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FORMAT	MEMBER PRICE	NON-MEMBER PRICE
PDF	**$17.00**	**$21.00**

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Paper Abstract

The reengineering of life expanded by perceptual experiences in the sense of presence in Virtual Reality and Augmented Reality is the theme of our investigation in collaborative practices confirming the artists´ creativity close to the inventivity of scientists and mutual capacity for the generation of biocybrid systems. We consider the enactive bodily interfaces for human existence being co-located in the continuum and symbiotic zone between body and flesh - cyberspace and data - and the hybrid properties of physical world. That continuum generates a biocybrid zone (Bio+cyber+hybrid) and the life is reinvented. Results reaffirm the creative reality of coupled body and mutual influences with environment information, enhancing James Gibson's ecological perception theory. The ecosystem life in its dynamical relations between human, animal, plants, landscapes, urban life and objects, bring questions and challenges for artworks and the reengineering of life discussed in our artworks in technoscience. Finally, we describe an implementation in which the immersion experience is enhanced by the datavisualization of biological audio signals and by using wearable miniaturized devices for biofeedback.

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Biocybrid Systems and the Reengineering of Life

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ABSTRACT

The reengineering of life expanded by perceptual experiences in the sense of presence in Virtual Reality and Augmented Reality is the theme of our investigation in collaborative practices confirming the artists´ creativity close to the inventivity of scientists and mutual capacity for the generation of biocybrid systems. We consider the enactive bodily interfaces for human existence being co-located in the continuum and symbiotic zone between body and flesh - cyberspace and data - and the hybrid properties of physical world. That continuum generates a biocybrid zone (Bio+cyber+hybrid) and the life is reinvented. Results reaffirm the creative reality of coupled body and mutual influences with environment information, enhancing James Gibson's ecological perception theory. The ecosystem life in its dynamical relations between human, animal, plants, landscapes, urban life and objects, bring questions and challenges for artworks and the reengineering of life discussed in our artworks in technoscience. Finally, we describe an implementation in which the immersion experience is enhanced by the datavisualization of biological audio signals and by using wearable miniaturized devices for biofeedback.

Keywords: Biocybrid systems, enactive interface, affordances, ecological perception, biofeedback, data visualization

1. INTRODUCTION

Art and Science explore the ontology of life with levels of reality that attempt to conciliate paradoxes and conflicts related to changes and challenges of life. Emergent realities and self-organizing dialogs between artificial and natural signals modify the concept of reality, which was always a philosophical concept. *What is landscape now? What is body now? What is urban life now? The main issue is the sense of presence modified by interfaces and the expanded perception provided by the invasion of* cell phones, bluetooth, GPS, biosensors, computer vision, satellites, modems and other technological systems The reengineering of life expanded by perceptual experiences with enactive bodily interfaces for human existence being co-located in the continuum and symbiotic in the sense of presence in Virtual Reality and Augmented Reality is the theme of that essay coming from the artists´ creativity close to the inventivity of scientists and mutual capacity for the generation of biocybrid systems. We consider human existence being co-located in the continuum and symbiotic zone between body and flesh - cyberspace and data - and the hybrid properties of physical world. That continuum generates a biocybrid zone (Bio+cyber+hybrid) and the life is reinvented. Results reaffirm the creative reality of coupled body and mutual influences with environment information, enhacing James

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Gibson's ecological perception theory [10]. A *cybrid bios[i]* expands human actions in zones that blend biological signals, cyberdata and also the hybrid properties of the physical space [5]. Coupled bodies interfaced to data revert the modern conception of the body separate from the cosmos. Science of interface and the cybernetic principle of feedback eliminate the concept of the sphere and what is inside and outside. We are inside the world as a living organism exchanging electrical potentials, heats, sounds and vibrations regulated by the natural laws and phenomena of out and in spaces. Anthropological issues and the sense of presence being adequated by the technological apparatus for human life in Software Art practices require the interface design for intertwined relationships body/environment/nets reaffirming the ubiquitous and mobile condition in physical world and cyberspace.

Our researches in Art and TechnoScience consider virtual reality and augmented reality as parts of the ecosystem, abandoning the original idea of synthetic separated worlds [7]. Enactive bodily interfaces in their sophisticated connecting manner bring a novel kind of art related to aesthetic, anthropological, philosophical changes and challenges in life experience and social relationships. Locative interface activates an interstitial zone between physical space and data space and configures a biocybrid existence [8].

