Passages – a 3D artistic interface for child rehabilitation and special needs

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ABSTRACT

Passages is an immersive, multimodal, user-controlled artistic interface. It consists of a three-dimensional interactive Virtual Environment that can be created, explored and interacted with in real-time. The installation has been exhibited in Grenoble, France, during the ENACTION_in_Arts conference (November 19-24, 2007) and in Pisa, Italy, during the Beyond Movement workshop (December 17-21, 2007). This paper outlines the design of the artistic installation *Passages,* and its potential in the field of rehabilitation.

1. INTRODUCTION

An outgrowth of the Computer Graphics research field, Virtual Environment (VE) technology has today become a fully independent research topic. VEs are simulated environments generated by a computer with which human operators can interact through different sensory modalities. Real-life applications of VE technology are an increasingly emergent phenomenon, although still in very specialized contexts. There are some fields that have shown a superior receptivity to VE concepts and techniques, the best example being applications of virtual prototyping in the Industrial sector, and in particular collaborative design, product presentation and training.

In the medical sector VEs are commonly used in surgical simulation tasks, medical imaging and neuroscience. One of the most promising medical applications for VE technology is rehabilitation. In this case devices and interaction modalities may present very different features depending on the therapy or the pathology being dealt with. In fact the great flexibility of Virtual Reality (VR) represents one of its great strengths, allowing the most disparate therapeutical needs to be addressed and adapted to the special needs of some users.

Indeed, VR is increasingly used to treat pathologies like autism (Gillette et al, 2007), phobias (Carlin et al, 1997) (Powers and Emmelkampa, 2008), brain lesions and neurological speech disorders (Rizzo, 1994). Such systems are designed in order to establish an efficient "interface" between patient and therapist, allowing the latter to define protocols and measurements which will be subsequently used to perform a quantitative evaluation about a patient's progress. Usually these systems are based on mainly visual protocols, using a range of different types of displays. These may be either standard screens or immersive technologies like head-mounted displays and/or CAVEs (Cruz-Neira et al, 1992). Such is the case in phobia treatments, for example. In the field of motion rehabilitation, however, force feedback devices like haptic interfaces and exoskeletons are also used heavily. These devices are robots able to exert controlled forces upon the user, to enable perception of the VE by means of touch. The generated forces may also be calibrated in order to assist or impede the patient's motion while performing a specific exercise, depending on the type of therapy. There are several types of robots for this purpose, depending on the functionality required (i.e. allowing planar or three-dimensional movements) or the interaction mode (the robot may be in contact with only one point of the patient, for instance a finger, or it may be completely wearable, etc.).

VE technologies are rapidly gaining traction in the fields of Art and Cultural Heritage as well, both for reasons of preservation and conservation as well as for educational purposes. Because VR allows for new perceptual experiences and research opportunities, it presents exciting possibilities for artistic expression and fruition, and therefore a platform for individual enrichment and cultural growth.

2. *PASSAGES*: INSTALLATION OVERVIEW

2.1 Technical setup

The *Passages* installation is composed of a stereoscopic projection screen, Infitec stereo glasses and a wand. The position and orientation of both the glasses and the wand are acquired by a long-range Polhemus electromagnetic tracker.

By moving the wand in space, the user can generate luminous traces into an immersive three-dimensional space, see Fig. 1. These traces are projected on the rear-projection surface (the powerwall), driven by two superimposed high resolution projectors connected to a PC rendering the virtual world. Real-time positional information of the user's eyes and wand are processed by the Polhemus system and passed to the rendering engine on the PC to generate the appropriate perspective for each of the user's eyes.

