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Envisioning Ecosystems – Biodiversity, Infirmity and Affectivity

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1. Introduction

Earth's biosphere, climate biodiversity crises and environmental issues are raising a profound level of awareness concerning the collective responsibility toward Earth's life and demanding the responsibility for promoting a healthy ecosystem. A new transdisciplinary group of Brazilian researchers at the University of Brasilia at Gama (FGA), working on the Biomedical Engineering Graduate Program, shares with the international community of Art and TechnoScience several themes related to the ecosystem biodiversity and the extremophile condition (Bec, 2007). We consider our responsibility and the urgent attention to life in our country's huge territory, while facing the effects of an endemic infection of tropical climates and working for the preservation of the Biomes in Amazon Forest, the lung of the planet. Our collaborative projects are concerned with infirmity of the territory and the human invasion and destruction of the ecosystem self-organizing defence. Consequently, we work on health care and affective geographies, in the sense postulated by the geographer/philosopher Milton Santos (Santos, 2008 & Santos, 2009) renewed by geolocated and ubiquitous condition and sentient technologies. Interventions in social networks allow people to exist in the sense of being here and there, consisting of a largely sense of place, to be co-located, being connected everywhere, with an awareness of place amplified by the power to take care of the ecosystem. Our project leads with landscapes - as a living organism - in a given geography, being socially engineered, from the conceptual subjective use of space to the advanced mobile telematic computing and ubiquitous data processing and data information visualization by applying the perspective of acting everywhere - and specially in extreme and hostile space.

Assuming the role pointed out by Louis Bec, we are engaged extremophiles (Bec, 2007), working in the direction of a cultural and anthropological paradigm, and, in case, concerned with the planet's health. We face the ecosystem as a living organism that claims for health care projects to build an inhabitable world for future generations. How to be silent when technologies provide us with sentient devices, satellites, geographical interfaces, mobile

technologies, and, for the expansion of the limits of our bodies, by sensor systems? The presence of wireless devices and the possibilities of affective mobile computing (Picard, 1997) modified the traditional concepts of ecosystem, by allowing informational flows, biofeedback data and affectiveness and health (Rocha, 2008) that can be reached by wireless networks, in an ecolocated world.

Until when will the ecosystem's biodiversity crisis persist, given that researchers discuss environment in molecular levels, nanolevels, and satellites put human's eyes, ears, hands and bots in the sky, and global positioning transforms us into extremophiles? As extremophiles artists and scientists, may we collaborate to deal with the environmental and ecological challenges regarding life on the planet, the biological transformations, the environmental and cultural changes? Can we advance the technological apparatus adapted to the ecosystem in a cultural, ecological and healthy social life?

We agree with Malina's beliefs and historical contribution of New Leonardos (Malina, 2007) in collaborative levels of convergent theories and practices which conduct the creative mind of artists, scientist and humanists, from the given to the extremophiles biodiversity engineered world.

We conduct art and Techno Science researches in order to collect, visualize, and analyse data from biological systems and the environment. This work is based on innovative collaborative practices involving artists, engineers, physicists, geographers and humanists. Our main goal is to advance and explore the available technologies for measuring physical parameters and processing biomedical signals, thus allowing an advanced study of complex life systems and the redefinition of the interaction between humans and the environment.

1.1 Biocybrid systems and the engineered nature

For facing the challenges of the ecosystem and the blurring limits in natural and the engineered nature on creative technological levels regarding ecosystem, the "nature itself" and the "future and engineered nature", the Group of researchers at UnB Gama in the Biomedical Engineering Graduate Program and in the Laboratory of Research in Art and TechnoSciences - LART develops biocybrid systems (Domingues, 2009). We consider human existence is nowadays 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 life is reinvented (Domingues, 2011).

The results reaffirm ontological levels of creative reality and mutual influences with environment information, coincident to the James Gibson's ecological perception theory (Gibson, 1986). The ecosystem in its dynamical relations between human, animal, plants, landscapes, urban life and objects brings questions and challenges for artworks and the reengineering of life discussed in our artworks in art and technoscience that challenges the regarding of the ultimate nature of the planet's life.

Our biocybrid systems are founded on networked cyberinfrastructure and physic territory actions. These actions use local mobile technologies and advanced scientific methods for analysing and evaluating biodiversity research on continental-scale environmental issues. Also, they are based on accelerated research strategies, and on communication strategies for collaborative work on biodiversity, ecological and geographic informatics, social platforms,

health process and learning experiences in the physical world and in the digital environment, in collaborations and reciprocity, by using technological common network protocols, for taking on 21st century environmental scientific challenges.

We will describe two of the types of research we conduct: SAPIO – biodiversity, infirmity and affective geography (Dengue infirmity and health care) and Frogs' signatures – Pantanal Bioma in Amazon Forest (preservation of ecosystem and biological community).