Enactive interfaces and the changes and challenges of the reengineering of life are discussed in three artworks. Flows of feedback during affordances in intertwined virtual environments/net cause the body to be affected and to affect the environment.

Our biocybrid interactive systems allow connected people to experiment a reengineering of life when acting by synthetic senses, living here and there in physical space and cyberspace – generating a different scenario for the theater of life through biocybrid narratives [6]. The world where we live is no longer the same we lived in before the explosion of interfaces in our lives. Mobile interfaces and ubiquitous computing disseminate cyberspace, and reality is expanded, reality is augmented, reality is mixed, because the virtual of cyberspace is increasingly present everywhere. The sense of presence is mediated by interfaces in our daily life. The concept of second-order cybernetics related to Science of Complexity and its emergent properties is fundamental for our speculative software written to respond to the complex relationship "art and life". A world without boundaries, in its whole state, and the enactive mobile condition, being connected everywhere, all reaffirm the relevant ideas of the Chilean philosophers Humberto Maturana and Francisco Varela, from the 1980s, regarding the observer included in the environment, and their autopoietic mutual feedback [12]. Biofeedback, networked connections and wireless connections qualify sorts of computer-mediated life that require an adequate design from the technological apparatus resulting from the human involvement in the communication with a system, provide social features engaged in a communication practice, exchanging the cognitive process with data in cyberspace, and expand the metaphors of artistic discourses. Art, emotion, and control and interaction mechanisms, included in the rules of a computer program, by software and the diversity of hardware interface, in every device that we use in our daily actions, even when we are in public and urban spaces, insert the cyberspace in our existence, by adding traces of virtual in real life and melting them, involving them in an "engineered reality". Those conditions create opportunities for artists and scientists to reinvent the nature of life.

The new paradigm of phenomenological perception, informed by the technological advances, reaffirm the creative reality of coupled body and mutual influences with environment information based in James Gibson's ecological perception [10]. The ecosystem life in its dynamical relations between human, animal, plants, landscapes, urban life and objects, bring questions and challenges for artworks and the reengineering of life discussed in our artworks.

2. THE CYBRID BODY

The *Opened Body Connection[ii]* performance is Camila Hamdan´s proposal for a biocybrid that co-exists among augmented and mixed reality, computer vision and the materiality of space. During a performance, she added a tattoo on her body, on its vital signs, by creating a biocybrid system, corresponding to her fantastic imagination design. The performance results in the act of drawing the tag whose code is a tattoo, and the tattoo artist, in real time, has inscribed on the back of the artist/performer the computation language of the code referred to the form of a wing. The code in script on the skin of her body, in real time, during the performance, added an augmented reality technology to her body. The tattoo became a mixed reality system, because it was mixed to the life of the environment. Mixed reality, derived from the augmented reality (AR) technology, and the use of tags for computational code and cameras in computer vision reads that code and the result is the projection of form of the skin, in this case, the tattoo, is out of Camila´s body. Meanwhile, the audience in the space of *Mobilefest* was there, and on-line people participated in the ritual. The tattoo

was done in the form of a label or tag with the computer code written on the body, setting on the skin tissue a three-dimensional animation for Camila´s whole life. In a previous version, the code of the tags was stamped or printed on the body, and the computer code, in augmented reality, appeared using the computer vision of cameras in the exhibition/performance *<body>*[iii]. In the latest version, instead of the stamp, the code was tattooed forever on the body, and cameras for computer vision read the tag. Immediately the correspondent tattoo, in this case, a wind, appears in a big display: larger screen, cell phone, monitor. The tattoo is also a proposal of *Living Tattoos*[iv] that was born in the physical space with data virtualized between body and support, and the emptiness of the room. In the interval of flesh – data - silicon, in a biocybrid ritual the tattoo phantom is held. Another part of the ritual occurs in the same way as in tribal logic, in the spirit of collective, community, communion: Camila´s body is offered on-line in a network through streaming as a CyberTV. The cyberperformance configures the relationship between human, computer, and the environment, a mixture of information transmitted in real time on-line, via streaming of sounds, images and texts. And the channel of interaction is a social network.

