The eXperience Induction Machine and its Role in the Research on Presence

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Abstract

The eXperience Induction Machine (XIM) is an immersive room equipped with a number of sensors and effectors that has been constructed to conduct experiment in mixed-reality. XIM is an abstraction and further development of its predecessor, the installation "Ada – the intelligent space" that was built for the Swiss national exhibition Expo02. We will outline the hardware and software infrastructure of XIM, and describe in detail one application of XIM, the Persistent Virtual Community (PVC). We will conclude with the description of the development work currently underway and an outlook of the future public exhibition of the space.

1. Introduction

The eXperience Induction Machine (XIM) is an immersive room, equipped with a wide range of sensors and effectors (Figure 1). XIM is designed as a general purpose infrastructure to investigate human-artifact interaction. More specific questions include how a spatial enclosure can affect and interact with its visitors, how humans can act, exist and behave in both physical and virtual spaces, the construction of socially capable believable synthetic characters and the development of a framework for interactive narratives. Such an installation can either be implemented as a pure input/output device, or it can constitute an autonomous entity, with its own "ghost in the shell". An abstraction of the input/output option and a precursor to the idea of an autonomous entity has been implemented with "Ada - the intelligent space" at the Swiss national exhibition Expo.02, a fair that has been visited by over 560.000 people over a period of 6 months [1]. Here we will describe in detail the hardware and software infrastructure of XIM and one of its applications called the Persistent Virtual Community (PVC). The conceptualization of the space as an autonomous, sentient entity it one of the key features which sets it off against other mixed-reality spaces e.g. the Allosphere at UCSB, the intelligent House at MIT, the Nanohouse at UTS and the Sentient Lab in the Faculty of Architecture, University ofSydney.

2. XIM infrastructure

XIM space covers a surface area of 5.5 x 5.5m, with a height of 4m. The majority of the instruments are mounted in a rig constructed from a standard truss system. The space is equipped with the following devices:

●Three cameras at the top of the rig provide a "bird's eye view" that is combined with other sensory modalities for the accurate and reliable tracking of the visitors,. ●three microphones (Audio-Technica Pro45 unidirectional cardioid condenser, Stow, OH, USA) in the center of the rig provide the system with auditory input to localize visitors and to recognize specific sound events. ● XIM is equipped with 8 steerable theater lights ("LightFingers") (Martin MAC MAC250, Arhus, Denmark). ● 4 steerable color cameras ("Gazers") (Mechanical construction adapted from Martin MAC250, Arhus, Denmark, camera blocks Sony, Japan) provide detailed visual information. The "Gazers" are mounted in the corner of the space at head-height of the visitors to display a different viewing angle than that of the ceiling-mounted cameras. At the same time, the visitor becomes aware of the fact that the space is "looking at her/him". ● A total of 16 speakers (Mackie SR1521Z, USA) with the corresponding sound equipment

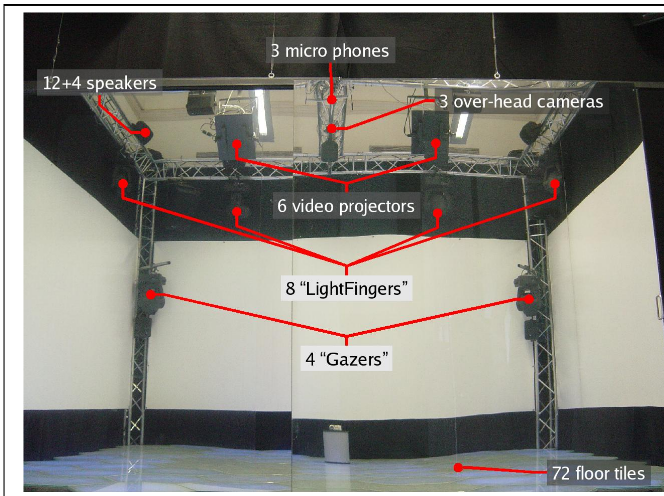

Figure 1: View into the eXperience Induction Machine (XIM). The room is 5.5x5m, and 4m high. A number sensors and effectors are mounted in a rig structure. See text for further explanation.

(MIDI sampler, matrix mixer, amplifiers) provide spatialized sound, while a PA system is used to present soundscapes. The space is surrounded by three projection screens (2.25m x 5m) on which 6 video projectors (Sharp XGA video projector, Osaka, Japan) display graphics. ● 72 interactive tiles [7] (Custom. Mechanical construction by Westiform, Niederwengen, Switzerland, Interface cards Hilscher, Hattersheim, Germany) constitute the floor of the space. The floor serves a dual purpose. Firstly each floor tile is equipped with pressure sensors, and provides real-time weight information on the visitors. Secondly, each floor tile incorporates individually controllable RGB neon tubes, which permits display patterns and light effects on the floor.

