As Wave Impels a Wave
Active Experience of Cultural Heritage and Artistic Content

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Abstract. This paper presents the interactive installation "Come un'Onda premuta da un'Onda" ("As Wave impels a Wave", a citation from Ovidio's "Metamorphoses" as a metaphor of time). The installation, presented in its early version at the Festival della Scienza 2009, introduces visitors to the rich history and artistic content of a monumental building: a virtual walk through the time. The core idea is to support an active experience based on novel paradigms of interaction and narration. The active experience is grounded on an informational environment characterized by an invisible "sound scent" map. The research is partially supported by the EU FP7 ICT I-SEARCH project.

Keywords: active experience of cultural and artistic content, multimodal audiovisual content search, Mixed Reality, museum ecology.

1 The Evolution of Museum Experience

The qualitative enhancement of a visit experience, according to the user behavior, is very important in a museographic context: for example, a dynamic control of lighting may influence the visitors flow, raise or lower the attention on specific exhibits, as well as the degrees and effectiveness of interactivity of an exhibit. The immersiveness can influence the understanding of a cultural message [1]. New technologies in the museums can be used to enhance the social interaction. Science centers and in general research on "infotainment" [2] contributed to a novel vision of "user experience": e.g, the San Francisco Exploratorium APE-exhibits (for *Active Prolonged Engagement*) [3].

The aim is, in our case, to create novel adaptive cultural experiences to facilitate an active fruition of cultural heritage. We propose a mixed reality installation based on non-intrusive technology (without wearable devices) to enable an "explorative discovery" of a monumental site: the Casa Paganini building. The creation of a strong *sense of presence* [4, 5, 6, 7, 8, 9] in the mixed reality environment enhances a more conscious sense of the place in the user: the ancient building "talks" with a new voice.

In effect, the relationships between cultural heritage and its users should occur with all respects to (i) the artwork/historic building ontological state, and (ii) the new audience "infotainment needs".

1.1   Active Experience of Cultural Content

With "active experience" we mean that users are enabled to interactively operate on audiovisual content in a cultural context, by modifying and molding it in real-time while experiencing. Two different perspectives contribute to achieve an effective active experience: *content-centric* and *user-centric*. The first concerns the need for a richer content modeling. The second concerns the various aspects of the users involved in the experience: for example, the understanding and exploitation of the behavior of the users while listening to audio content which is characterized by its stereo audio file and by a number of further data, including features obtained by means of advanced signal processing techniques (e.g., spatial rendering, to control the 3D audio localization of music sources). The active listening experience depends on and is shaped by the individual as well as the social behavior of the users. In this framework, the automated analysis of non-verbal user behavior (e.g expressive gesture conveying emotions, social signals in small groups of people) supports the design of such multimodal systems. User Centric Media [10] will be able to analyze users' non verbal behavior, expressive gesture and intentions. In a museum context, for example, smartphones exploiting the growing number of sensors (e.g. videocamera, accelerometers, microphone…) can contribute to detailed real-time measures of visitors' behavior. State of the art approaches vary from wearable sensors to smart environments: the former are based on development of hand-held and context-sensitive prototypes. In this case, integrated sensors capture the current position of the user to make adaptive feedback (for example, with PDA devices). Ambient intelligence and user centric technologies were proposed to extend the possibility of interaction in museum spaces: for example, Chittaro and Ieronutti [11] focus on the tracing of users' behavior in virtual museum environments; Wakkary and Hatala [12] (see also [13]) explore "the design issues of 'situated play' within a museum through the study of a museum guide prototype that integrates tangible interfaces, audio displays and adaptive modeling" [12, p.171]; the ethnographic studies on museum visiting styles have been included in the research path of Zancanaro et al. [14], to personalize information through experimental mobile multimedia systems.

InfoMus–Casa Paganini developed since early nineties innovative interactive multimedia systems to enable active and social experiences of audiovisual content [15, 16]. Recent research provides novel engaging paradigms of interaction with pre-recorded music content, enabling a large number of non expert users to re-discover the musical heritage they may not be familiar with (EU-ICT Project SAME). Further, these active experience paradigms have been extended to the audiovisual content, in particular in a novel permanent interactive exhibition: *Viaggiatori di Sguardo* (Genova, Italy) enabling visitors to explore virtually the UNESCO Treasure of "Palazzi dei Rolli" in Genova (2010).