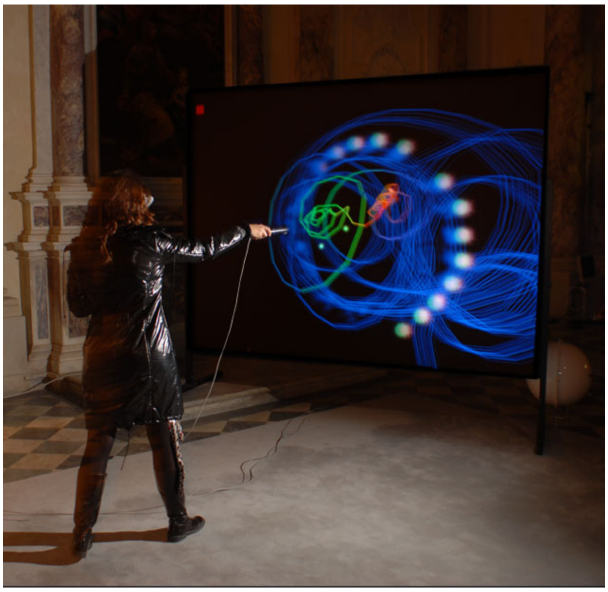

Figure 1. *User interacting with Passages.*

The environment is realized using XVR (eXtreme VR) technology (Carrozzino et al, 2005), a development framework targeted at VR application development. Supporting a wide range of VR devices (such as trackers, haptic interfaces, immersive rendering systems, etc.) and using a state-of-the-art graphics engine for the real-time visualization of complex three-dimensional models, XVR allows the development of applications ranging from simple 3D web presentations to advanced off-line VR installations. XVR applications are developed using a dedicated scripting language whose constructs and commands allow for the easy inclusion of 3D animation, positional sound effects, audio/video streaming, real-time physics and advanced user interaction. The *Passages* application software runs within Windows and its output is displayed full screen in Internet Explorer.

2.2 Expression through movement and gesture

Immersants in the installation expressively interact with an abstract environment centered on the concept of bodily exploration and enactive knowledge (Varela et al, 1991). As the user moves and traces his or her "passages" in the space through the use of the wand, luminous coloured lines are created that can be modified through further movement. The color of these expressive beams of light changes relative to their distance from the numerous sparkling lights that move in the three-dimensional space, as shown in Fig. 2.

Figure 2. *Installation output.*

The user can create architectures of light and colour that always move relative to his or her perspective; the traces can be interrupted with a specific gesture (a quick shake of the wand) or can be carried on by other users. This virtual world is designed to evoke an emotional experience of awe and discovery, where the user's gesture becomes a direct form of multimodal composition.

In the two exhibitions mentioned previously, *Passages* has been experienced by numerous users, see Fig. 3, and has proven to be a powerful tool for creativity and bodily expression by providing a high sense of immersion and engagement. Indeed, the potential of Passages as an "Expression Interface" for rehabilitation was suggested during user evaluation by participants of the installation.