2. SAPIO: Biodiversity, infirmity and affective ecosystem

The System for the Acquisition and Processing of Ovitrap Images (SAPIO) is a project developed, in its origin, by the University of Brasilia at Gama (FGA/UnB) and the Federal University of Pernambuco (UFPE). It aims at developing an automated tool for monitoring, studying, fighting, and preventing dengue. Before describing the project in more detail, we briefly comment on the nature of this disease, and how it affects the lives of millions of people in Brazil and neighbour countries. Our recent proposal expands SAPIO in Art and TechnoScience, through creative extremophile plans under the theme of the infirmity of landscapes, and techniques for data visualization of social information underlying information processing and communication technologies (Diamond, 2009). Data visualization design methods and affective aesthetics focused around the central theme of affective geographies information visualization deal with creative technologies and the research tools and computational technologies developed regarding the practice of analysing data patterns, making these invisible ecosystem structures and social patterns be visible. In case of social platforms, then data visualization process becomes interactive, and is transformed into learning methods for health care and dengue infirmity in our territory.

An endemic disease in the Southwest Asia and with several epidemics having occurred in Brazil and other tropical countries, the dengue is caused by an arbovirus transmitted by the female *Aedes Aegypti* mosquito. The initial symptoms may vary significantly from people to people, and include high fever, muscular pains, headaches and nausea. A haemorrhagic variety of the disease can occur, and is characterized, after the first stages, by mouth and nose bleeding, internal bleeding, and intravascular coagulation. Infection can also happen to different organs, and can lead to death. Between 1995 and 2001, for instance, more than two million cases of dengue in American countries were reported to the Pan American Health Organization (PAHO), including around 50 thousand cases of the haemorrhagic type and more than five hundred deaths (WHO, 2011).

The prevention of the dengue disease depends mainly on fighting the *Aedes Aegypti* mosquito, as dengue vaccines are still not commercially available. The population of risk areas is instructed to avoid accumulating water in recipients for several days in exposed areas, as the female mosquito can deposit the eggs in these recipients, and the water allows the larvae to develop. Specific, yet affordable, measures can help preventing the mosquito to reproduce, including the use of coffee grounds in the exposed areas, as coffee was found to kill the larvae.

Some other methods used to combat the *Aedes Aegypti* mosquito are based the ovitrampas, which are special traps that collect the mosquito's eggs and allow the study of infestation tendencies and the prompt definition of control actions. In this context, the SAPIO project is

aimed at obtaining and analysing ovitrampas images, in order to automatically count the deposited eggs and to disseminate the collected information through the World Wide Web.

The SAPIO is divided into two main stages: the Ovitrampas Images Processing (PIO-SAPIO) and the Geographic Information System (SIG-SAPIO).

2.1 PIO-SAPIO

The PIO-SAPIO explores image processing and Artificial Neural Network (ANN) techniques, which it is one of the intelligence system techniques, in order to automatically estimate the number of deposited eggs. The images from the ovitrampas are filtered and binarized, and morphological operations allow the evidencing of present objects. Finally, an ANN classifies the depicted objects, thus allowing the eggs to be detected and counted (Elpídio, 2010).

The present proposal addresses the use of an ANN Multi Layer Perceptron (MLP) (Haykin, 1999) to automate the process of identifying *Aedes Aegypti* eggs in areas of Lamina of the Ovitrap. The algorithm developed to automatically identify the *Aedes Aegypti* eggs in digitalized images of ovitraps was elaborated with Matlab software, version 7.6. In this study, 5 samples of typical ovitraps, previously digitalized were used. The images measure, on average, 23000X6000 pixels and were submitted to a subdivision process to generate a bank of sub-samples of original images to test and validate the ANN. The sub-sampling of the original images has as an objective, to help the training of the ANN and later to compare the results obtained with the manual analysis completed by trained technicians.

In the process of segmentation the Regions of Interest (ROI) were extracted (Gonzalez, 2008), resulting in 217 sub-images, organized in 7 data banks, being that 6 were used in training and one for testing. This strategy resulted in 7 possibilities of system validation with the variation of the bank designed for the test. Figure 1 illustrates the process of sub-sampling and ROI extraction of the digitalized images of the ovitraps.

