TRACE-avatars in virtual space, which trigger the soundspace inspiring further movement. The TRACE-avatar becomes an extended body of communication between user and information space as well as between the individual users.

In "Murmuring Fields" the avatar is neither a virtual constructed self, nor an externalised virtual body detached from participant's real body. The concept of an extended body of communication means that the avatar is understood as: 1) a medium of interaction and communication between the participants, 2) a mechanism connecting participant's bodily

awareness of real space with his perception of the virtual space and other participants.

The majority of current approaches try to resolve the discrepancy between sensual perception in real and virtual worlds by holding on to the visual as the dominant sense of perception. The other problem we realise is that these approaches tend to result in the focus on developing visual forms of representation mimicking real world visual appearances as close as possible. Resulting communication and interaction possibilities try to mimic real world physical interaction (such as movement of extremities accompanying avatar movement) - again relying on the visual as the dominant mode of perception.

The TRACE-avatar breaks with the tradition of realistic visual form as the criteria for individual user representation. As a first step in looking for new solutions we have deliberately driven the visual to extreme abstraction and simplicity. We have focussed on movement and gesture as two basic channels of presence and communication. Movement requiring a dynamic visual form providing the minimal information needed for localisation in space and time. Gesture enabling a more detailed and dynamic reaction to movement connected to the participant's real body through senses other than the visual.

The current simple realisation of the TRACE-avatar stresses the impact of connecting the avatar to user's body movement even through relatively simple means allowing similar kinds of presence for different interface channels (visitors in the real space and visitors from the Internet). At present the TRACE-avatar is realised using a video tracking system which tracks movement of several users in real-space and delivers data for the creation of corresponding two-dimensional traces. We are currently experimenting with different electric-field sensor devices which track participants' gesture.

3. RECONFIGURING SPACE AS A MEMORY SPACE: NON-LINEAR VERSUS LINEAR SPACE

The structure and content of the information space "Murmuring Fields" provides audio-visual information. The statements of the four "media thinkers" : Paul Virilio, Villem Flusser, Marvin Minsky and Joseph Weizenbaum are structured as a field of increasing density moving from the superposed collage of noise, through a field of words to finally a field of broken phonemes. Graphical signs accompany the sounds signifying four extinct languages. As the sounds deconstruct into meaningless rudiments of language the signs become smaller changing in scale from that of a house (centre) to that of a human body (field of word) and finally to that of a child (outer field of phonemes).

The centre of the model is understood as an overview where visitors can differentiate and compare content. From this blind spot the outer world is perceived as fictive landscapes inciting discovery. Here space inspires movement and action towards the outer periphery. As the visitor moves outwards meaning is abstracted and held together only by the memory and association of the visitor. Conversely, moving back towards the centre phonemes merge into words, which in turn merge into statements. The experience and memory of the visitor becomes that which holds together the space in a meaningful entity. Movement causes the coding and decoding, arranging and re-arranging of content. In "Murmuring Fields" meaning is found between the density of the polyphony of noise and degenerated silence.

3.1 Scale relationships in "Murmuring Fields"

By moving about in the mixed reality visitors experience the audio and graphical information of the virtual environment. Due to the non-linear structure of the information space, linear distances in the real space (the physical interaction space) map non-linearly onto distances within the information space. Firstly the spaces are in a scaled relationship to one another (1m in real space equals 10m in virtual space) and secondly the decreasing size of the graphical signs augments the sense of perspective. This renders a feeling of being able to quickly cover even infinite distances in the information space and thereby transcend the outer periphery of the information space to view it from the outside.

In "Murmuring Fields" space is concrete and abstract at the same time. In real space we relate to our environment through our bodily scale. In "Murmuring Fields" the signs, as placeholders for the sounds, relate to the visitor through setting up the same scale relationships. As one moves around in "Murmuring Fields" one is confronted with a world abstracted from real world experiences.