 The back of the performer´s body is offered as a landscape in mixed reality and presented to the network thanks to the camera placed in the ceiling, and the computer vision reading the tag and transforming it into a wing. The tag has the form of the sign of a copyleft, that is - the letter "C" (inverted) of a marker – in a 3D shape. To read the "C" the camera and computer vision use the ARToolKit open source library, decoded by computer vision, using cameras, cameras of cell phones, webcams. Camila's body was shared across social platforms such as Orkut, Twitter, and Facebook. For two hours, three-dimensional animations traveled through the body being tattooed, in a ritualistic moment, experienced in the interstitial space between flesh and cyberdata. On the back, the copyleft figure tattooed as a tag in augmented reality allowed the insertion and projection out of the body of three-dimensional animated wings. Accordingly, the marker or tag makes a pun with the concept of "copyright", which is commonly used in reference to the rights granted to the author of an original work. Thus, "copyleft" opens to newly thinking "copyright" as a way of subverting the laws of copyright protection and remove barriers to use, distribution and modification, in this case, of a creative work, demanding that the same freedom is preserved in modified versions.

Opened Body Connection is an artistic proposal that refers to the body without authorship, the right to copy, to collective and artistic production with the use of free software and open source. "If someone comes into your flight, but rather the sylph or a cloud, a shadow, is a self, one way airline involved, engaging, happy to be vague, for living on the edge of the visible and invisible" [1]. In this sense, the body is not unique, but open, constructed by the multiple meanings of the connection. There are cyberdata flowing through it and beyond it, in direct contact, invisible, intangible net sensations. It is freedom to relax the boundaries that transform the organic into a cyborg, and a cybrid body. Skin with cloud data that are perceived and experienced by the sharing of information coming from computers.

Camila Hamdan ritualized her body, and gave it away to the copyleft tattoos - the body was both the skin and the open interface to external eyes of cameras and projections that virtualize her label or tag in a form of fantastic imagination, as for the global brain that transmits her painted body transformed in a biocybrid reality. Virtual images are embodied in a single existential context of the process of the body as an interface that promotes new sensory syntheses of the flesh, beyond the biological. Trials of post-human, post-organic, post-biological, neo-biological, transhuman, from the effects of biofeedback, recontextualize life as well, "lent wings to that love, because we feel for instinct that, in the sphere of happiness, our bodies shall enjoy the right to cross the room as the bird through the air" [1]. Hamdan´s artwork proposes the premisse of natural flesh , artificial wing, and the binomial nature / cultural if we take the symbolic unconscious desire to fly represented in the performative ritual of tattooing the flesh in the hidden code of the Tag in augmented reality - *copyleft* - the code is the unique way for sharing her body in the network, breaking with the structure of craft practices and maintaining anthropological links by the body in *copyleft*.

3. AUGMENTED MOBILE REALITY AND GEOTAGNESS FOR MIXED LANDSCAPES

3.1 The 14 Bis Biocybrid Plane

Expanded interactions and mixed landscape generated the *14 Bis* biocybrid system, to celebrate Brasilia's 50th birthday, in a public event that explored mobile and locative interface in mixed reality. LART creative practice put in the Brazilian capital's sky the historical plane 14 Bis (see Figure 1), invented by the pioneer of aerospatial engineering, Santos Dumont. The virtual plane in real scale (with a length of 15 meters) is geolocated in augmented reality, with the tag code placed in the satellite exploring the *Global Positioning System* and results into the datavisualization