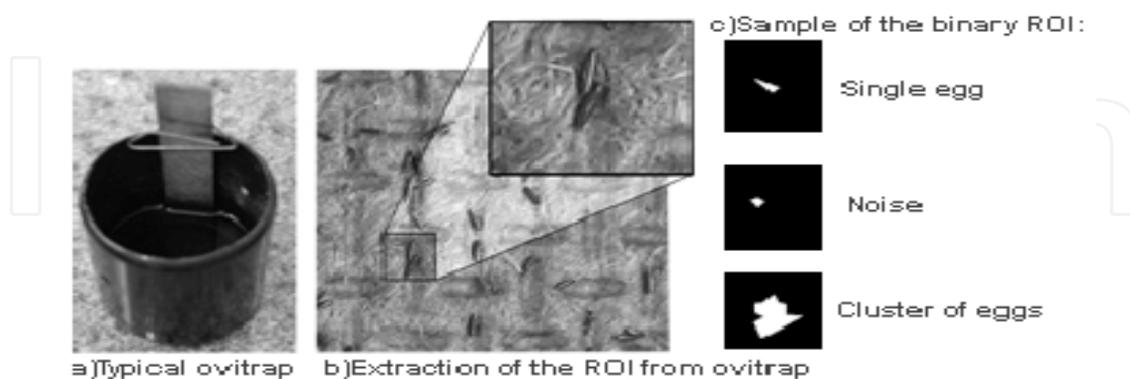


Fig. 1. Example of extraction and classification of ROI obtained from a typical ovitrap.

Before the classification process of the *Aedes Aegypti* eggs with the ANN MLP, each sub-image was submitted to a pre-processing process, where they were binarized by tonality of the ROI. An average filter was applied and the morphological operations of opening and closing to minimize noise effects (Gonzalez, 2008). These operations are useful in the

identification and extraction of image characteristics, besides helping in the identification and minimization of noise that interferes in the form of objects contained in the image. In general, the application of the morphological operations simplifies the objects of interest and enhances essential characteristics of the same. Therefore, the objective of the interactive application of the opening and closing operations is the elimination of artefacts of the image that interfere in the identification of the ROI without distorting the global geometry of the characteristics that it intends to preserve.

Finally, the labelling of the objects present in the binary image, whose result was used as a desired value in the classification of ANN, was completed. The desired value was classified in: no labelled object, noise, single egg or cluster of eggs. The classification of the desired value considered factors such as average size of the egg, area of the labelled object, among others, to complete classification. The entrance of the ANN was extracted from the histogram of the binarized sub-images, originated after the process of segmentation.

The ANN MLP perfects the process of identification of Dengue mosquito eggs, on the digitalized image of the ovitraps, and acts as a deciding mechanism to facilitate classification of ROI. The ANN MLP used was tested with various configurations and the best results were obtained with the following architecture: a rate of learning from 0.95 and one term momentum with the value of 0.01, two hidden layers containing 16 and 50 neurons, respectively. The exit layer was structured with 4 neurons that correspond to the possibilities of classifications of desired value.

In tests developed with the ANN MLP, it was possible to achieve an average quadratic error (Haykin, 1999) of approximately 0.09 and about 94% of cases classified correctly. During the classification, the performance of the ANN was analysed with the hyperbolic functions tangent and sigmoid (Haykin, 1999). It was observed that the ANN MLP obtained better performance during the classification with the use of the Sigmoid function. Figure 2 presents the results of the training with both functions and the consequential performance of the ANN MLP.

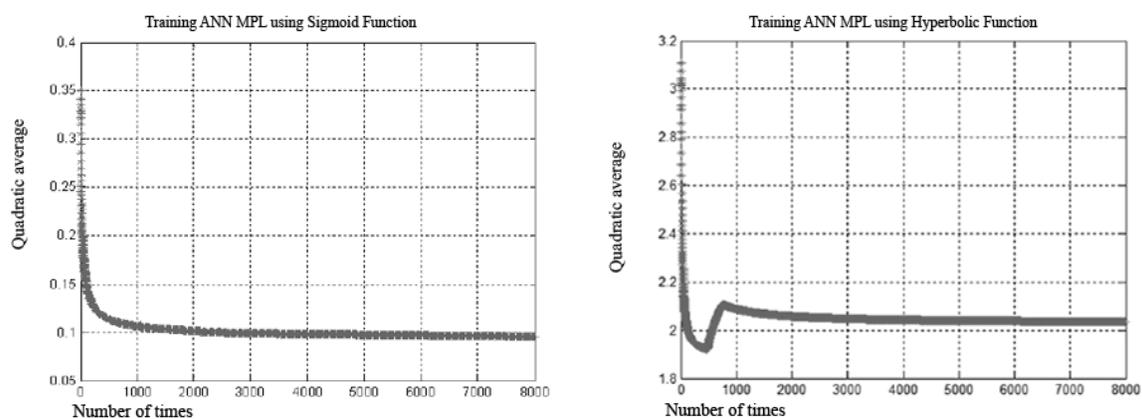


Fig. 2. Performance of the ANN MLP (variation of average quadratic error) according to the type of function.

Table 1 presents the set of data resulting in the classification of the ANN MLP according to the set of image database.