"Murmuring Fields" attempts to comprehend the spatial consequences of VRML space. VRML space is void and endless in any direction, free of context it relates a scaleless and timeless set-up. By inhabiting the void we seek to make sense of this artificial space. In "Murmuring Fields" the spatial understanding seeks not to construct a defined absolute form within the space but to produce a density within the void. This density is not as much visual form as audial content, the sound space being of prior importance to the visual space. By relating the interaction of the visitor to spatial production - as the space only "happens" when the visitor creates connections between the sounds – the time of the interaction is embedded into the

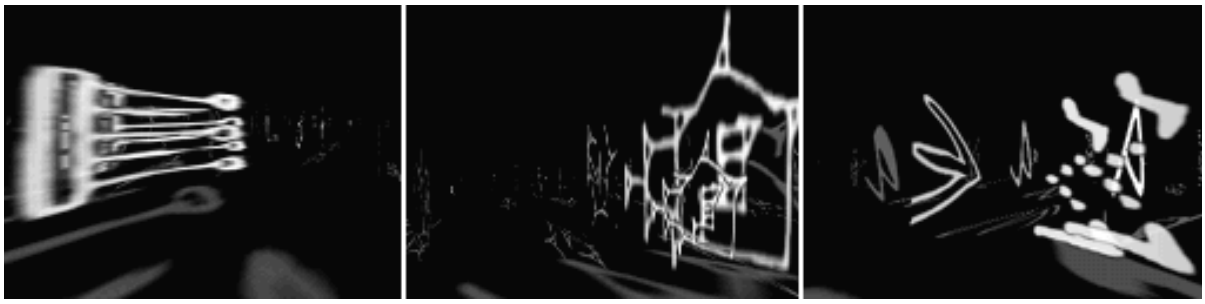

Fig.5 Hörbilder

space. The virtual environment of “Murmuring Fields” is a dynamic space of transformations and changes held in time.

3.2 Spatial information – information space

In "Poetics of Space" [1] Gaston Bachelard describes how space can be used to structure virtual worlds as memory spaces, meaning that one could organise data like one organises a building or furnishes a house. We are interested in how information organised spatially can give new experiences of information retrieval and consumption. Spatial elements within the virtual environment could reveal underlying hypertext information, as when one opens a drawer to reveal its content. As a visitor travels the space a trace of retrieved information – a memory trace - could be gathered. The re-opening of such a “memory-trace” could happen not by "pointing and clicking" but by "virtual touch" analogous to association.

4. COMMUNICATION IN “Murmuring Fields”

Communication in “Murmuring Fields” is not about conveying known meanings using a given system of expression (such as saying “How are you ?” or waving hello). Movement and gesture connect the participants with each other not directly, but through their effects on the environment. The effort is not to understand the relationship between one’s actions and the effect’s perceived. It becomes more interesting what one is creating than how one is doing it. Participants don’t think how they are going to move in “Murmuring Fields” – they simply move, guided by the impressions of the resulting soundscape and their bodily experience of space and other participants.

In “Murmuring Fields” participants meet in a situation in which they discover their mutual interdependence in exploring and perceiving the world. Through their interactions within the space, they interact with each other. Being in mixed realities is being in real and virtual space at the same time. This is already a changed condition in perceiving oneself and the world. Being in such an environment with others amplifies this changed perception. Always displaying several viewpoints of different participants adds to the awareness that multiple realities are not only the real and the virtual space but also others’ seeing and perceiving the world differently.

The “interface” in “Murmuring Fields” connects the participants with each other, not the participants with the machines. The whole situation in which participants find themselves is the interface, not the mapping between participants’ actions and their effects on the environment.

5. IMPLEMENTATION

Derived from an artistic point of departure, the installation “Murmuring Fields”, e-MUSE (electronic multi user stage environment) is the underlying VRML-based platform for developing networked mixed-reality environments in which visitors’ exploration and experience of virtual space are connected to real space as well as other participants’ experiences.

5.1 e-MUSE

Figure 6 depicts the the structure of the e-MUSE system for the realisation of “Murmuring Fields”. It consists of three main parts: the external user interface driver, the multi-user driver and a VRML browser.