apparition of the historical plane flying in the city sky[v]. Other similar apparitions were allowed in different cities' skies such as Buenos Aires (Argentina), São Paulo (Brazil) and Aix-en-Provence (France) as different terminals for 14 Bis in mixed reality and biocybrid life. The absence/presence state is homologated through the cell phone camera, which allows the datavisualization in computer vision using the mobile technology (see Figure 2). The system reaffirms the post biological extrusion of human vision, by the act of seeing shared with the satellite eye in the sky and the handled eye of the mobile device, by expanding the human perception. Tags in AR placed in GPS (*Global Positioning System)* and the possibility of geodesic coordinates create a co-located event for human body. What is vision now? What is real and virtual world? It is the neuropsychophysiological expanded perception that is propiciated by the technology, characterizing the biocybrid human condition.
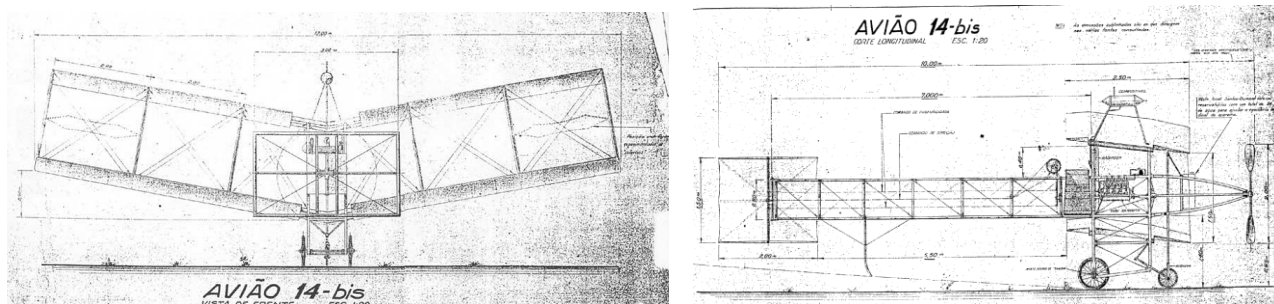

Figure 1. Original diagrams of the 14 Bis airplane. Latin America Memorial, São Paulo, Brazil. September 2010.
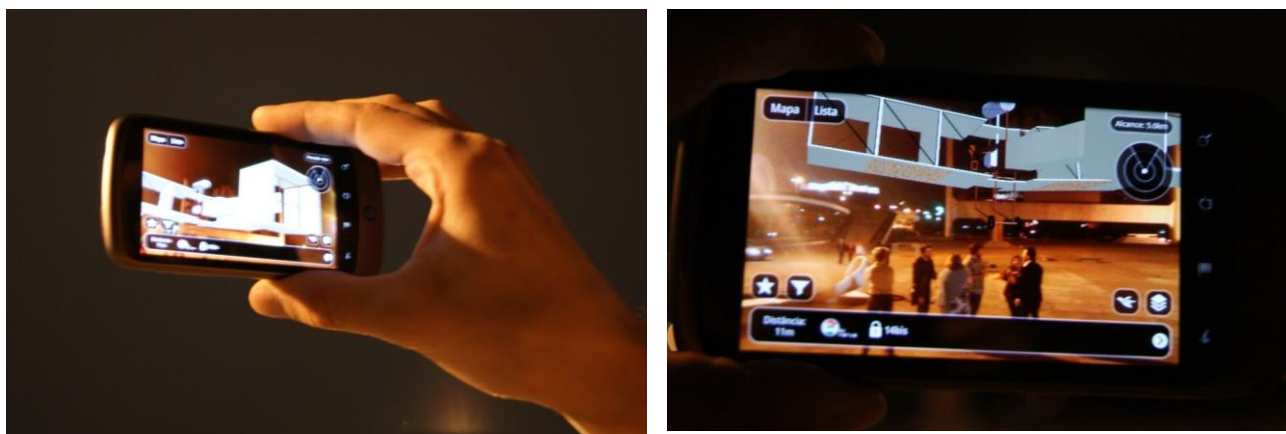

Figure 2. Views of two cell phones showing the virtual 14 Bis, in the biocybrid system. Latin America Memorial, São Paulo, Brazil. September 2010.

Intervention in urban life, using mobile augmented reality (MAR) and computer vision, GPS and net connections, allows the ecological geolocated art event celebrating *Borges Fantastic Creatures in Buenos Aires' streets*. Synthetic creatures appear in the physic space of Buenos Aires city. Using mobile and locative interfaces in mixed reality we inserted 3D virtual reality models of biomorphic shapes, such as serpents, minotaur, pigs and others, from the fantastic imaginary of the Argentinean writer Jorge Luís Borges. For the apparitions, we used the same procedure of tag code geolocation by GPS as in the 14-Bis plane, but this time using virtual models located in the ground and mixed to local people in the urban flow, instead of the sky. Computer vision of the mobile cellular phone was responsible for reading the code translated into datavisualization of synthetic animals. Synthetic senses of technological apparatus allow the reengineering of life and offer a different scenario for human narratives.

