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Enaction, Immersion and Performance in Interactive Installations

Enação, Imersão e Performance em Instalações Interativas

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Abstract
This article presents an analysis of four interactive installations created by the authors and exhibited in several events from 2009 to 2021. When describing and evaluating AURAL (2009), AURAL2 (2011), SELFHOOD (2017) and RABISCO (2020), the text presents a new methodological perspective to compare infrastructure, immersion capacity, emphasis on modality and visitors' behavior within the installation. The article analyses how the development of installations produces results orbiting around artistic manifestations and technological development that further implicate other areas of knowledge.
Keywords: Interactive Installations, Generative Arts, Robotics, Soundscapes, Evolutionary Composition

Resumo
Este artigo apresenta uma análise de quatro instalações interativas criadas pelos autores e expostas em diferentes eventos de 2009 a 2021. Ao descrever e avaliar as instalações AURAL (2009), AURAL2 (2011), SELFHOOD (2017) e RABISCO (2020), o texto apresenta uma nova perspectiva metodológica para comparar infraestrutura, capacidade de imersão, ênfase na modalidade e comportamento dos visitantes dentro da instalação. O artigo analisa como o desenvolvimento de instalações produz resultados orbitando em torno de manifestações artísticas e desenvolvimentos tecnológicos que envolvem ainda outras áreas do conhecimento.
Palavras-Chave: Instalações Interativas, Artes Generativas, Robótica, Paisagens Sonoras, Composição Evolutiva.

1. Introduction

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A new kind of art experience has come into being with the advent of computer-based interactivity. In these interactive artworks, the visitor's activity is not only psychological, but is also constituted through exchanges of information that occur between a person and an artefact, and between artefact and artefact. The advent of these new technologies focusing on alternative digital media raised fundamental questions on the role of embodiment, the virtual environment and the man-machine interplay (Muller et al., 2006; Kwastek et al., 2013; Jeon et al., 2019). Dialoguing with these developments, this article approaches an installation as an immersive and interactive infrastructure in which it is possible to generate, interact, analyses and store multimodal information (audio, video, images, human movement and bio-signals).

In order to reflect on how a unified experience evolves coherently in time while data and visitors are merged in the installation, the text presents an analysis based on four criteria for comparing their infrastructures, immersive potentials, modality emphasis and the visitors' induced behaviors. They are studied as infrastructures enabling immersive, enactive and embodied behaviors. Kaipainen et al. (2011), with their so-called "enactive systems", hints towards the idea of human and computer not as separate systems, but as a "coupling" between the human being and the computational technology. Their premise, inspired by the seminal work of Varela et al. (1993), is that interactions are embodied, i.e., guided by the body's involvement and the human agent's spatial presence. An enactive system, as proposed, can detect both deliberate and non-deliberate information from the body (e.g., movement or physiological readings) and respond accordingly. This, in turn, generates a response in the person, and the enactive cycle goes on (Duarte et al., 2021).

The audiovisual material displayed in an installation can be connected to the context of Generative Arts. Generative systems have many similarities with systems found in various areas of science; they may provide order and disorder, as well as a varying degree of complexity, making behavioral prediction difficult. However, such systems still contain a definite relation between cause and effect. The artist (or creator) generally provides basic rules, and then defines a process, random or semi-random, to work on these elements. The results continue to happen within the limits of the domain of the rules, but also may be subjected to subtle changes or even surprises (Moroni and Manzolli, 2012).

In what follows, the next section briefly describes the installations AURAL (2009), AURAL2 (2011), SELFHOOD (2017) and RABISCO (2020) (Moroni and Manzolli, 2014; Manzolli et al.,

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2018; Dezotti et al., 2020; Moroni et al., 2020). It follows an analysis of them, according to four criteria: Structural, Immersiveness, Modality Emphasis and Behavioral. Then, the last paragraphs discuss the kind of installations studied here, the use of digital technologies besides computers, and the engagement and reaction of the visitors to the multimodal stimulus.