3. XIM application: The Persistent Virtual Community

One of the applications developed in XIM is the Persistent Virtual Community (PVC), which is one of the main goals of the PRESENCCIA project. PRESENCCIA (www.presenccia.org) is an Integrated Project funded under the European Sixth Framework Program, Future and Emerging Technologies (FET), which is tackling the phenomenon of subjective immersion in virtual worlds from a number of different angles. Within the PRESENCCIA project, the PVC serves as a platform to conduct experiments on presence, in particular social presence in mixed reality.

The PVC uses all aspects of XIM as a mixed-reality platform which provides a venue where entities of different degrees of virtuality can meet and interact. These entities are: ●Real visitors in the XIM. ●Avatars i.e. alter egos of remote visitors. ●Fully synthetic characters controlled by neurobiologically grounded models of perception and behavior. The mixed-reality world of the PVC consists of the Garden, the Clubhouse, and the Avatar Heaven (Figure 2, top). The Garden of the PVC is a model ecosystem. Its development and state depend on the interaction with and among visitors. The Clubhouse is a building in the Garden and houses the virtual XIM. The virtual version of the XIM is a direct mirror of the physical installation: any events and output from the physical installation are represented in the virtual XIM and vice versa. This means e.g. that an Avatar crossing the virtual XIM, will be represented in the physical installation as well. Conceptually the physical installation is "embedded" into the virtual world. This means that visitors in the physical installation looking out of the space will see into the virtual world. The major difference between real and virtual XIM is that in the virtual version, the space is able to control the influx of visitors to the space (Figure 3).

Access to the PVC is given via three portals: Visitors can either access through XIM, by way of a Cave Automatic Virtual Environment (CAVE), or via the internet from a PC (Figure 2, bottom).

Ultimately the mixed-reality installation of the PVC will be open to the general public. In this way the PVC provides a showcase for the key technologies developed in the PRESENCCIA project.

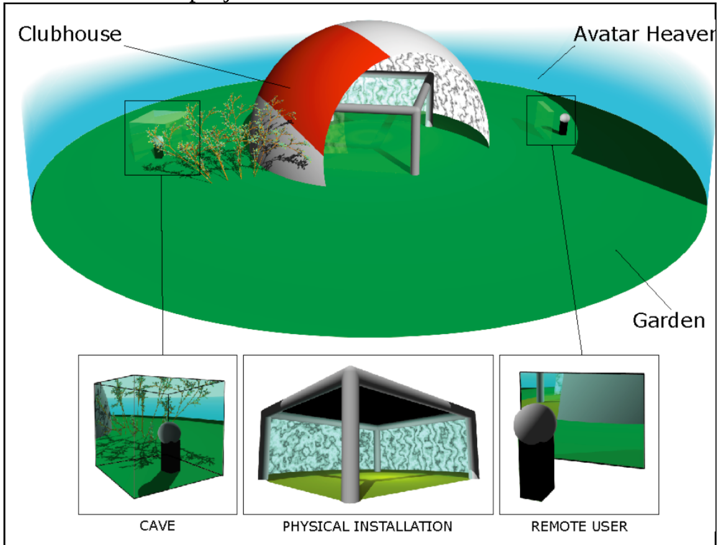

Figure 2: Layout of the access to the Persistent Virtual Community (PVC). The mixed-reality world consists of the Clubhouse, the Garden, and the Avatar Heaven. The virtual counterpart of the physical installation eXperience Induction Machine (XIM), is located inside the Clubhouse. Users can either access through the physical installation, or a Cave Automatic Virtual Environment (CAVE), or via the internet from a PC (remote user).

In relation to the PVC, XIM fulfills a double role: on one hand the XIM is an interface to the virtual world, and hence allows visitors physically present in the room to interact with Avatars and synthetic characters. On the other hand, the room has a "ghost in the shell", i.e. it is an autonomous, sentient entity which is engaging in interactions with its visitors and actively monitoring and modulating their behavior.

XIM is constructed to induce and study collective and social presence where groups of visitors share the same frame of reference. This is a weaker form or presence than that delivered in a CAVE. However, a CAVE can by necessity only cater a single user. In case one wants to scale up to multiple users in mixed reality a XIM-like system is the most effective approach. The aim of integrating XIM into PVC lies in the exploration of two facets of social presence. Firstly the facet of the perception of the presence of another entity in an immersive context. This type of presence depends on the credibility of the entity the visitor is interacting with. In the XIM/PVC case the credibility of the space is affected by its potential to act and be perceived as a sentient entity and/or deploy believable characters in the PVC that the physically present users can interact with. In the CAVE case, the credibility of the fully synthetic characters depends on their validity as authentic anthropomorphic entities. In case of XIM this includes the preservation of presence when the synthetic characters transcend from the virtual world into the physical space, i.e. when their representational form changes from being a fully graphical humanoid to being a lit floor tile The second facet of social presence covers the collective immersion experienced in a group, as opposed to being a single individual in a CAVE. To this purpose, the XIM offers a unique platform, since the size of the room permits the hosting of mid-sized groups of visitors.