Image Database	Number of images submitted to testing	Average Quadratic Error	Correct Classifications	Percentage of correct classifications
1	23	0,0414	21	91,30%
2	41	0,0475	37	90,24%
3	23	0,0497	23	100 %
4	33	0,0425	30	90,91%
5	35	0,0387	33	94,29%
6	35	0,042	33	94,29%
7	27	0,046	26	96,3%

Table 1. Results of the ANN MLP Classification.

It was found that the major part of the ANN classification resulted in the cluster of *Aedes Aegypti* mosquito eggs. Even though the quantifying of egg clusters has already been considered in earlier work (Elpidio, 2010), as the objective of this approach is to provide a new strategies to validate the algorithm developed, besides making improvements in its performance, currently the efforts made are being invested in broadening knowledge of the ANN MLP to identify the limit between eggs in clusters and making the automated counting of eggs in ovitraps viable.

2.2 SIG-SAPIO

The main objective of the SIG-SAPIO, which the geographic information systems are considered one of the intelligence systems, on the other hand, is to develop a World Wide Web platform that describes the geographical proliferation of the mosquito, based on information periodically extracted from the ovitrampas and automatically uploaded to an online database. It represents an important effort in keeping the local populations informed about the mosquito and the risk areas, thus helping to maintain prevention measures. Our developed tool is ready to be used in large-scale, to provide dynamic and easy-to-read information in an illustrated and didactic manner. The version first of the SIG-SAPIO was presented in the (Amvame Nze, 2011). At following, we present the stages of the new version of this system.

One of the SIG-SAPIO stages is the trapping technique that uses plastic buckets are filled of stained water with a wood slide on the edge, Figure 3. This bucket and slide (ovitrap) is currently used as a trap for the mosquito. A smell from the wood slide is used to attract the *Aedes Aegypti* into the trap and lay the larva on it: this is the ovitrap technique.

A human health expert collects the wood slides and manually counts the eggs deposited by the mosquito. The first part of this project, automates using a special algorithm the eggs counting by image processing techniques, and compares it with the manual technique, Figure 3.

The resulting data collection obtained from the Acquisition and Image Processing group (SAPIO's first stage) is filtered by a script then directed into a free relational database being part of the Web-based group (SAPIO's second stage). This database is dynamically maintained as data comes from the first stage.

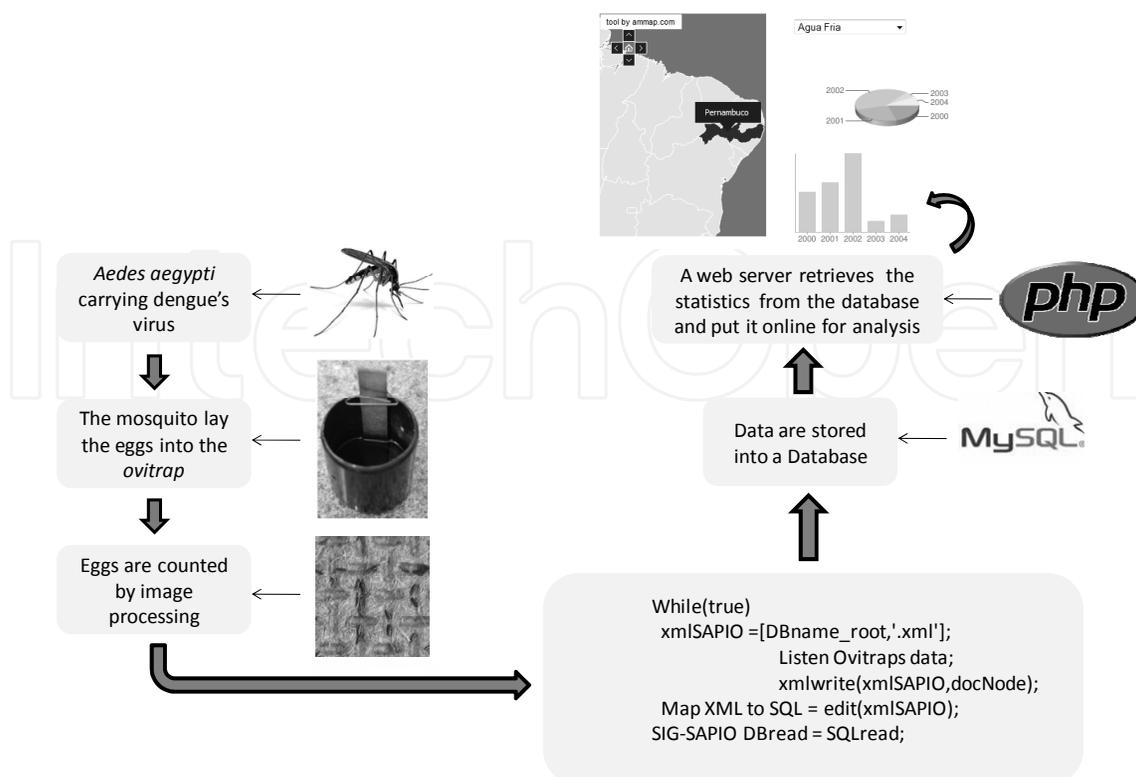


Fig. 3. Diagram showing the methodology leading from egg counting to web-based monitoring.