2. Trajectory of the Installations

The compositional, technological processes and generative design of the four installations were deployed to build novel ways of mediated perception and interaction using new immersive digital media. It is a trajectory of artworks generating interactive narratives supported by robotics and computer vision, digital music, virtual soundscapes and synthetic visualization. Despite such a panoply of resources and devices, there is a coherent integration among these installations, starting mainly by the concepts that connected the design and development of each of them. AURAL (2009) and AURAL2 (2011) started upon the concept of arTbitrariness, defined as a theoretical perspective for studying automatic and semi-automatic processes of artistic production (Moroni et al., 2002, Moroni and Manzolli, 2010). In these two installations arTbitrariness was also aligned with an audiovisual generative approach controlled by evolutionary computation. In order to expressively explore the constraints concerning action and perception in an installation, in SELFHOOD (2017) the interaction was inspired by the body's perceptual, cognitive, motor and kinesthetic responses. More recent, RABISCO (2020) was conceived as an artistic creative environment that uses hand's movement to generate visual compositions as a form of self-expression.

2.1 AURAL: from Evolutionary Composition to Robotic Sonification

AURAL (2009) environment used real-world devices such as mobile robots and an omnidirectional vision system for generating music material. The behavior of mobile robots in an arena was used as a compositional strategy. Beyond the foregoing works (Moroni et al, 2002a, 2002b) AURAL attempted to autonomously generate complex sonic structures by exploring the dynamics of the real-world interaction between artefacts and their environment, including man-machine interaction.

Similar to the systems developed by Manzolli and Verschure and (2005) and Murray et al. (2005) AURAL generated a sequence of sound events based on the interaction of mobile

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robots in an arena. Unlike these two systems, the sound generation was controlled by robotic trajectories associated to a fitness function of the evolutionary sound environment, JaVOX (Moroni et al., 2006).

Figure 1 shows the Nomad robot, the iRobots, the projected scenery and, hanging from the ceiling, the OmniEye, the artificial vision system specially created for the AURAL environment. For the visual tracking, different color panels (red, blue, green) were fixed on the top of each robot, since OmniEye tracked each robots' trajectory based on its color detection.

Figure 1. On the left, AURAL installation at UNICAMP Art Gallery (March, 2009). On the right another setup of the AURAL at FILE festival 2009 (Moroni and Manzolli, 2014)

On the last day of the exhibition at the Unicamp Art Gallery (March 2009), a dancer, three musicians and the AURAL system itself, with four robots, performed an interactive music and dance concert called Robotic Variations (Figure 2) (Moroni and Manzolli, 2009). The same trajectories used to generate the material for the composition were also used in the score of the parts performed by three musicians, a pianist, a marimba player and a computer performer. A scenery, generated in real time, projected images from the robots on the walls. The choreography was conceived so that the robot with a red panel was replaced by the dancer,

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using a red hat. In this way, her position was tracked by the visual system, interfering in the sound generation and incurring in another human machine interaction cycle. AURAL performance videos can be seen at (Moroni, 2009).

Figure 2. The dancer and two musicians are interacting with robots during the performance of Robotic Variations within the AURAL environment exposed at the UNICAMP Art Gallery.

2.2. AURAL2: Robots and a Generative System in an Algorithmic Composition Process

An artificial vision system, mobile robots and a generative process were applied for sound production in AURAL2 (2011), another robotic artistic installation (Moroni et al., 2014). In the AURAL2, fragments of synthetic digitally generated sounds, sounds from game and everyday sounds were stored into a database, the memory of the system. Each sound fragment was associated with a cell in a virtual grid, projected on a winding format platform (3m x 3m wide, 0.3m high) (Figure 3). A hole inside the robots' navigation platform enabled trajectories that could be travelled on by one robot, two robots or three robots. The robots had a border sensor and they changed their trajectories when a border was detected. This design of the platform´s navigation surface generated conflict among the robots when they tried to escape from confined areas, from collisions with each other, sometimes avoiding to fall in the hole in the middle of the platform.

A webcam was used to track the robots navigating on the stage, applying the same color detection algorithm developed for the AURAL, the robots (x, y) position in the arena was sent to the computer system. This position was associated to a cell of a virtual grid representing the

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stage in a TV display. Each cell triggered a sound fragment in the database, therefore, the robots' navigation on the winding stage (re)created soundscapes in the installation sound diffusion system.

Figure 3. People interacting with the AURAL2 environment.