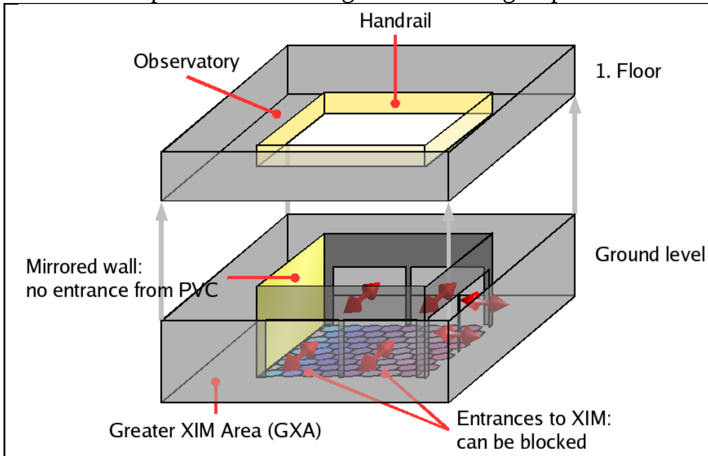

Figure 3: Embedding of the virtual counterpart of the physical installation XIM in the virtual world of the PVC. Avatars and synthetic characters can enter the space from three sides. The forth side is covered by a mirror; in the physical installation this is the side where visitors enter. In the virtual world, visitors can access an observatory on the 1st floor. Arrows indicate the regions were the interfacing between physical and virtual entities occurs

4. The Ghost in the Shell

Visitors to the eXperience Induction Machine (XIM) and its virtual counterpart should experience the space as an autonomous, sentient entity. What the visitor will encounter is — borrowing from the title of a Japanese cyberpunk manga — the “Ghost in the Shell”.

To achieve this, the space requires coherence of perception and behavior, as well as action regulation and learning on different temporal scales. Short-term behavior control and learning of expression in addition to means to influence the visitors will be based on the Distributed Adaptive Control framework (DAC)[3]. DAC is a general purpose adaptive learning model, which uses three strongly coupled control layers, reactive, adaptive and contextual, to learn the appropriate reactions to stimuli. Using robot based models of DAC5, it was shown that robots could learn complex rules in real-world situations [5].

Mid-term action selection requires a motivational system that provides the “Ghost in the Shell” with behavioral goals, and empowers it to assess deviations from a desired goal state. This framework gives us the opportunity to implement and evaluate models from motivational psychology, especially models of social motivation such as the “Zurich model of social motivation” [6]. An early prototype of this was implemented in Ada that mapped the ability of goal-achievement onto emotional states [8].

On the long-term time scale, the behavior of the “Ghost in the Shell” is defined by a circadian rhythm. This rhythm will be coupled to the day-night cycle of the PVC’s virtual world (which for scenographic reasons is shorter than in the real-world). This means that the long-term behavior of the space is defined by an intrinsic clock, which in turn is entrained by the state of the virtual environment, specifically by the lighting conditions. The long-term behavior regulation will be based on psychoneuroendocrinological models, such as the ones of circadian networks. Also Ada used such cycles albeit at a scale of minutes and not hours [1].

XIM can express itself graphically through floor tiles and projections. A second major means of expression is music. For this purpose we use the real-time music composition system Roboser [4], which produces musical structures in real-time as a result of the interaction between the system and its human and non-human environment. The audio feedback should be able to reflect as authentic as possible the synthetic emotion or behavioral state of the interactive system. The validity of the composition system is evaluated by comparing the emotional states induced in humans by the system and the initial synthetic emotional state observed for the interactive system.

5. The large-scale neuronal systems simulator iqr

An installation such as the XIM needs an “operating system” for the integration and control of the different effectors and sensors. We use the XIM and PVC as a platform to apply and test large-scale neuronal models. These models will on the one hand realize the “ghost in the shell” of the space, and on the other hand control autonomous synthetic characters acting in the PVC. For both purposes, the “operating system” and the test of neurobiological models, we use the multi-level neuronal simulation environment iqr developed by the authors [2]. This software provides an efficient graphical environment to design and run simulations of large-scale multi-level neuronal systems. With iqr neuronal systems can control real-world devices — robots in the broader sense — in real-time. iqr is employed to develop and run the perceptive, cognitive, emotive, and behavioral control of the XIM. The key features of iqr are: ●graphical on-line control of the simulation, ●change of model parameters at run-time, ●on-line visualization and analysis of data, ●the possibility to connect neural models to real-world devices such as cameras, mobile robots, other hardware etc., ●pre-defined neuron and synapse types, ●open architecture for new neurons, synapses, and hardware interfaces. iqr comes with a wide range of pre-defined interfaces to hardware devices. These include modules to control Khepera and Koala robots (K-Team S.A., Lausanne), Lego MindStorms, and the blimp robots used in the AMOTH project. iqr is fully documented and freely available at http://www.iqr-sim.net