After data acquisition, a web-based is use to show mapping and statistic information collected from the first stage as shown in Figure 3. Google Maps API is used to support current implementation and phpMyAdmin is used for database acquisition. The prototype demonstrates how dengue monitoring would be displayed for web users. A general map is presented for the user to have direct statistic information from any state, and in need of more detailed information from that state, a link calls Google Maps to provide accurate positioning of the dengue proliferation.

This work has shown the development of an automated web-based application that can provide the monitoring and analysis of dengue proliferation. Its database is filled with data coming from an automated *Aedes Aegypti* image processing egg counting from ovitraps. This platform should be used for monitoring and prevention of the disease as an alert for citizens and government officials in real time.

Moreover, we have built a PIO-SAPIO/SIG-SAPIO with a human/environment/net, natural/artificial, remote/local and rural/urban structure in mutual contamination, with dengue ecological information analogous to the principle of the ouroboros mythic serpent, and self-regenerating emergent narratives about health care and dengue.

At the convergence of the scientific methods, the efficiency of social biocybrid platforms provides the awareness of the territory's infirmity and of people's behaviour in the physical environment and the cyberspace. This is made possible by the interaction with large amounts of data, especially those provided by geographic interfaces such as GPS systems, Google Maps, Google Earth, SMS, MMS and the tweeter, Facebook, Messenger or other

networks. These interfaces create an affective geography, concerned with the infirmity – locus, and inform about the health conditions. The individuals are co-located in the virtual environment and the physical environment, and they live in a social platform where they share skills, affectivity and knowledge about dengue. The individuals are positioned in the virtual and physical environments, and they share an existence in the social platform, where they learn and teach. Their experiences and knowledge are shared, in favour of the group's health and against dengue.

The project uses virtual environment to reengineer reality and blurs people's life and social behaviour in cyberspace and in daily life always looking for a healthier physical environment. Data collected by interface devices generate a locus by processes fundamentally different of photography, television or other media information that, until now, are dedicated to dengue public campaigns. The social platforms allow access to different sources of data signals coming from cyberconnections and from mobile devices providing a networked process of learning about the dengue epidemic during collaborations and reciprocities, by sharing behaviour and affectivity regarding the territory and their experiences and knowledge in favour of the group's health and against the dengue epidemic. The existence is an endless social process of learning and teaching, in mutual and intertwined influences referred to the ecosystem and the infirmity of the landscape.

Data visualization scientific techniques and their information processing of biosignals of the ecosystem, and communication technologies information are visualized and transform data to representations intelligible on a human code which culminate into icono(geo)graphies. In the art history, the artists revigorate the landscape language and methods, enhancing the abstractionism domain, and in close relation to the *land art* and *environmental art* and participatory forms of landscape in social models. Consequently, information processing and scientific forms in data signals processing of natural phenomena transform the artistic landscape in data visualization landscapes as new forms of landscapes in Contemporary Arts. The participation of communities in communication technologies and data mining systems reveal the affectivity to the territory in social behaviours and the data visualization of *graphos* coming from search engines are transformed in emergent maps of the affection and the care of the landscape.

This project is outstanding and should cover the immediate needs of the dengue configuration in the national territory and the increasingly expansion of the disease in several states, mainly reaching the Distrito Federal which is affected since 1991, and producing autochthons cases in 1997 as affirms Catan, Fontes et al. *"Its distribution in the Distrito Federal is uneven, presenting higher rates in places the perverse urbanization in the peripheral countries and the decline of the public health system in these countries. In Brazil this disease reemerge in the 1980's, after almost 60 years without any case in without infrastructure."*

Thus, the aim of our work is to improve the Dengue extinction in Brazil and dealing with biomedical research topics and Art and Technoscience contribution in data visualization landscapes and collaborative affective platforms regarding a healthier territory.

3. Biocybrid system: Frogs' signatures in the Pantanal Biome

A second ecosystem-related line of research developed at LART investigates the frogs' populations in the Brazilian Pantanal area, and explores the richness of information

conveyed by the frogs' vocalizations. A set of microphones will be strategically distributed over an ecological sanctuary, and the acquired audio signals will be transmitted to a remote cave (Domingues, 2003) for data visualization and analysis. In this stage is possible to use an ANN, which it is one of the intelligence system techniques, to classify the frogs' vocalizations.

Once the audio signals are received, 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 briefly describe below, and it will project dynamic images that change, over time, according to these properties.