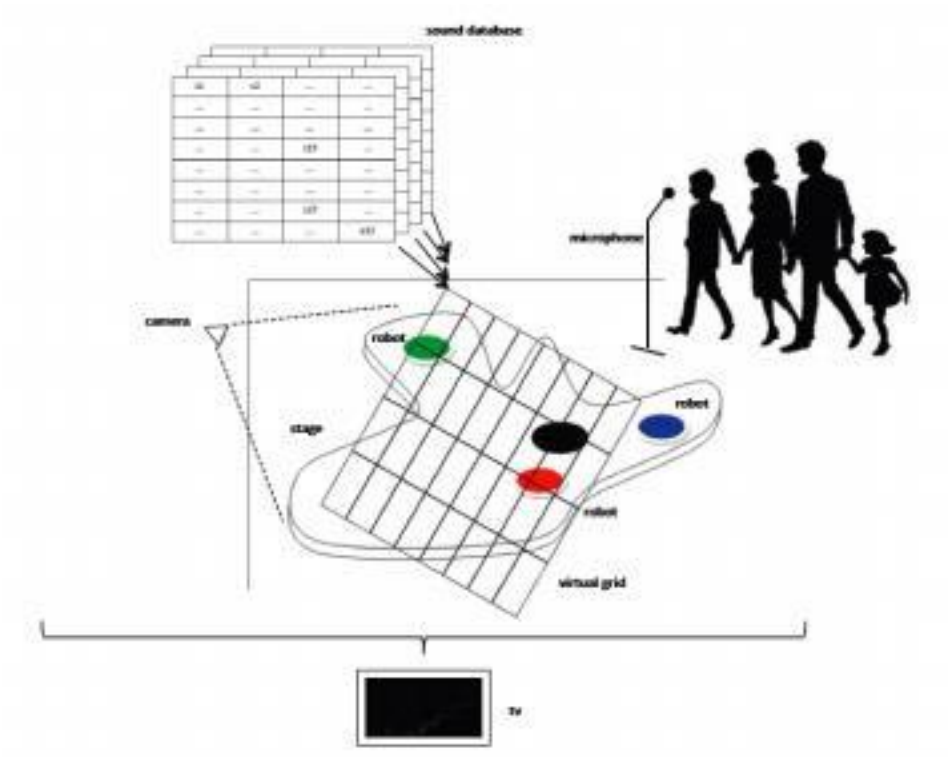

Figure 4. The components of AURAL2: sound database, camera, microphone, robots.

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The TV display showed the virtual grid in several angles, as well as the cells activated by the robots (Figure 3). The visitors interacted with the system by talking, singing or screaming at a microphone. Following visitors' intervention process, sound fragments extracted from their voices and sometimes from the installation acoustic environment were inserted into the database to be played in the future when triggered by the robots. This continuous process of recycling sounds from the database produced a vibrant soundscape that never ended.

2.3 SELFHOOD: an experience around the self

SELFHOOD was an installation in which two particle systems based on the algorithm Boids (Reynolds, 1987) were used to generate images and digitally synthesized sounds. The generative sound system of the installation was the CromaCrono≈ computer environment, that operated with a set of algorithmic compositional procedures, making possible real-time generative sound control (Manzolli, 2015). Figure 5 shows the components of the SELFHOOD installation and CromaCrono≈ interface.

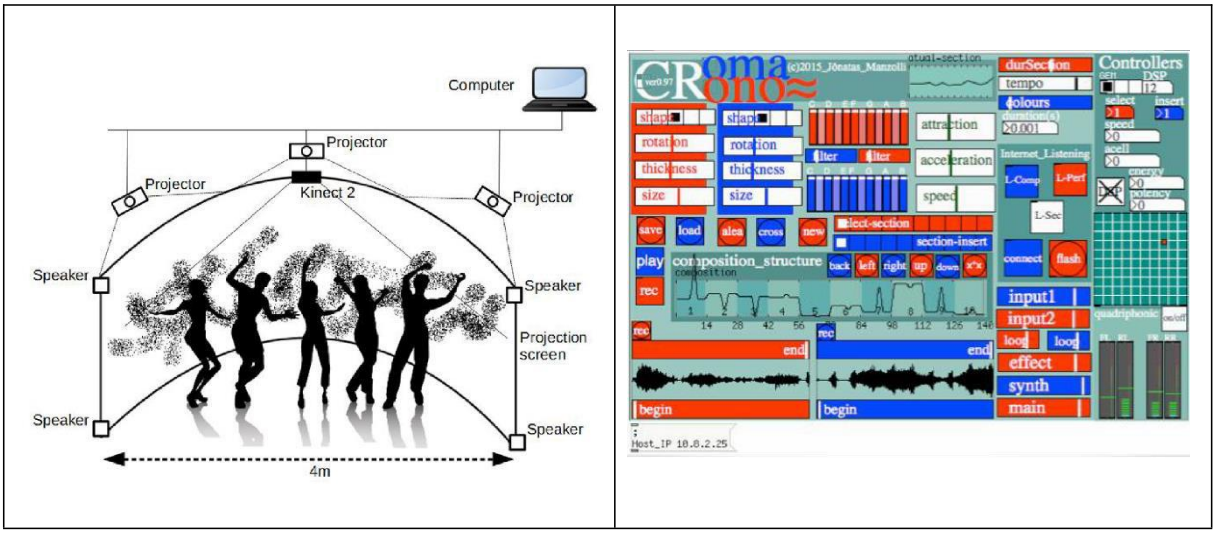

Figure 5. On the left, the components of the SELFHOOD installation. On the right, the CromaCrono≈ interface.

