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ABSTRACT

The creation of interactive installations is a process which implies to bring back together phenomenological evaluations of visitors' experiences and motion analyses which inherently highlight the core material of interaction design. In this paper, we present an interactive and immersive work, *See me through you*, which ambition to provide a rich experience where enlightenment, hedonism and social elements coexist. We present the first steps toward a multidimensional evaluation of the visitor's experience. Focus-groups evaluations are presented and some elements about future motion analyses are provided.

Author Keywords

Multiuser interactive installation; science center; focus-group; mixed approach.

ACM Classification Keywords

H.5.2 User Interfaces: Evaluation/methodology; Interaction styles (e.g., commands, menus, forms, direct manipulation); User-centered design. H.5.3 Group and Organization Interfaces: Synchronous interaction.

INTRODUCTION

Interactive installations and immersive exhibits are now flourishing in both art museums and science centers. They are not limited to cases where hands-on experiences are relevant for pedagogical purposes. They emphasize the

memorable dimension of emotions and sensations they usually promote [1].

This new "experience economy" [8] argues for mixed experiences where access to rich knowledge can be articulated with the attracting and hedonic aspects of dynamic interactions. The design of such complex compositions remains an iterative process where the audience plays a central role. New approaches are being developed to provide valuable feedbacks from participants [4]. Interdisciplinary research teams experiment various methodologies where the exhibit itself is the experimental space [2]. Qualitative methods such as video-recalls, interviews, and observations are used to qualify the visitor's experience as a whole [3]. These rich phenomenological evaluations could advantageously be coupled with quantitative motion analyses, which inherently highlight the core material of interaction design. Thereof, beyond scientific reductionism, the adoption of a pluralist epistemological stance appears to be a promising research approach towards an embodied account of visitors' journey.

In this research note, we present an original interactive and immersive work, *See me through you*, where single-user direct visual and sound interactions are augmented by computer-mediated multiuser interactions according to the equations of General Relativity. Along both phenomenological and behavioral dimensions, we evaluate the experience of visitors in a science center where *See me through you* was installed. First, we carry qualitative analysis with focus groups. Then, we explore the possibility to perform a complementary quantitative analysis based on the concept of the visitors' journey [10], which is supported by the installation embedded capabilities.

RESEARCH PROJECT

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The single and multi-user interactive installation *See me through you* was created by des Vues de l'esprit for the exhibition, *A light Odyssey*, at La Cité des Sciences et de l'Industrie, Paris, France, to offer a sound and visual immersion in deep space where astronomical objects evolve and effects of General Relativity take place.

La Cité des Sciences et de l'Industrie

La Cité des Sciences et de l'Industrie is the largest cultural center of science, technology and industry in Europe with about five million visitors each year. Located in Parc de la Villette in Paris, France, includes Explora (three levels of permanent and temporary exhibitions with a planetarium), La Bibliothèque des sciences et de l'industrie (a library for the general audience and the youth, with a focus area on history of sciences), Carrefour numérique (a digital space with a Fab Lab and a Living Lab), La Cité des métiers (a resource center for training and employment), La Cité de la santé (a resource center for healthcare), the Argonaute (a submarine), La Géode (an IMAX theatre), and La Cité des enfants (special areas for children and teenagers).

A light odyssey

In the frame of the International Year of Light in 2015, the Astrophysics Department, AIM Laboratory, CEA-IRFU, in collaboration with the Institut d'Astrophysique Spatiale (IAS, CNRS, Univ Paris-Sud), set up an exhibition for the general audience, *A Light Odyssey*, at La Cité des Sciences et de l'Industrie, over 280 m² in Explora, from March, 17th to October, 12nd, 2015.

The exhibition traced the journey of two particles of light: the first one, Max, comes from the very early Universe, the second one, Soho, originates from the center of the Sun. They both reach the Earth where they lay essential information on the mechanisms that gave rise to them and the spaces through which they have been travelling. Each trip was divided into five major stages showing the similarity of the physical processes at the scale of the Universe and across the stars.

The visitors were invited to embark upon either Max or Soho's path. Large explanatory backlit panels defined each stage of the journey (fusion, diffusion, transparency, propagation, and absorption). They were supported by video materials and astrophysics artefact (Eddington's Coelestat, models of Planck satellite, HFI and GOLF instruments). In the middle of Max's journey, the visitors could enter the hall of mirages offered by *See me through you*.

See me through you

See me through you is a relativistic composition for visitors, sensors, loud-speakers, computers, and videoprojectors (Figure 1). When a visitor stepped in, she or he effectively took a thousand and two hundreds billions steps in the Universe. With associated galaxies, visitors were immersed in the deep Universe around a black hole, which was simulated with forty times the mass of our sun in the center of a 90 m² space. According to Einstein theory of gravitation, this extraordinarily heavy object locally distorts space-time

such that the trajectories light follows therein are bent and mirages, genuine optical illusions, are created. The black hole curiously revealed the visitors it was hiding behind. The bright images of visitors' galaxies were then turned into luminous arcs or even Einstein rings. Hence, the presence of other visitors modified the environment such that the visitors' behavior was entangled. *See me through you* is a hall of mirages where visitors directly experience the effects of gravitational lenses and the relativity of observations. Visitors see through each other.