Liminality, Engagement and Place Identity. Bell [17] describes the museum in terms of cultural ecologies, identifying three components: *liminality*, *sociality* and *engagement*. The first feature defines museums as places where an experience apart from everyday life (rich in suggestion and occasions to pause and reflect) happens. The second defines museums as social places for groups such as pairs and families. The third proposes the museum experience as composed by learning and entertainment parts. Multimedia technologies increase these characteristics. In a Virtual Reality application, any action or interaction (and related feedback) happens in an inclusive space, in a 3D world where the "navigator" is able to freely move, following not pre-conditioned paths, but exploring in real time all available space [18]. The interactive installation we propose is based on Mixed Reality, "a particular subset of VR related technologies that involve the merging of real and virtual worlds somewhere along the 'virtual continuum' which connects completely real environments to completely virtual ones" [7, p.1321]. The full comprehension of the "place identity" [19, 20] of a monumental building is important to exploit the sense of liminality and engagement. From a phenomenological perspective it is possible to identify three dimensions [19]: *physical setting* (the concrete characteristics of the environment), *activities* (afforded by the place) and *meanings* (e.g. memories, associations, connotations and denotations linked to the place). A social aspect can be added. The dimension of *meanings* (through the history of the building) is particularly "dense" in the case of a monumental site, and the sense of place remains an *emergent property* [19] of interaction between individual and environment. We try to create an innovative experience of time through an experience of the space (having a strong "place identity") (see also [21]).

Presence and Sense of Place. Presence is "a psychological state or a subjective perception in which (...) the subjects gets involved in the task, in objects, entities and event perception, as if technology was not present" [22, p.58]. Three among different characteristics of presence are very significant in our case: presence as *transportation*, *immersion* or *realism* [6]. The first concern the sensation of "you are there" (where the "there" is a real augmented place); the second involves the extent to which the senses are engaged by the mediated environment (but through disappearing technology); the third, finally, pertains to the degree to which a medium can seem perceptually realistic (the fresco fragments in the Spiral of the Time are in a display, but are coherents with the place and its characteristics, while the sounds evoke the past of the building). Presence is not only a *perceptual illusion of non-mediation* "produced by means of the disappearence of the medium from the conscious attention of the subject" [8, p.28]: presence can be also related to the concept of attention, especially in an installation where "only" fragments (audio and video) guide the interaction. The concentration and attentional factors are fundamental to determine the user's sense of presence [23, 4]. The *embodied presence* theory [24] proposes a "mental representation of the environment in terms of pattern of possible actions, based on perception and memory" [9] (in "As Wave Impels a Wave", for example, the user creates a mental map of sounds while perceives and discovers their position). The immersion is a result of the interaction between user and installation (man and environment): in turn, presence is a property that emerge from immersion, and the "being there" is enhanced by the possibility of "acting here" [25, 8].

Museum Ecology and Informational Environment. From an ecological perspective [26], the environment is, perceptually, correlated to the subject: if perceptions "support actions in the environment capturing opportunities, permissions or affordances" [8, p.30-31], we are able to use the spatialized sound to thinly guide the user along the discovery of the installation space, according movement and directionality in the 3D space (the approach or the moving away from the sound source) to loudness. In this "immersion perspective", it is necessary to considerate the user, moving in a rich informational environment, as an "informavore" [27] to strongly engage her in the interaction. The installation designer has not to "extract" or "distract" the user from the "ecological" context (the monumental building): the challenge is to increase the sense of presence of the user in a context of MR, respecting (and communicating!) the strong "place identity" of the monumental site. The visitor is enabled to walk in a whispering, augmented space, following the "scent" of sounds, which guide her at the discovery of the multimedia content. In the interaction design discipline, "*information scent is the (imperfect) perception of the value, cost, or access path of information sources obtained from proximal cues (…) representing the sources*" [28, p.10]: "If the scent is strong, the information forager can make the correct choice; if there is no scent, the forager will have to perform a 'random walk' through the environment. The forager's perception of which direction offers the optimal information source or patch is changed by sniffing for scent activities; so the forager is constantly adapting decision making and direction*" [28, p.11].