By using these tools, the SELFHOOD environment created a representation of its visitors in the form of a set of particle systems (Manzolli et al., 2018). Each body representation contained 25 particle emitters associated to each one of the visitor's body joint with a different color for each person. These emitters created the colored particles that represented the individual's selfhood and it is possible to see in Figure 6 the representation of the selves through the

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particle systems display. The particles were created with a random initial velocity, at a random direction, affected by a gravitational force defined in the simulation. Depending on the distances between the bodies, the self-representations of each body interfered each other, by sharing and acquiring particles of different colors. The closer the participants were, the more particles of the other color they shared.

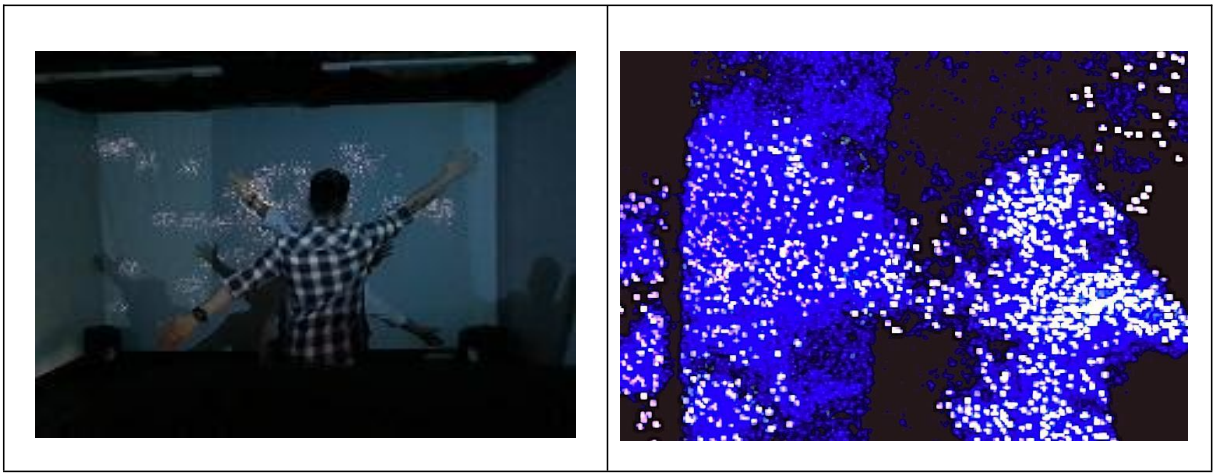

Figure 6. Self-representation in the SELFHOOD installation.

The key point discussed in SELFHOOD is that the interaction of an agent or group of agents with an immersive space, using various interactive devices, indicates how these processes affect their behavior and the meaning that is constructed by them. These systems can be evaluated from the perspective of the interaction between agents and devices generating sounds, video and 3D graphics. Videos showing people playing at the SELFHOOD installation can be seen at (Moroni and Manzolli, 2017, Moroni et al, 2017).

2.4. RABISCO: an environment for self-expression

RABISCO is an interactive installation that aims to provide, even to a naive visitor, a creative and expressive experience, through another form of interaction based on movement detection. RABISCO allows the visitor to produce multifaceted two-dimensional compositions. It captures the movement of the visitor's right hand and shows its path on the computer screen, in analogy with a scribble (“rabisco” in Portuguese), in different colors and visual effects (Dezotti et al., 2020; Moroni et al, 2020).

RABISCO has three main components: 1) a physical motion capture sensor; 2) a programming environment/language for visual effects; 3) a projection screen, depicted in Figure 6, on the

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left. Conceptually, in RABISCO the visitor will be drawing on the face of a cube at every moment, as depicted in Figure 6, on the right. However, on each face of the cube, the coordinate system changes, causing a surprise reaction and inducing the participant to an adaptive behavior. Thus, the same movement produces different results on each face. Figure 7 shows compositions created with RABISCO.