System description

The real time simulation was performed using ray tracing and modern GPU shader technologies (GLSL 4). The whole space was immersed in deep cosmos using 11 videoprojectors. Rendering was distributed over 4 computers, each equipped with nVidia Quadro 4000 graphics cards. Space distortion and light bending effects were computed on pixel space based on Schwarzschild approximation of General Relativity [9]. We applied a commonly-used paradigm in ray tracing rendering: we rendered light rays backward.

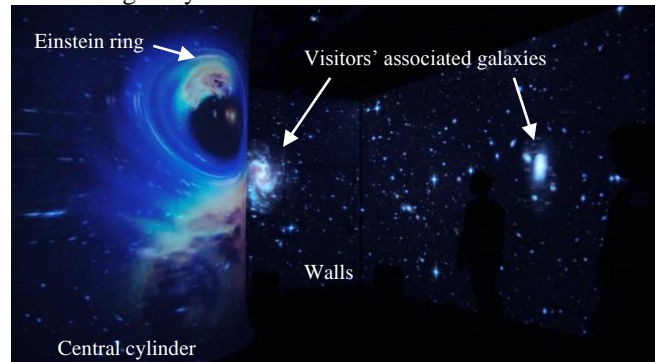


Figure 1: Inside the hall of mirages of the installation *See me through you*. On the left, the central cylinder inside which a simulated black hole deflects the light coming from a galaxy, a visitor located on the other side, further left, of the cylinder to reveal gravitational lens effects. On the right, the surrounding deep space with additional galaxies, associated to every visitors, projected onto the walls.

Each ray started its course at the observer position and was cast toward the rendered pixel, which provided the direction and the original minimal distance to the black hole of the "incoming ray". We then computed the deviation angle using Schwarzschild radius. The new direction of the out coming ray, bent by the black hole, points toward the original color in space, emitted by the original light. This ray tracing approach required selecting a finite set of "observing-visitors", preferably on opposite sides of the central cylinder. Visitors were tracked using a set of 8 kinect sensors equally-placed on the top of the central cylinder. According to the visitors' position around, we enabled from one to three "observers" of potential gravitational lens effects. Every visitor, including "observers", were associated to a galaxy, which was projected onto the deep space of the walls and which followed them across the room.

Qualitative evaluation methodology

The study of visitors' experiences in interactive installations can be considered as a relatively new field of research. This exploratory research context induces the necessity to start with a qualitative approach to get a holistic view of the experience and to reveal relevant research questions.

In accordance with the multiuser dimension of the interactive installation, we decided to set up focus groups and run a thematic analysis on transcribed discussions. As for individual interviews, such an analysis is based on the premise that words extracted from the interviews can be reduced to categories in which words share the same meaning or connotation. Our unit of analysis was the focus group as visitors had shared some common frame of reference in their experience. One advantage of focus-groups is that it capitalizes on day-to-day interaction routines and let emerge many different forms of communication, like in every-day life (jokes, anecdotes, teases, arguments).

The role of researchers (often in the number of two) in focus groups is less interventionist than in individual interviews. Acting more like facilitators, they encourage people to talk to each other rather than to address themselves to researchers. Researchers may take a back seat at first and then adopt a more interventionist style: urging debate to continue beyond the stage it might otherwise have ended and encouraging the group to discuss the inconsistencies both between participants and within their own thinking. Disagreements within groups can be used to foster participants to elucidate their point of view and to clarify why they think as they do.

For each visiting focus group, a 10 minute visit was led by one of the researcher throughout the exhibition *A light odyssey*. Visitors were explained the effects of gravitational lenses. Then they were invited to read a basic guide for *See me through you* before they entered and explored the installation for 3 minutes. At the end of the interaction, two researchers accompanied the group in a quiet and comfortable room where the focus group discussions took place. Refreshments were made available (Figure 2). The visitors of each focus group were suggested to discuss their experience first according to what they had perceived, second according to what they had felt, and third about what they had understood. This framework aimed at limiting the focus on analytical thoughts and getting a more complete picture of the visitors' experience. Focus group discussions were recorded to ease subsequent manual transcription. The analysis was then performed as follow: 1/ iterative annotation using RQDA (R package [5]) 2/ identification of core themes at the basis of clustering labels 3/ Synthesis of themes, enriched with quotes.

In the qualitative approach, the sample size may well be small as most of the information is already provided by each individual. The iterative procedure of the analysis stops when an additional experience does not add to the interpretation process. The saturation point is reached. Here,

identified categories were saturated at the fourth group with a total of 16 participants (8 woman; mean age= 41.4; std age= 18.0).

Focus groups outcomes

The analysis of the four discussions resulted in the constitution of three core themes composed of seven sub-themes. In this research note, a brief overview is provided about their content.