Different types of physical and behavioural 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 (Glaw, 1991), as well as for the discovery of new species (Vences, 2010). Furthermore, they provide valuable behavioural information and reflect reactions to the environmental conditions (Vielliard, 2010).

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, which we briefly discuss below.

3.1 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 colour 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 (Cohen, 1995 & Cohen, 1998), 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' vocalization. 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.

In order to illustrate some of the data visualization techniques we wish to apply, we show, in Fig. 4, an example of a segment of frog vocalization, as a function of time. In Fig. 5 and Fig. 6, we show the corresponding spectrogram, respectively in its 2D and 3D forms.

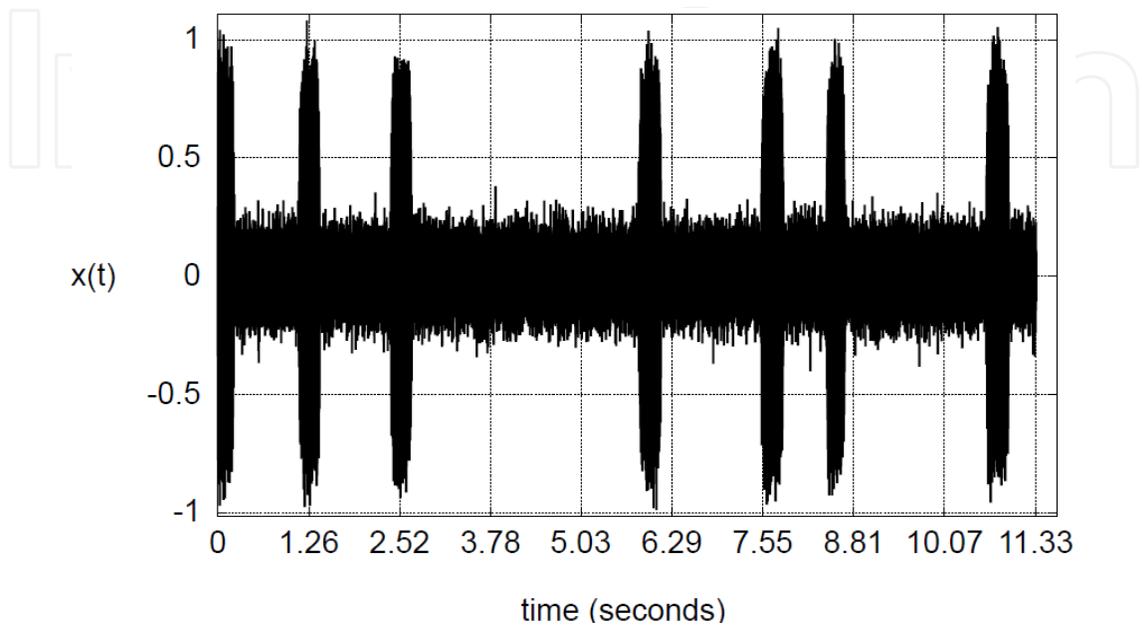


Fig. 4. A segment of a frog vocalization, as a function of time.

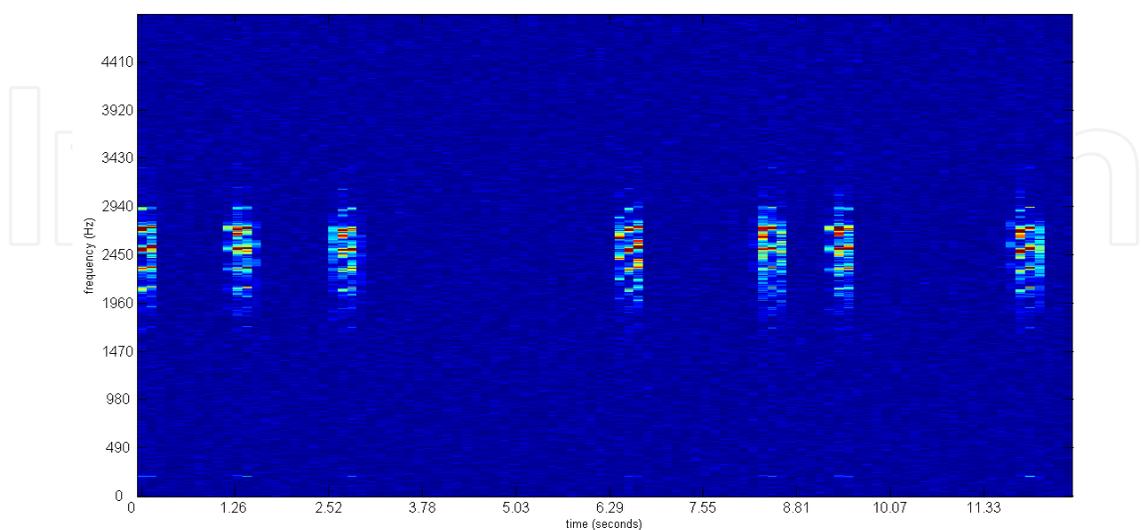


Fig. 5. The 2D spectrogram corresponding to the frog vocalization in Fig. 4.