2   Active Experience of a Monumental Building

We propose an active experience in sensitive spaces exploiting expressive body movement, in a perspective of valorization of cultural heritage and to enhance the level of engagement and communication of cultural content to visitors. The user is actively involved in her learning experience, watching and listening to cultural content embedded in a responsive environment.

The MR "virtual continuum" [7] is referred, in our case, to the "mixture" of classes of elements participating in the interaction experience: real environment (the Auditorium of Casa Paganini) is augmented by means of virtual objects (graphic fragments of a "Spiral of Time" in a large display and audio "spotlights" spatialized on the stage) evoking the history of the monumental building. "As Wave impels a Wave" (a citation from Ovidio's "Metamorphoses" [XV, 181-184]), refers in its name to the chasing and coming waves as a metaphor for the time, which flees and follows as the past impels the present and the future. The goal of this installation is to increase the sense of presence of the user in a special, cultural place: it means, at the same time, increasing also the sense of place which "immerses" the visitor. In effect, a real place "is a particular space which is overlaid with meaning by individuals or group" [19, p.205], and it is possible to summarize this aspect in the equation "place= space+meaning" [29]: in a cultural heritage context, as the building of Casa Paganini, the challenge is to allow a dialogue between user and historical place. Therefore, on the one hand, the user is free from any device constraint (e.g. sensors, wearable

devices, handhelds, and PDA in general: increasing sense of presence by disappearing technology) and is enabled to interact only with the responsive environment; on the other hand, the building is respected as monumental and historical site (increasing sense of place "immersing" the visitor in the real, "ecological" environment).

The Monumental Site. Santa Maria delle Grazie La Nuova, named Casa Paganini, is a monumental site, rich in fresco paintings (from 15th to 18th century) and archaeological relics (6th-5th century BC). Along its history, the building was a roman villa, a convent (near to 15th century decorations and medieval persistences, the contributions of many artists actives in Genova between 16th and 18th century, e.g. Valerio Castello, Andrea Ansaldo, Giovanni Andrea Carlone, immediately stand out to the visitor crossing the ancient convent threshold. Religious decorations cycles centred on Marian main themes are common in the whole building), a typography, a ballroom, a school of music, a theatre, and finally, since 2005, after a long restoration (from 2000 to 2004), it hosts the Casa Paganini – InfoMus Intl. Research Centre (University of Genoa). The building includes an auditorium of 230 seats, a foyer, a gallery and museum rooms.
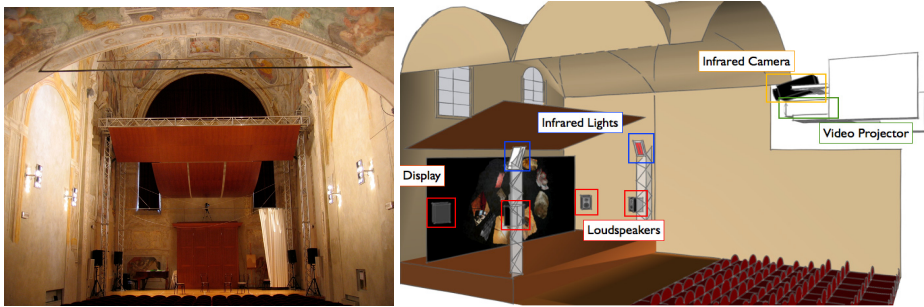

Fig. 1. The Casa Paganini Auditorium (the formerly church nave with fresco paintings) and the installation set up: an infrared camera detect the active area of the stage. The feedback of movement in this area is emitted by loudspeakers all around and on the big display of projector.

Set Up and Scenario. The dimensions of the sensitive space on the Auditorium stage are about 9.5x4.5 m. Infrared lighting up the surface where the users move, while 4 loudspeakers assure the sound spatialization. A large display (8,85x4m) is located on the wings as a "virtual wall" where the time-spiral appears during the interaction. The user path on the stage is detected by an infrared camera at 9,55m in vertical height. As is possible to mark from the Figure 1, each technological device is perfectly integrated in the monumental substrate.