Figure 2: First group during the focus group session.

Theme 1: Information and Understanding. Although the discussion was oriented toward perceptions and impressions at first, visitors extensively talked about the understanding of the phenomena at play in the installation. This theme 1 is organized in three sub-categories: "Expectations, context, and knowledge" deals with how the context of the science center and the experiment fostered informative expectations, in relation with personal knowledge. The "Understanding" sub-category accounts for what visitors think they understood, and therefore the limits of their understanding. As a result, "Information needs" logically occurred.

Theme 2: Approach and Interaction. The descriptions of the visitors' interactions revealed a wide array of approaches: discovering, testing, playing and contemplating emerged as complementary stances/intentions behind the movements done during the experiment in the installation. Visitors were wavering between understanding and enjoying the experience, which is highlighted by the sub-category "frame of mind". The descriptions of the various activities/movements attached to the different phenomena were grouped in the sub-category "movements and interaction". The single-user interaction was straightforward for visitors. It arouses the visitors' curiosity for more. As soon as they caught their associated galaxy on the wall, they explored object deformations and collisions, sound interactivity, and eventually the multiuser interactivity.

Theme 3: Impressions and Affects. The first set of emerging feelings visitors expressed was about the relaxing, quiet, agreeable, and magical characteristics of the installation. The installation led some visitors to a contemplative experience. The second register of feelings was about the interesting, educational, discovery, curiosity, surprise, and playful characteristics of the installation. The educational feeling carried the impression to see the real phenomena at play and the playful side seemed also closely related to the discovery

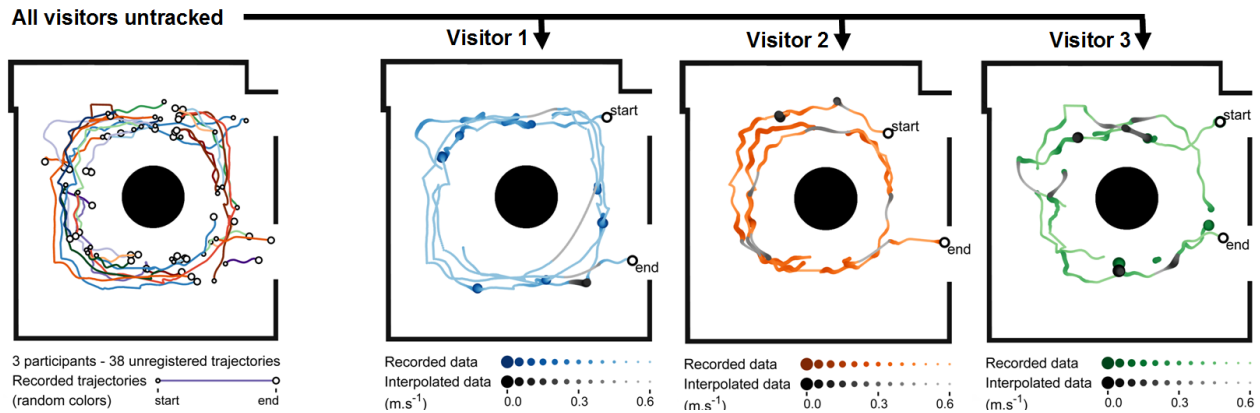


Figure 3: Example of trajectories reconstitution of three visitors interacting during 3 minutes with the installation.

process of new physical phenomena. The third register of feelings was about the attracting, disturbing, captivating, hypnotizing, and immersive aspects of the installation. They somehow relate to local attention and global immersion. This was made possible for the visitors thanks to the sound landscape, the deep cosmos projected everywhere around, and the impression of a vast space.

Toward a quantification of visitors' journey

This analysis provides a detailed, contrasted, and holistic account of the experience. The group-level evaluation has the limitation of making difficult the identification of individual profiles of experiences. A second interpretation process at the individual level with a focus on how categories are associated (frequencies of co-occurrence in sentences) could solve this limitation. Another limitation of this method is the difficulty to associate specific behaviors and motions with experiential elements. The fact that interactive elements of the installation are based on 2D displacements of visitors in the room open up the possibility to quantitatively analyze visitors interaction patterns via the concept of the visitor's journey [10]. Displacement trajectories can be categorized via clustering [7][6]. As *See me through you* is equipped with 8 kinects, visitors' trajectories can be fully recorded and reconstituted by re-playing the datalog as in Figure 3. Thus, the next step of this research project is to articulate qualitative outcomes from focus-groups with interaction profile emerging from unsupervised motion analyses such as clustering.

CONCLUSION

This ongoing research project articulates the creation of an interactive and immersive installation, *See me through you*, in the context of a large cultural center of science with a pluridisciplinary evaluation approach which attempt to capitalize on complementary strengths of phenomenological evaluations of visitors' experiences and motion analyses of their dynamic interaction. First outcomes from focus-groups reveal a rich experience and the feasibility of an additional motion analysis has been presented. Future works will explore the articulation these two approaches.

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