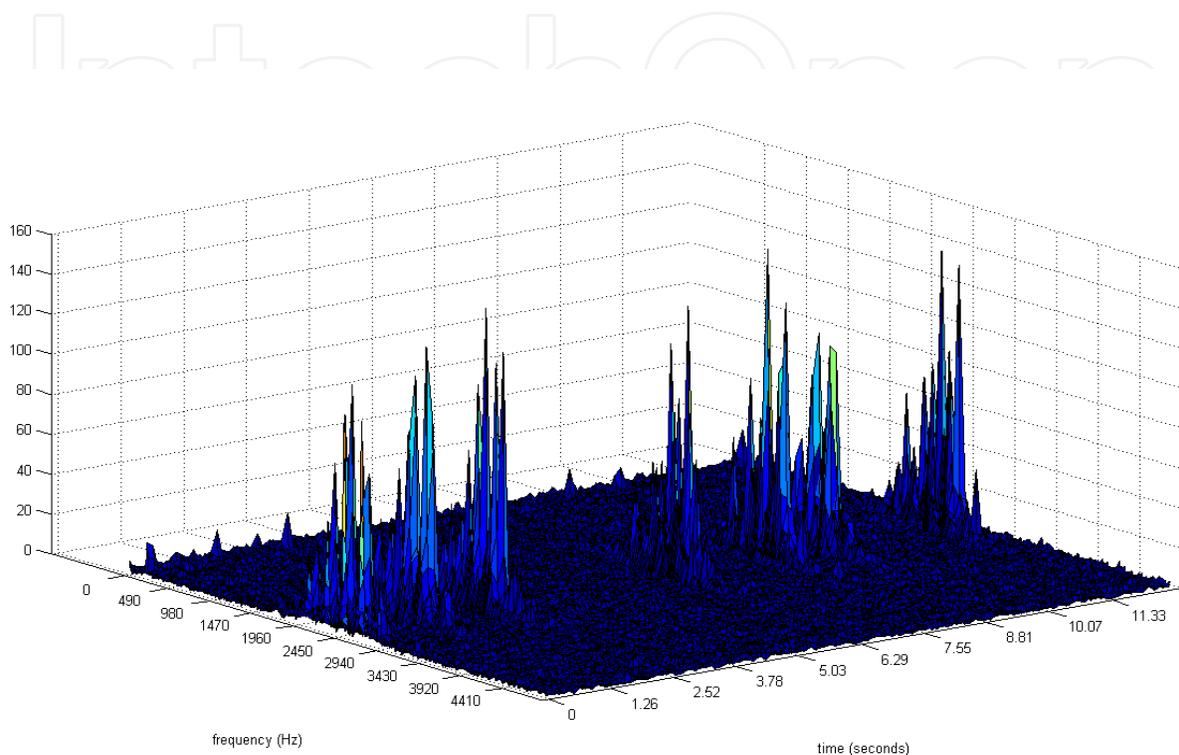


Fig. 6. The 3D spectrogram corresponding to the frog vocalization in Fig. 4.

3.2 Second stage: Species classification and localization

There are around 20 frog species inside the analysed 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 (Glaw, 1991); actually, a description of the vocalizations is almost mandatory when characterizing newly found species of amphibians (Vielliard, 2010).

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 behaviour 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.

3.3 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 behaviours. 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.

3.4 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 colours will correspond to different levels of the analysed 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.

3.5 Study of the local biology

Besides 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 behaviour and reactions to the environment. Other potential applications include the measurement of the impact, to several biological groups, of cities overlapping their natural habitats.

Also, in developing the biocybrid system we provide the human proximity to the datalandscape and the manipulation of visual and sonic information, during enactments of human body dialogues with the distant Pantanal Biome. People wearing rings, bracelets, T-shirts, shoes and glasses equipped with biosensors are users working close to the environment. Metaphorically, we propose the frogs' signatures and the human behaviour dealing with laws and phenomena of the cosmos, 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 advanced by the technological apparatus.

4. Life systems and pattern formation

Note that, in developing research on complex life systems, we emphasize the study of pattern formation. The scientific community has recently devoted significant attention to the study of this process. In fact, pattern formation occurs in several natural phenomena, and thus constitutes the object of study in different scientific fields (Cross, 1993). Some of these phenomena are well known, such as Rayleigh-Bénard convection (Bénard, 1900; Rayleigh, 1916 & Getling, 1991) and the Belousov-Zhabotinsky reactions (Petrov, 1997). The

essence of biology itself is the self-organization and the subsequent pattern formation with the raising of emergent properties. Some examples include: morphogenesis, which comprises a loss of symmetry, as the spatial differentiation rises from a homogeneous environment (Ingham, 1998); the non-homogeneous distribution of plankton in the oceans (Vilar, 2003; Lehman, 1982 & Mackas, 1985) and the distribution of other species in ecological systems (Levin, 1992).