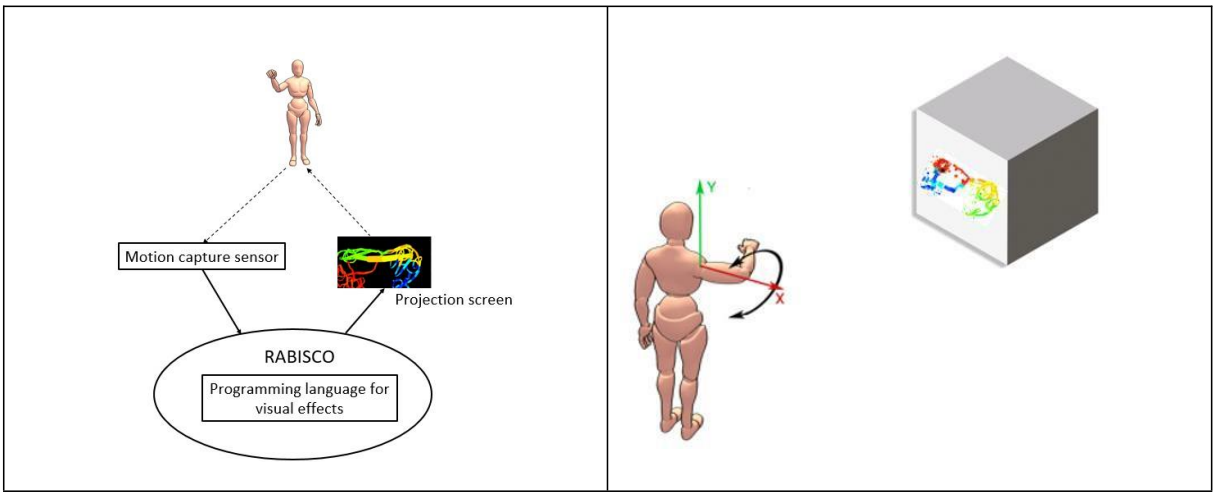

Figure 6. On the left, the three main components of RABISCO: the sensor, the graphical programming environment, the projection screen and a person interacting with the system. On the right, the conceptual space of RABISCO: the visitor draws on the face of a cube.