The interactive experience is structured into a sequence of four layers, with growing levels of interactivity, each corresponding to a different paradigm of interaction. In this perspective, metaphors enhance the feeling of participation, the immersion and the sense of presence: for example, the "explorer", the "archaeologist", the "detective" are different roles that enable users to perform active experiences. The first layer of interaction is a simple walk in an "empty" space, to discover sonic objects hidden on the stage (*exploration paradigm*: the resonant environment); in the second layer,

visual fragments linked to the sounds emerge on the "virtual wall" (*discovery paradigm*: the spiral of time); at the third layer, finally, there is an in-depth experience of audiovisual narrative content related to the fragments discovered during the previous two phases of the experience (the *"archaeologist" metaphor* of interaction paradigm: to discover the hidden content). To achieve the experience of all the layers, it is necessary to discover all the fragments hidden in the sensitive space.

Layer 1–The Exploration. The visitor enters in the half-lighted Auditorium, then she approaches the stage. Under the fresco paintings of the formerly church single nave, an atmosphere of suspension waft. The user now is immersed in the large, apparently empty space of the stage faintly whispering (a background, low-level soundscape is started as soon as the user enters the sensitive space). The user begins to move and, suddenly, misterious short sounds emerge from the "whispering background": a cannon shot, something like a brushstroke, a choral singing, etc.. The user walks and creates an invisible path on the space: she meets active places, and, step by step, she understands that every sound corresponds to specific regions on stage, like in a geographic map. Sounds are spatialized: a sound heard in a given space of the explored stage is perceived as its source were in that position, and the user motion towards a specific direction is "supported" by the "scent" of presence of audio content in others regions of the stage.

Layer 2–The Discovery. The visitor continues the exploration: whenever a sound previously discovered is met again, a corresponding visual fragment appears on a large display (a "virtual wall") behind the stage. For example, the evoked image of a fragment of a fresco representing an angel is associated to a sound of brushstroke. The background projection on the display is similar to one of the ancient walls of Casa Paganini, which remains static until visual fragments emerge, like relics of semi-destroyed frescos. This evokes the experience of the visit to the real monumental building: in many cases only partial fragments on the walls and ceilings of the building are available. The visitor walks and discovers other fragments with their associated sonic materials. Each fragment is located like in a spiral: the Spiral of the Time.

Layer 3–The Archaeologist. Once the discovery phase is concluded, i.e. all the fragments of the building are brought to life, the third experience layer becomes available. By stopping a few seconds on a specific region of the stage, the user can now discover further hidden content, a short audiovisual clip explaining the meaning of the corresponding sonic and visual fragment discovered in the previous phases: when the visitor stops in correspondence to the "fresco angel" fragment, on the "virtual wall" a short documentary film about the painter starts. In the final version of the installation, the user can interact by her behavior with such audiovisual content, suspend, or interrupt to continue the exploration of the content linked to other fragments in the time-spiral. The interaction paradigm is the "archaeologist": the user can go into more details, evoke other movie clips explaining and shading light to the "secrets" of the fragment she is exploring. The spiral-displacement on the display does not correspond to analogous positions on the active stage: the user has to explore the stage, remember the positions of the fragments to build the spiral of time, try to understand the content in order to discover hidden details (like an archaeologist) of the cultural content, buried under the virtual "dust".

Layer 4–The Detective. The fragments of audiovisual content refer to objects (frescos, archaeological relics) which are concrete part of the building. Once the user terminates her "virtual" experience, she has collected elements to search and discover the real frescos and artworks in the building around her: the active experience on the stage has the role of stimulating the curiosity, in a "detective game", aiming at discovering the building and its rooms in search of the tangible relics.