The external user interface driver is responsible for passing data for controlling avatar movement from input devices to the multi-user driver. The multi-user driver updates the user’s local VRML scene according to the output of user’s input device(s). It is a simple Java applet which runs inside the Web browser and communicates with the VRML browser via the external

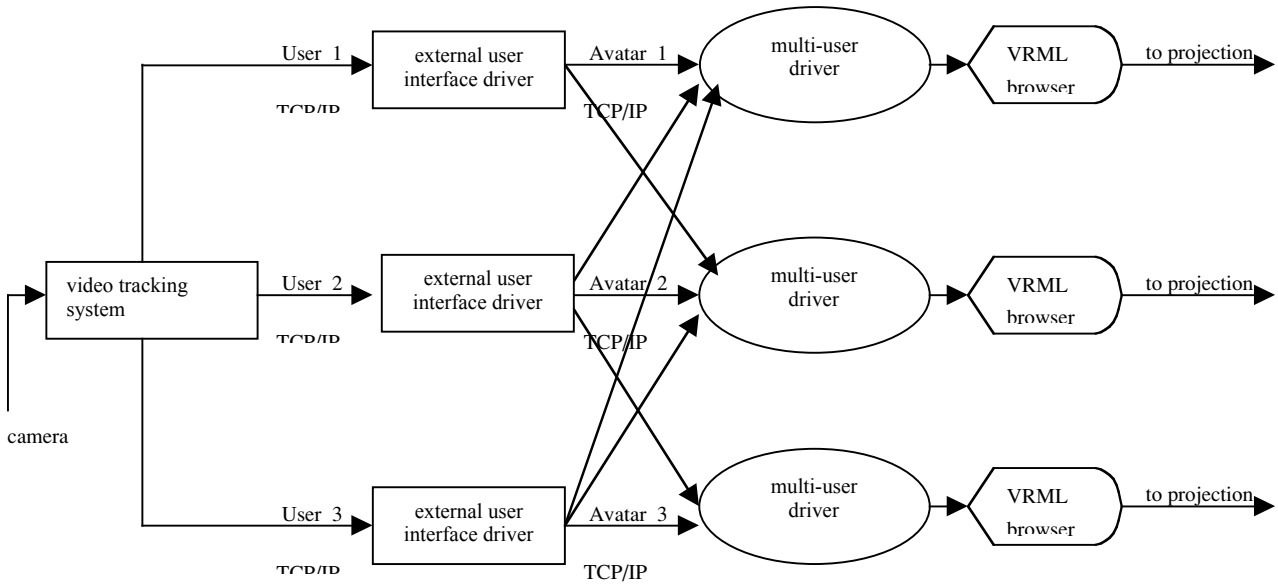

Fig. 6 Organisation of e-MUSE

authoring interface (EAI) [10,13]. The VRML browser renders the VRML scene and is one of the publicly available modules such as the CosmoPlayer plugin for the Netscape Navigator.

The external user interface driver reads data from input devices, transforms it into appropriate VRML coordinates and passes these values to the multi-user driver over a socket connection. Input data for controlling participants’ avatars can come from

any given input device provided it adhers to the format expected by the EUID. The EUID can run on the same machine to which a given input device is connected or on a remote machine connected to Internet. It can communicate with the input device via sockets or reading from standard input. As this module is independent of a particular interface it enables the use of any desired input device for controlling movement and navigation in the VRML scene.

The multi-user driver is a set of Java classes invoked by a Java applet that is referenced as part of the HTML page in which the VRML file describing the virtual space is embedded. It communicates with the external user interface driver over a socket connection. It updates the local VRML scene using the external authoring interface to access user avatar nodes and set appropriate position and orientation values, and to dynamically create objects representing the trace of user's movement. Since different viewpoints can be grouped with each avatar, the position of viewpoints is also appropriately updated.