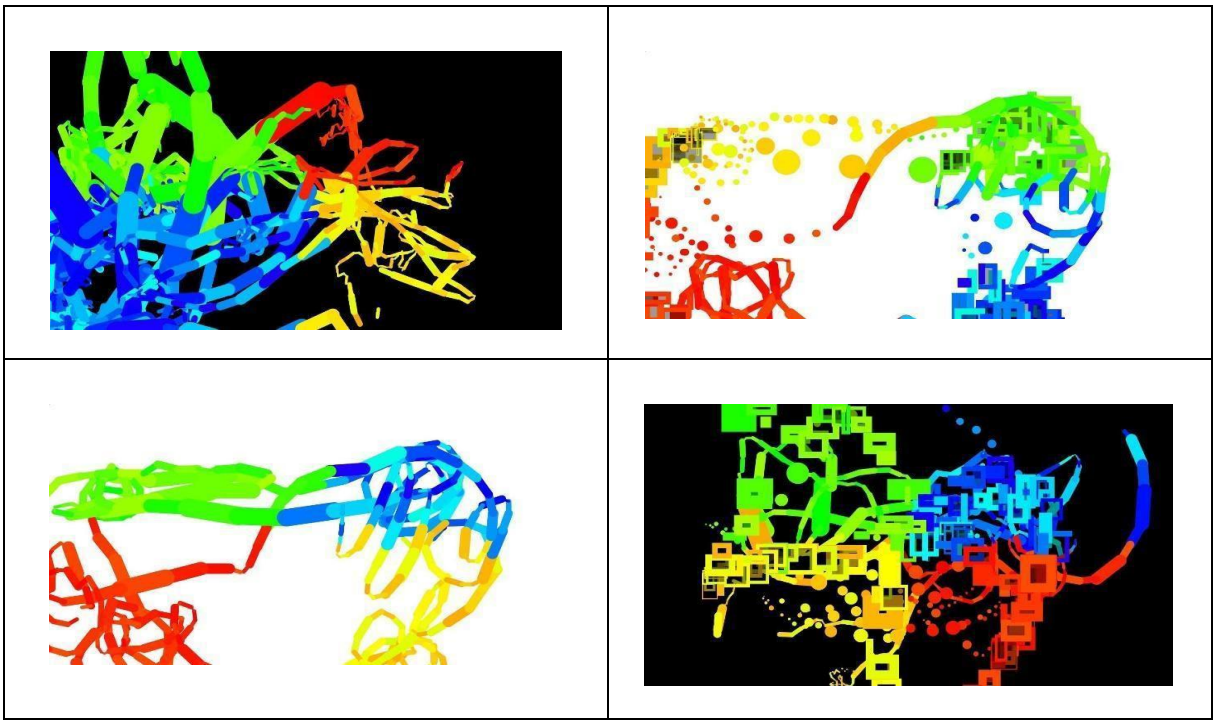

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Figure 7. Compositions created with RABISCO

3. From Infrastructure to a Comparative Analysis

The installation infrastructure provides physical space and audio-visuals to experiment with sonification and visualization, and to interact with digitally synthesized processes such as soundscapes, interactive video, animation and 3D-graphics. It is also possible for the agents (human/machine) to perform music, dance and acting. All these possibilities are linked to the concept of an installation where agents in the physical world and maybe also avatars exchange information in real-time.

3.1 Matrices of Comparative Analysis

This subsection presents a comparative analysis of the four installations presented in the previous section: AURAL (2009), AURAL2 (2011), SELFHOOD (2017) and RABISCO (2020). The purpose of the analysis is to put in perspective the design and resources used in each installation aligned with the mechanisms to control interaction and production of audiovisuals. Further, we understand also that the analysis presented here can be applied as a methodological approach to evaluate other interactive installations. Table 1 presents a summary of the criteria we will use in our analysis.

TABLE 1: Criteria of Analysis

Criterion	Definition	Parameters
Structural	elements of the installation that are linked to its assembling	spatial dimensions, technological resources, number of people involved, time of development
Immersiveness	How the immersion in the installation takes place from the point of view of the visitors and how the agency between the different states of the installation induce participation	Individual, collective, participation: active or passive
Modality	The description of which is the predominant modality in the installation	aural, visual, haptic, olfactory, tastetory
Behavioral	Type of integration between perception and action that the installation induces its visitors	Gestures, movements and actions in space

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In Table 2 we integrate the four installations presented in this article in the same analytical matrix. In other words, we compare them against the criteria presented in Table 1.

Table 2: Comparing AURAL, AURAL2, SELFHOOD and RABISCO

	AURAL	AURAL2	SELFHOOD	RABISCO
Exposition	**2009**	**2011**	**2017**	**2020**
Area	Stage: 4m x 4m Area for audience	Stage: 5m x 5m Area for audience	7m x 7m	Stage: 3m x 3m Area for audience
Resources	Computers (2) Omnidirectional vision system Robot Nomad iRobots (3) User interface Generative visual and sound modules Sound system Projector	Computer Artificial vision system iRobots (4) Winding stage Microfone Video screen	Computers (2) KinectV2 sensor Sound system Projectors (3)	Notebook KinectV2 sensor Sound system Video screen
Team members	10	4	3	3
Development	3 years	6 months	9 months	6 months
Immersiveness	Individual Collective Active Passive	Individual Collective Active Passive	Individual Collective Active Passive	Individual Collective Active Passive
Modality	Visual Aural	Visual Aural	Visual Aural	Visual Aural
Behavioral	Drawing at user interface Dancing Playing together Observing	Talking at microphone Observing	Gestures Movement Actions in space	Gestures Movement

3.2 Analysis Discussion

3.2.1 Concerning Structural Criterion

Structural Criterion concerns elements of the installation needed to its assembly, such as its spatial dimensions, number of people involved in its development, the technological resources and the time for its development. In this regard, the aim is to describe the material attributes, both from the point of view of infrastructure and human resources.

We verify that AURAL had more equipment, a bigger team and the longest development time. Indeed, AURAL was a very complex installation, with two different types of robots, Nomad and iRobots, what demanded the development of two different trajectory modules for the robots,

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besides the development of the omnidirectional system. AURAL2, less complex, had its beautiful winding stage with corridors of different widths, promoting conflicts among the robots and fascinating the observers. SELFHOOD, eight years younger than AURAL, had a shorter development time and a smaller team, but not a less expressive result. In fact, this development took advantage of a very sophisticated infrastructure available, the immersive room at the ImCognita Lab at NICS/Unicamp, and the CromaCrono≈ system, which together with the KinectV2 resulted in an environment where the performers could interact with regions of the space in a very precise way. Finally, RABISCO, with its economic infrastructure, small team and fast development, became a finalist in phase 1 of the OpenCV IA competition.