3.2 Biocybrid Fables: AR reinventing the act of reading

The intimate scenario of a personal office, offers the reading of a book with the fantastic Borges' fables inside an Augmented Reality in installation in the same Borges' fables theme (see Figure 3). The reader is co-located in the world or digital data mixed to the physical world, in this case in the office environment with an illuminated desk[vi]. A light bubble in an old-fashioned apparatus illuminates the pages (see Figure 4). Surprisingly, when people turn the pages of the book, transbiomorphic creatures living there come out of the space of the paper. What is the mystery? Tags or labels in computer code are read by the eye of a hidden camera in computer vision. And our eyes are in symbiosis with the synthetic vision of the camera. The creatures of the Jorge Luis Borges' fantasy and his universe of shapes are only revealed because we are coupled with a synthetic eye which can read the computational code (the words modeled in virtual reality transform the paper's surface into a living scenario). Every act of browsing generates mixtures of real and virtual, and the act of reading is the enaction to the physical space and the properties of the paper, light, wood table, and other materials in a hybrid mixture with the cyberspace data, becoming cybrid. The body is then in the state of enaction, by using the external eye of the camera for the synthetic vision. Affordances occur iteratively through the mixed gestures and responses of the reader co-located in the digital-world (data-world), in the physical world, inside the room, in front of an illuminated desk, in a new, biocybrid condition[vii].

Figure 3. Borges' creatures in augmented reality, mixed to the landscape.
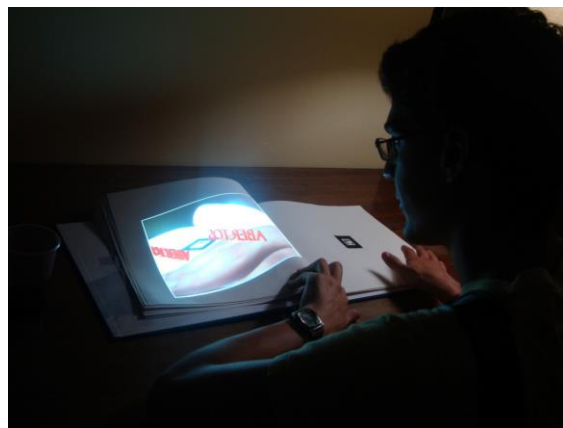

Figure 4. Augmented reality and the experience of reading.

4. BIOCYBRID WEARABLE ART SYSTEM (BWAS)

Our artworks in wearable art and biocybrid systems in LART are investing in technological innovation regarding the miniaturization of hardware systems that have enabled the development of network sensor nodes, which allow new applications for interconnected wireless networks and assistive medical applications. According to [2], those sensors have the ability to detect or measure some phenomenon of nature, processing and transmitting data or information to other sensors. In our artworks the circuit of sensors a node of sensors are built in an intelligent network sensor inserted in a set of accessories - rings, bracelets, visors, glasses, hats, or other wearables - which coupled to bodies configure a Biocybrid Wearable Art System (BWAS) [9], that allows people to monitor, process and send to other biosensors vital signals information and data over a long period of time. Biosignals connections in cyberspace expand body life in physical space and it is configured the biocybrid condition. In this direction we are collaborating for the technological innovation in Art and TechnoScience, in the field of Software Art, BioArt, Wearable Art, Device Art, developing interfaces: hardware and software. In the case of BWAS, with mobile wireless node of biosensors using non-invasive sensors for the body, we use the capture of electrophysiological signals of galvanic skin resistance, and sensors for acquisition and transmission of breath and heartbeats.

The biocybrid condition regulated by biofeedback is very shamanic in the sense it gives the power to capture biological information from the body moving in the physical space , and they exchange energies. Body and environment send signals and the system is performed by inputs and outputs of wireless sensors embodied in a network area [13]. New states emerging from the body in the environment connected to cyberspace and governed by the experience of its presence status in reciprocal behavioral changes reaffirm the enactive interfaced by the very alive human condition transduced by the sensorial physiology of the body and the qualities of urban life in which the enaction occurs. The structure of the sensory-motor interfaced subject contextualized by mobile devices determines how to act and be modulated by events in the environment. These results, in the near future, biocybrid systems will allow to interact with everything, with everybody, with every space, with everywhere, with nobody. By sharing internal and external signals, feelings, beliefes, values, emotions and desires, during rituals - the flâneur is alive and located in the landscape, in urban space and expand the vital signals to life.