2.1   Crossing the "Limen"

In our system technology disappears, leaving the visitor the full control of experience, crossing the "limen" [17], in an "optimal flow" perspective [30]. According to the Gibson's *affordance* [26], the installation exploits non-intrusivity, pervasivity and transparency of technical devices: the user body is the only interface to explore the space-time dimensions. The user confronts herself with a museographic site (the installation *with* and *into* the building), implements a creative editing between different temporal planes (the monumental site: to historically reconstruct and to analyze in its decorative and figurative context) and present (the laboratory of the Research Centre). We try to create an "invisible" scenery, where the information scent is represented, at the first layer, by the sound spatialization in 3D space: users should first "navigate" according to the sound (whispering in an increasing loudness up to the perceptual clairness), and when the location of sound source is founded, a bright fragment in the Spiral of Time appears, suggesting the possibility of others proximate significant regions (the second layer). We're able to guide a "discovery walk" in the apparently empty space with a sort of "whispered sound texture" which acts as information scent. When the user approaches a meaningful area on the active space, a sort of sound-spot (a 2-3 seconds audio) progressively emerges from the background and attract her attention. The Auditorium is never really silent: a sound-map is virtually superimposed on the stage and the "information scent" [28] of every meaningful area contributes to create the background audio-texture (structured as a grid of interrelated gaussian regions). The user is
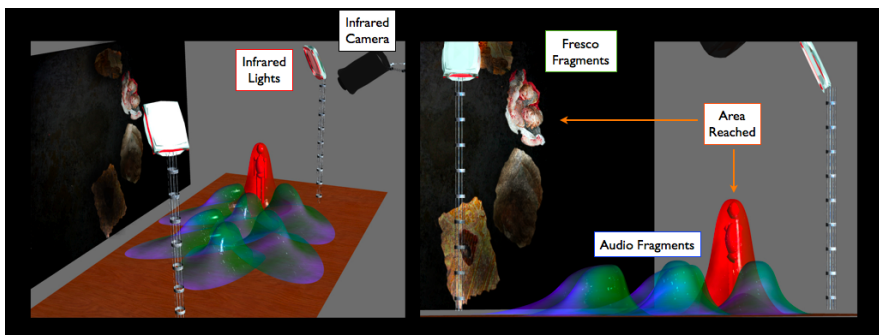

Fig. 2. In this installation scheme, the user discovers significant regions on the space, corresponding to specific sounds and, in the Spiral of Time, to different fresco fragments. Furthermore, in the whispering texture of the installation "soundscape", the audio fragments surrounding the user current position increase their volume, attracting her in different areas.

free to follow any "sound-scent", which includes the directional information on the related source, attracting her in one or another direction. The "scent" of informations is a "trigger" to explore, search, find audio and visual (virtual) fragments which the user is able to explore, search, find and discover also in the real environment around her. Any interaction layer allows a continuous information exchange [31] between installation (virtual space), monumental building (real place) and user.

3   System Implementation

EyesWeb XMI (for eXtended Multimodal Interaction) [32] is the open software platform supporting the design and development of the installation presented in this paper. The EyesWeb Trajectory Analysis Library contains a collection of modules for the extraction of features from trajectories in 2D (real or virtual) spaces, while the EyesWeb Space Analysis Library is based on a model considering a collection of discrete potential functions defined on a 2D space. In this case, the space is divided in a grid of active cells where the user is tracked (as a point moving in the space). Regions in the space can also be defined: it is possible that some regions exist on a stage in which the presence of movement is more meaningful than in other regions. The insisting of a user in a given place, or the trajectory to reach the place can influence the active mapping with audiovisual content. A certain number of "meaningful" regions (i.e., regions on which a particular focus is placed, a spot sound or a spiral fragment in our case) can be defined and cues can how much time a user occupied a given region to accede to hidden content.

4   Open Questions and Future Work

The first prototype of the installation provided useful feedback from the extensive experience with about 1700 of users during the Festival della Scienza (2009). Current work concerns a deeper use and exploitation of users' expressive gesture, which in the present prototype is used at a basic level. In effect, from observational analysis, user noticed a certain difficulty to follow exclusively the audio feedback in the empty space: a sort of "horror vacui" makes difficult the exploration, despite the "sound-scent" attracting the attention in different directions. To get over this problem, we avoided any silent area on the stage: when the user is far from any active region on the stage, she hears a diffused whispering resulting by the sonic scent of the nearest active regions. Such sonic scent is characterized by a 3D position and direction, and an emphasis of the loudness of its components corresponding to the user tendencies to move toward a given region. In this way, the directionality of the sonic scent is emphasized and anticipated.

Furthermore, we aim at extending the possibility to shape and mould the experience of audiovisual content (third layer), by taking into account the individual behavior and history (e.g. path trajectories) of the user: how a user behaves can influence the audiovisual content presented. In the basic version of the installation, multiple users cannot enter the space at the same time. In further versions of "As Wave Impels

a Wave", we aim to introduce a social experience of the installation, by exploiting non verbal social signals: that is, to exploit the automated measures non-verbal social behavior of users during the experience [33], in order to adapt the cultural content presented to the group, depending, for example, on the activity, trajectory in the active space, and coherence of the behavior of the group.

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