3.2.2 Concerning Immersiveness

We define the Immersiveness Criterion as how the immersion in the installation takes place from the point of view of the visitors and how the agency between the different states of the installation provide participation. We define participation in two aspects: individual and collective. In the individual case, the installation is focused on the interaction with an individual and the relationships are established through a first-person view. In the collective case, the installation is focused on the establishment of collective actions, the relationships are established through a third person view or the formation of groups as in the case of a game. Further, given that visitors act and participate in the installation, we verify how they behave in two ways: passive or active participation. Passive participation is focused on an interaction in which the visitor observes the installation's behavior and immersion occurs through the perception of audiovisual stimuli presented to visitors. In active participation, the visitor has the opportunity to modify the generative process of the installation based on his personal action. We consider here what is the participatory potential of the installation, as we know that even in a participatory situation, the visitor can opt for a state of passive appreciation.

AURAL installation supported different possibilities of interactivity. People could actively drive the robots by drawing curves at the user interface, which were sent as trajectories to the robots, guiding the sound production. People could dance, substituting the robots, also interfering in the sound production. In a passive mode, people could hear the sound production, appreciate the performance of the robots and the virtual scenery. And different from all the other installations, AURAL promoted an inversion, musicians played a composition created by a computational system by using the robots´ trajectories, acting also as partners.

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In AURAL2 people could actively interact with the installation by talking, singing or screaming at the microphone, all these situations were observed. People could passively observe the robots trying to navigate on the winding stage, sometimes conflicting in the narrow regions. They could also passively appreciate the transitions of the scenes in the video screen or the sonification product. But AURAL2 had a unique characteristic compared to the other installations. Sometimes sound fragments were extracted from the environment and inserted into the database. Eventually, a sound fragment of the voice of a person passing by could be inserted into the database. In this case, the person *actively and inadvertently* interfered with the sound process.

In SELFHOOD, people could opt to just observe, or move around, appreciating the effects they caused just by being there. But they also could intentionally explore the space and manipulate it, resulting in a sound composition, like a Theremin that could be actioned with all the body. For this, they had to investigate how their movement affected the space, prospecting the results of their actions in the air, in a strong engagement.

RABISCO, from a compositional point of view, provides a gestural interface, three types of strokes and a four-color scheme, but the variation of the coordinate system on the different faces of the cube surprises and induces the participant to a continuous reorganization. The audience can passively observe a person performing a visual composition in RABISCO and eventually engage, but the participant is always active.

3.2.3 Concerning Modality

The Modality Criterion is defined as the predominant modality in the installation. Concerning to it, the installation may have different elements with different emphases such as a soundscape, computer graphics, a haptic interface for the visitor to interact or perceive the elements displayed in the exhibition. Be that stimulus from a device such as, for example, a projection screen, or by several others. In this criterion, we also project stimulus conditions that were not present in the four installations we discussed here. We understand it is possible to develop various perceptive response channels of the visitor. In this way, it is possible to describe how the integration between the modalities takes place and how the installation project sensitizes visitors stimulating their five senses: vision, hearing, touch, taste and smell.

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Regarding this criterion, all the installations work with visual and sound attributes, which act also as visual and sound stimuli, with exception of RABISCO, that worked only with visual stimuli when it was presented. By this moment, we are sonifying the faces of the cube and considering associating each stroke with a different sound, which can modify the performance of the participant. It is worth to say that AURAL, when presented, instigated in the visitors the desire to touch the robots but for security reasons this was not allowed.

3.2.2 Concerning Behavioral Criterion

The Behavioral Criterion is defined by the visitors' behavior integrating induced perception and action. The installation can stimulate visitors to move around the space, produce sounds, occupy part of the space, use devices available or relate to each other creating a collective behavior. Thus, the Behavioral Criterion is directly related to the Immersiveness Criterion, as the individual or collective responses, passive or active, that regulate the behavior of visitors. When analyzing the overall visitors' behavior within the installation, we are describing how the response to stimuli present in the environment leads the public to establish correlations and narratives.

Concerning this criterion, AURAL was a laboratory for a dancer and musicians, that explored and interacted with the installation. The audience observed and showed curiosity about the robots, talking to each other and asking questions about.