5. REENGINEERING NATURAL ENVIRONMENTS

In this project, an important part of the immersion experience will be associated to the visualization of the audio signals emitted by frogs, in an ecological environment located in the Brazilian Pantanal area. A set of microphones will be strategically distributed over the ecological sanctuary, and the acquired audio signals will be transmitted to a Cave or large-scale displays. The visualization system will then prefilter these signals, in order to extract the frogs' callings. Finally, it will extract and interpret different properties of interest, which we describe in the subsections below, and it will project dynamic images that change, over time, according to these properties.

Different types of physical and behavioral properties, as well as environmental parameters, can be extracted from the frogs calling activity, as shown in recent research in bioacoustics. For instance, the emitted sounds are an important characteristic of each species, and have thus been used as a tool for species differentiation [11], as well as for the discovery of new species [14]. Furthermore, they provide valuable behavioral information and reflect reactions to the environmental conditions [15].

We will explore this aspect to visualize the acquired sounds and different properties extracted from them. The system will be developed in four different stages. First, we will implement dynamic spectrograms of the frogs' callings, to be projected inside the Cave. In the second stage, the sounds will be used to classify the different species present, and localize them in the different regions of the ecological sanctuary; a dynamic graphical representation of how the species are distributed will be shown in the Cave. Next, once the sounds from different species can be separated, we will differentiate the individuals of the same species, thus estimating the number of individuals from the same species. Finally, we will build abstract images where different colors will correspond to different levels of physical parameters determined from the sounds, such as temperature, humidity, and light conditions. The next subsections provide more details about each stage.

Despite improving the immersion experience using a visualization tool, this development will represent a contribution to the study of the local biology, by providing information about the species localization and population sizes, as well as their behavior and reactions to the environment.

Furthermore, we will explore a promising way to solve the data visualization problem for the much larger scale displays, datalandscapes, biofeedback and human mobile expanded condition. Display researches will include Immersive Virtual Cave and Mixed and Augmented Reality for Scientific Visualization in Artwork projects and Environmental Art and BioArt themes. Research in this area explores the use of spatially immersive virtual reality and MR and AR systems. Interfaces BWAS are used for expanded biofeedback and networked sensors tracking system. Immersive virtual reality and biofeedback mobile systems can play for the sensorial user's effectiveness when interacting with data and understanding complex laws of living organisms in large-scale visualization systems.

5.1 First Stage: Dynamic Spectrograms

A spectrogram is a graphical representation of the time-frequency distribution of a signal. Typically, in the bidimensional case, the horizontal axis shows different time slots, whereas the vertical axis corresponds to the frequency components; in this case, each point in the plane correspond to an specific time and a single frequency component, and the color or gray level associated to this point indicates the magnitude of that particular frequency found in the signal at the indicated time slot. In a tridimensional representation, the third axis indicates the magnitudes of the components.

Note that, in order to build the spectrogram corresponding to a particular signal, it is necessary to decompose it in the frequency domain, for each time interval considered. Different time-frequency techniques, such as the short-time Fourier transform and filter bank decompositions, are found in the literature [4], [3], each with its advantages and disadvantages and with different levels of compromise between time and frequency resolution. In this project, we will compare different techniques as applied to the frogs' calls.

After the prefiltering stage to isolate the frogs' sounds from the environmental noise, we will divide them into time intervals by applying appropriate windows, and build a spectrogram for each considered interval. In fact, since we want a dynamic visualization that changes as the audio signals evolve, spectrograms will be built for time segments of a few seconds, with the represented times in each spectrogram being the subdivisions of those segments. The main objective will be to improve immersion by providing a visual perception of the frogs' calling activities. Using 3D spectrograms evolving with time, this will show how the sound amplitudes of each frequency increase or decrease over time in the observed regions.