6. The system architecture of XIM

As mentioned previously, in the mixed-reality application PVC, the XIM fulfills the dual role as an autonomous sentient entity and as such is a gateway into a virtual environment. The second role is a new functional requirement compared to the precursor installation Ada, and led to the redesign of most of the subsystems. These subsystems include the synthetic real-time music composition engine Roboser, the moving light and camera (”LightFinger” and ”Gazer”) control, the sound localization, the floor control, and the tracking system. We based the system architecture design of XIM (Figure 4) on two principles: Real and virtual XIM are functionally equivalent, and the ”cognitive” component of XIM is decoupled from its physical and virtual representations. The first maxim entails that in the virtual counter part of XIM, effectors have to have the same functional effect on visitors, but not necessarily be a faithful representation of the physical device. This functional equivalence is crucial for creating a coherent interaction in the mixed-reality environment.

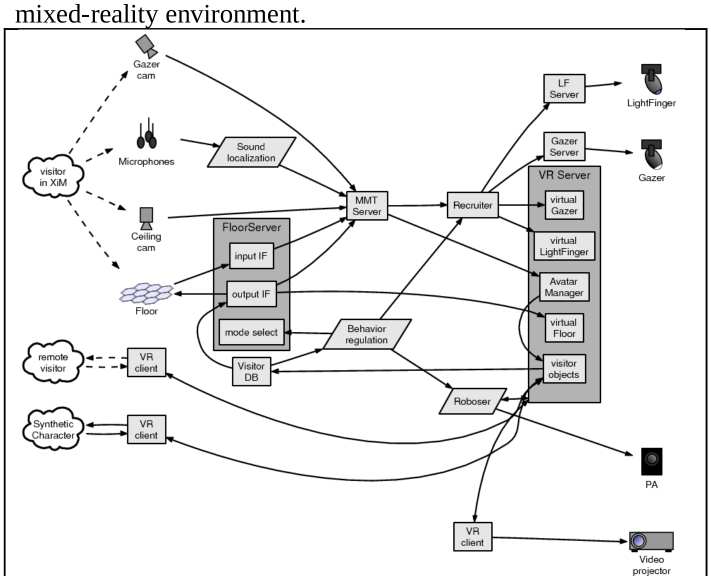

Figure 4: System architecture of the integration of XIM with the PVC. At the heart of the architecture lies the representation of the mixed-reality world. This is the role fulfilled by the VRServer (Torque game engine, GarageGames, Inc., OR, USA). Remote visitors alike synthetic characters (clouds) are interfacing to the virtual world via network connections to the VRServer.

The second maxim implies that any event occurring in the real or the virtual space is indistinguishable for XIM’s cognitive system. This allows for the permanent existence of the persistent virtual community despite its transient and indirect coupling to the physical XIM. The complexity of the tasks that the software architecture has to fulfill has increased. At the heart of the new system architecture stands the representation of the mixed-reality world. This is the role fulfilled by the VRServer. Remote visitors and synthetic characters are interfaced to the virtual world via network connections to the VRServer. Visitors to the physical instantiation of XIM are captured by the pressure sensitive floor, the overhead cameras, and the ”Gazers”.

7. Conclusion and outlook

In this paper we have presented the eXperience Induction Machine (XIM), on the one hand as a general purpose infrastructure for research in the field of human-artifact interaction in mixed reality, and on the other hand introduced a concrete application of XIM in the Persistent Virtual Community (PVC). We have described the general hardware infrastructure, and the specific system architecture developed for the integration of the XIM with the PVC.

Current development includes the realization of an automated demo with an interactive narrative, whereby the space presents and explains to the visitor its infrastructure and its capabilities as well as introduces the visitor to the PVC.

The current realization of the XIM installation is a prototype space; we aim to deploy the XIM installation as a permanent exhibit at the communication campus of the UPF. The “22@BCN” installation will be significantly larger than the prototype space and covers an area of ~150m^2. The installation being part of a public exhibit brings about the advantage of a constant influx of naïve subjects. From the engineering point of view, the prospect of deploying the installation as a permanent exhibition means that the prototype space has to be modular in both the physical and the technological aspects in order to generalize easily to the larger interactive space.

8. Acknowledgements

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