In AURAL2, the interaction through voice instigated the young people, who wanted to talk, to scream, to manifest their feelings about. Most of the adults observed entertained, even enchanted with the movement of the robots on the winding stage.

SELFHOOD was by itself an immersive environment. Two very different behaviors were perceived in the participants. Some just appreciated it, walked around, curious about the effect of its presence there, eventually talking to each other or trying a more expansive gesture. Others, with musical skill, were very engaged and carefully explored the space, trying to understand how it worked, completely immersed in their thoughts and experience.

In RABISCO, it is possible to perceive the pleasure of the participant with the visual composition resulting from her gesture, and notice the surprise when trying to use another face of the conceptual cube, with a different response. The performance excites the audience,

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instigating people to experiment. The excitation of the audience, in turn, is perceived by the performer, perceptibly changing her behavior, modifying the gestures, expanding or retracting them.

3.2.3 Concerning Digital Technologies

The use of digital technologies in installations extrapolates the computer systems, there is a set of other devices and systems that can be also described and analyzed. We understand there are three systems working together: 1) Effector System: produces visual and audio stimuli and receive information from the sensing system and from a Database; 2) Sensing System: produces multimodal signals to be used as controller of the effector system and storage information; 3) Storage System: storages all information that circulates from sensing and effector systems.

We also acquire that in these processes the computer acts as an autonomous adaptive sentient guide that assists humans to explore creative spaces and discover novel patterns driven by both their implicit and explicit (re)actions. The parametric control on the computer GUI and/or visitors' movements captured by tracking systems are called here as Explicit Interactions. On the other hand, *Implicit Interactions* are related to capture of bio-signals to infer affective states and subliminal perception. *Ubiquitous interaction* is remote agent interaction over the Internet such as in the *Internet of Things* paradigm. Figure 8 illustrates all the aspects briefly covered here: the two kinds of interaction within an installation (implicit and explicit), and the expansion of the local experience to ubiquitous interaction using mobile devices.

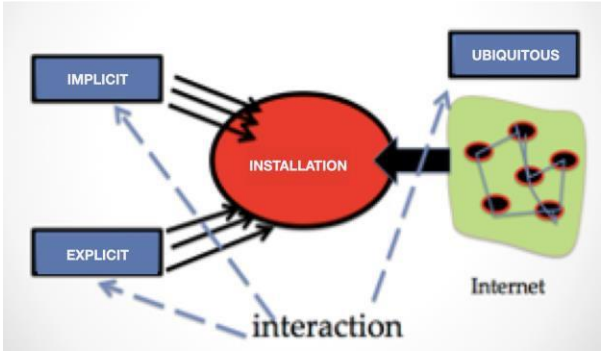

Figure 8: Diagram of the general schema based on implicit, explicit interaction on a mixed reality environment and ubiquitous interaction over the Internet.

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The four installations evaluated here describe Explicit Interactions since visitors' interaction is based on their body movements and on the use of computer GUI. Their Sensing Systems use tracking technology derived from computer vision techniques and their Effector Systems use computer graphics and audio diffusion systems as immersive strategy. Finally, only AURAL2 used a Storage System, the other three installation generated audiovisual material direct from generative rules.

4. Conclusion

The article presents the development of four installations based on a methodology anchored in interactive computer design, evolutionary computation, robotics and generative processes instantiated on the computer and applied to both images and sounds generation. Each installation has specific characteristics, different aspects in which their interactive narratives are constructed. We analyzed these installations based on four criteria: Structural, Immersiveness, Modality and Behavioral.

The criteria for analysis presented here could serve as a guide for analysis of other installations. There are many other aspects and there are also criteria that escape a more objective analysis, however, the authors' intention, when comparing four installations created at different times under the same scrutiny, was to seek to understand how the development of installations produces interdisciplinary results that orbit around artistic manifestations, technological development and also has implications in other areas of knowledge. Thus, the criteria used here might be useful for indexing the field of research and producing evaluation for the assessment and taxonomy of interactive installations in general.

Finally, it is possible to point out that Art, in particular generative and digital Arts, play an essential component in the study of creativity. Whereas Science is by necessity bound by the state of the art and the opinion of peers, Art can boldly leap beyond the shackles of collective expectations and norms, elaborating and validating new principles. Further, the notion of "body" is expanded in the trajectory presented here, encompassing physical, mental, emotional and social dimensions. Finally, the intermingling of human and non-human brings about new concepts and possibilities, designing the future of the design of embedded and embodied environments. Therefore, how are we situated in these new realities and world views?

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