5.2 Second Stage: Species Classification and Localization

There are around 20 frog species inside the analyzed ecological sanctuary. As the vocal activity of frogs has very specific characteristics for each of the species, it is possible to differentiate them from the collected sounds [11]; actually, a description of the vocalizations is almost mandatory when characterizing newly found species of amphibians [15].

In the second stage of the visualization development, we will implement a classifier that will allow us to differentiate the acquired sounds in terms of the species (neural networks and statistical classifiers will be compared). As we dynamically project the different classes inside the cave, this will illustrate the behavior of the species, in terms of geographical distribution. The dynamic images will also show how they respond to each other's movements and possibly to human presence.

5.3 Third Stage: Individuals Classification and Counting

The sounds emitted by the frogs can also be used to distinguish different individuals in each of the species present. Hence, after the sounds from each of the species are separated, it is possible to estimate the number of individuals, in each considered region.

Inside the cave, we will project a graphical representation, by region, of the estimated number of individuals. This will provide a more in-depth visualization of their behaviors. Additionally, the technique can be used in a different context, over longer periods of time, to estimate the growing or shrinking of the populations, in an indirect, noninvasive manner.

5.4 Fourth Stage: Dynamic Abstract Images Related to Physical Properties

In the last planned stage of the visualization development, we will build abstract images that show physical properties like temperature, humidity and light conditions, which are extractable from the sounds. In these images, the positions in the plane will map the different areas from where the sounds are collected, and different colors will correspond to different levels of the analyzed variables.

The dynamic images show the evolution of such parameters over time, as well as, combined with the visualizations from the first three stages, the individuals' and species' responses to the environmental conditions.

5.5 Enactions and Life : Frogs'signatures and biocybrid ecologies

The biocybrid system explores human proximity to the datalandscape and the manipulation of visual and sonic information characteristics during enactions of human body dialogues with the distant Pantanal Bioma[viii]. People wearing rings, bracelets, T-shirts, shoes, glasses or others portables garments are users working up close the environment. BWAS containing portable microcircuits of sensors influence live of the large display. Bodies'behavior and vital signals manipulate the data, when people are close, much closer, breathing, moving... The display may not be easily physically affected or reachable, people may prefer to not have to not move back, one user and groups manipulation may provoke different input, biofeeback and computer vision in augmented reality and mixed reality are in the list of the possible enactions. Metaphorically, we propose the frogs'signatures and the human behavior dealing with laws and phenomena of the cosmos, in case, by influencing life of nature inside the world as a living organism exchanging electrical potentials, heats, sounds and vibrations and the sense of presence being adequated by the technological apparatus for reengineering life.

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[i] Muniz Sodré, a Brazilian communication scientist, proposes the *bios midiático*, and Diana Domingues set up the concept of *cybrid bios*, concerning the human condition connected to cyberspace in the era of ubiquitous computing.

[ii] The cyberperformance was realized at the Museum of Image and Sound / MIS, during the IV International Festival of Mobile Creativity / Mobilefest, on november 14th, 2009, in São Paulo / SP. Collaborators: Dra. Diana Domingues, Tiago Franklin, Juan Arteiro, Roni Ribeiro and Nycolas Albuquerque. Acknowledgments: Dr. Oliver Dyens, Paulo Hartman, Team Mobilefest 2009 and the Museum of Image and Sound / MIS-SP.

[iii] <body>. National Museum of the Republic, Brasília, Brazil, 2008.

[iv] Reference to Diana Domingues artwork *Living Tattoos.*

[v] The virtual airplane was modeled by the fellow Luís Gustavo Souza Silva, under the grant IC CNPq

[vi] The installation was created by the artists Diana Domingues, Camila Hamdan, Tiago Franklin and Leci Augusto, at the Cultural Center San Martin, Buenos Aires, Argentina, in November 2010.

[vii] The modeled objects were developed by Adriano Barboza, Breno Cruz and Luís Gustavo Souza Silva, funded by CNPq.

[viii] Gonçalves de Oliveira, André Luis is the author of the topics related to sonic rules in the present artwork of Environmental Art and BIOART. The LART artwork will develop a sonic landscape using the technological apparatus and sound signals of the Bioma in the remote Pantanal. The complex traces and self-organizing properties of the biocybrid system are the focus of his PhD thesis at PPGArt UnB.