In VRML, the world is always seen through the eyes of an imaginary avatar of the user. This means that the user's avatar is always bound to the current viewpoint. In e-MUSE the avatar is separated from viewpoint control. Thus it is possible to use avatar-bound viewpoints for exploiting VRML proximity sensors and collision detection scheme (which is tied to the VRML avatar), while displaying an arbitrary combination of avatar-independent and avatar-bound views.

The number of participants can be changed by setting the corresponding parameter in the HTML file referencing the VRML scene. Dynamical addition and removal of users to and from the world yet needs to be implemented. The length of the trace for the TRACE-avatars is set in the same manner.

As can be seen in fig. 6 e-MUSE is structured as a star-shaped network – there is no single copy of the virtual space for all users, and actions of every participant are propagated to every other participant directly and immediately. Every participant has to have the external user interface driver installed beforehand. He fetches a local copy of the VRML scene and of the multi-user driver applet by referencing a given HTML page. Once fetched, the multi-user driver of every user establishes a connection with the local external user interface and with the external-user interfaces of all other users. In this way the changes in movement and position of all users are immediately propagated to the individual multi-user drivers who update the corresponding local VRML scene. Since it is not needed for the "Murmuring Fields" scenario, there is no event synchronisation mechanism, which additionally simplifies the technical realisation of e-MUSE.

To overcome Java security restrictions we have used the Netscape security model that allows signed applets to request a user to grant them permission for connecting to a local host. This has a drawback insofar that the user must trust the applet and its author. Given the scope of e-MUSE as an experimental and prototyping environment this is not a serious limitation.

The described structure of e-MUSE enables keeping separated levels of control and implementation for rendering and displaying the virtual world, for multiple user support and for attachment of non-standard input devices. It also provides great flexibility for different configurations of viewpoints and connections of real and virtual space.

5.2 Interfaces

Our concept of "situation as interface" makes the development of physical devices that serve as interfaces with the system strongly tied to the development of content" itself. The purpose of the environment is to connect participants with each other, keeping the interaction with underlying physical devices invisible. Participants must not have to consciously create connections between their actions and resulting effects on the environment. To make this possible appropriate unobtrusive devices which allow free bodily interaction and engage different senses have to be developed [4,14].

A straightforward approach for connecting participant's movement in real space to movement and navigation in virtual space is the use of a video tracking system. Such systems try to find humans in real-time camera images of the observed space, based on certain form or colour information.

For use in interactive systems such as "Murmuring Fields", the tracking system has to be fast enough so that avatars in the virtual scene respond with no or little time delay to the movement of the participants. Furthermore it has to be independent of the appearance of the participants and has to function in different scenarios with no constraints on illumination conditions and on spatial arrangement of the objects in the observed scene.

Our system [14] uses the mTRACK software developed by Hoch [14] as a framework to implement our own techniques for image segmentation [8]. Since we are at present using only one camera, participants are localised in a two-dimensional image. Thus the two-dimensional image coordinates of the tracked regions have to be mapped on 3D-VRML coordinates to allow navigation in a virtual scene. Resulting coordinates are sent to the external user interface driver which forwards them to the connected multi-user drivers of the e-MUSE system.

6. DISCUSSION AND FUTURE WORK

Two major improvements that could be implemented in the future are adding a second camera to gain real 3D information and implementing more sophisticated methods for image segmentation. Some improvements could also be made by using colour look-up tables to produce better tracking results under changing and inhomogeneous lighting conditions.

Since the tracking system provides a relatively rough account of movement and localisation in the space at large, we are experimenting with other devices for additional, finer sensing of movement and gesture in local regions of space. The Virtual Balance [5] is a platform that transforms changes in the user's centre of gravity to data for controlling movement and navigation in virtual spaces. MARS Field [14] is a device based on electric-field sensors that we built in order to pick-up user's gesture in local regions of space. Using such devices provides additional channels for influencing the shape of the trace and providing its full spatiality. Thus one gains additional channels of interaction and communication between users, engaging additional senses such as the sense of balance and dynamic gesture.

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