One can argue that all those systems seem to violate the second law of thermodynamics, when in fact other principles are violated, like mixing, ergodicity, and in some cases the fluctuation-dissipation theorem (Costa, 2003). In our research, we note that, in most cases, the rise of emergent properties, such as spatio-temporal synchronization (Morgado, 2007) and pattern formation (da Cunha, 2009), are consequences of some kind of memory.

In (Morgado, 2007), we show that the synchronization phenomena in systems described by the logistic equation with stochastic noise, an equation that is widely used for population models, are accomplished when we introduce in the equation a memory term, which describes the temporal interaction between generations. We find that synchronization only occurs when the memory has sufficient intensity and/or range, indicating that both parameters are important. In fact, we find a subset in this parameter space where synchronization is present.

In (da Cunha, 2009), we study the problem of bacteria growth, using the Fisher Equation. This equation extends the logistic equation and adds a diffusive term, while retaining the growth and competition terms. But in these, the interactions are local, which does not correspond to the reality in most cases. For example, the spread of chemical toxic substances as a result of metabolic activity is a non-local interaction that affects the growth rate and the competition for resources. To address these problems, we propose a generalization of the traditional Fisher equation, in order to include non-local growth and competition terms, by means of memory terms. These memories extend the growth and competition over a controlled range in the growth domain. We find that the pattern formation only occurs in a subset of the parameter space, just like the synchronization phenomena discussed before. More than just a coincidence, these results indicate that memory plays a significant role in the development of emergent properties.

5. Conclusion

Cyberculture, scientific, artistic, technological and social aims in self-organizing complex biocybrid systems favour the human responsibility, reciprocity and generosity, and contributes to the ecosystem health.

Transdisciplinary methods and blurred boundaries of disciplines allow researchers to incorporate their subjects' concerns and questions as Ecosystem, biodiversity, affective aesthetics, art of landscape and social behaviour into the research process. Wireless networks have all created an ideal environment for an explosion of human capacity of reinvention of life and the desire of reengineering nature in data visualization; mobile devices add several levels for being ecolocated. Biocybrid systems and the layering capacity of GPS, Bluetooth, geo-tagging, SIG, augmented reality, neural networks, our eyes, ears and hands in the sky by the extrusion in the satellites and sensors, provide localization and

personalization capacities in new forms of life and the responsibility to the ecosystem. The innovations in scientific data visualization, and social data visualization information and communication enable a healthier future for the planet in ways that were unpredictable, not visible, intensely giving us the sense to take care the health and to deal with the biodiversity challenges of the earth's biosphere and control biodiversity crises and environmental issues, thus responding to our profound level of awareness concerning the collective responsibility toward Earth's life and providing us with some extremophile initiatives to the responsibility for promoting a healthy ecosystem.

In Malina's words, *"a new Renaissance is under way, and at no time in human history have the challenges of a sustainable civilization on our planet been more daunting. It is surely through the work of these new Leonardos that we will change our ideas about the world and how to act in the world."*

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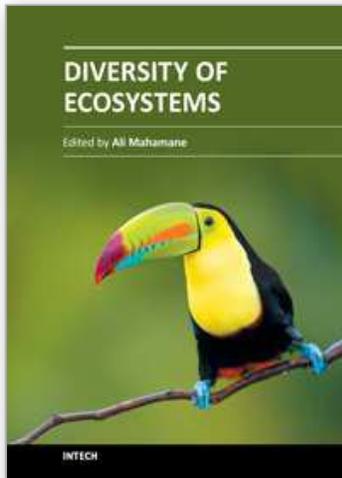
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Diversity of Ecosystems

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The ecosystems present a great diversity worldwide and use various functionalities according to ecologic regions. In this new context of variability and climatic changes, these ecosystems undergo notable modifications amplified by domestic uses of which it was subjected to. Indeed the ecosystems render diverse services to humanity from their composition and structure but the tolerable levels are unknown. The preservation of these ecosystemic services needs a clear understanding of their complexity. The role of research is not only to characterise the ecosystems but also to clearly define the tolerable usage levels. Their characterisation proves to be important not only for the local populations that use it but also for the conservation of biodiversity. Hence, the measurement, management and protection of ecosystems need innovative and diverse methods. For all these reasons, the aim of this book is to bring out a general view on the function of ecosystems, modelling, sampling strategies, invading species, the response of organisms to modifications, the carbon dynamics, the mathematical models and theories that can be applied in diverse conditions.

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