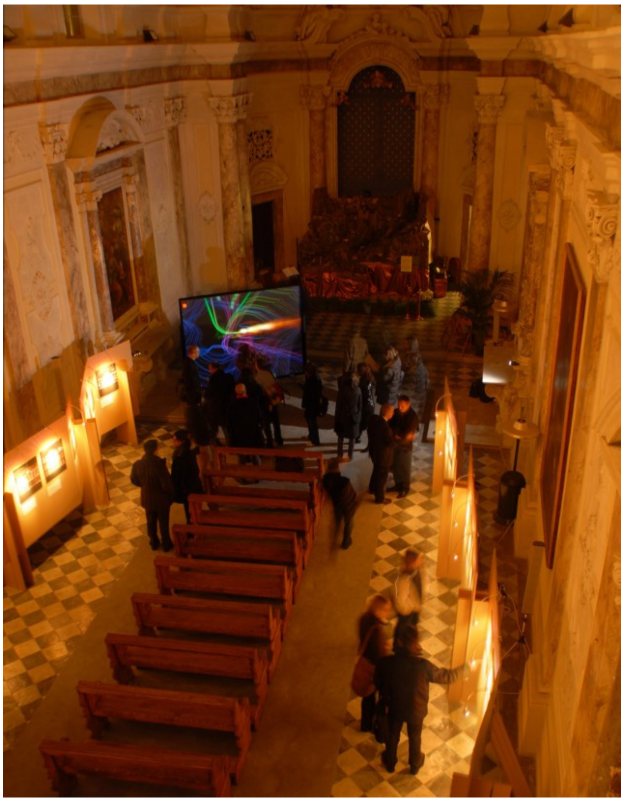

Figure 3. *Passages at Beyond Movement, Pisa, 2007*

3. ENACTION_in_Arts: AN EMPIRICAL EXPERIENCE EVALUATION

3.1 Enaction_in_Arts and ENACTIVE 07

The Enaction_in_Arts exhibition was particularly valuable opportunity for the evaluation of the experience, due to the wide visiting public and diverse typology of visitors. The Enaction_in_Arts exhibition was an open event organized in the framework of the Enactive 07 conference, promoted by the European Network of

Excellence ENACTIVE (*www.enactivenetwork.org*). The exhibition, featuring nine artistic installations, attracted over 900 persons. Among them, twenty percent were conference participants, forty percent were regulars of the contemporary arts, and the remaining sixty percent were members of the general public. The conference participants had a mixed background (Engineers, Computer Scientists, Philosophers) but as members of the Network (at date in its forth year) all of them were familiar with the themes of enactive knowledge, creativity's role in science, VR and related paradigms of interaction.

3.2 Methodology and results

Participants were provided with a very basic explanation of the installation setup, limited to instructions such as "wear the stereoscopic glasses" and "move your hand to trace a line with the wand". The user interacted for an average of 10 minutes with the installation, during which time more instructions were provided if the user expressed his or her intention to end the interaction without having performed all of the performable acts (i.e., "if you come closer to the stars the traces change their colour"; "if you quickly shake the wand, the coloured traces will all disappear"). The evaluation of the system was carried out through non-structured interviews during the interaction, allowing users to express their emotions and reactions to the installation as their knowledge of it grew. In this way qualitative research findings were gathered about the installation that provide an ethnographic basis for future iterations of the design of the system (Laurel, 2003).

It is interesting to underline the differences between the general audience and expert users (the conference participants). In general, the experts needed less instruction and were more active in exploring the VE autonomously. The main difference consisted in the fact that while the experts were immediately aware of the three-dimensionality of the space (and thus moved back and forth perpendicularly to the screen and not only in parallel to it) the general audience was much more limited to a two-dimensional spatial model. The most frequent "figure" performed by 3D-aware users was a spiral, that they traced and then entered within quickly. On the contrary, the favourite activity of 2D-users was writing. Furthermore, almost all expert users suggested rehabilitation as possible application field, especially for children.

4. POTENTIAL FOR REHABILITATION

The following discussion summarizes what has emerged from our consultation both with recent literature about rehabilitation, art and creativity, and from the suggestions of expert users.

As a tool for rehabilitation, *Passages* would be particularly suitable for children due to its playful and colourful aesthetics and its "magic-wand" interaction metaphor. Indeed, environments in which users have "immediate" control (through movement) over sensual feedback of suitably interesting content is both aesthetically pleasing and capable of providing much therapeutic value (Lincoln and E G Guba, 1985), as it provides individuals with a level of self-motivation and coordination that may not otherwise be expressed.

The interface, expressly designed to avoid imposing the user a specific task to accomplish, encourages a free bodily expression and space exploration. Navigation and spatial awareness are encouraged by the sparkling lights allowing colour modulation of the traces that motivate further action.

Playful and active engagement can potentially improve an individual's recall of spatial layout and orientation, provide motivation for free-body movements among children with motor disabilities and incentive for further self-initiated actions (Standen et al, 1996). Evaluation and training of spatial awareness in children with physical disabilities could also be provided by an unbounded interaction of this nature.

The actions of users as they interact with one another over time create a luminous landscape of motion, since the wand can be passed from one user to another. This feature represents an interesting potential for children affected by intellectual disabilities such as Autistic Spectrum Disorders (ASD), since it encourages a form of communication, mutual coordination, creative co-presence in the virtual space and social behaviour.

The virtual space in *Passages* is totally dependent on user-driven gestures and motions, and does not aim to represent an architecturally understandable space or a familiar environment. Precisely this "abstractedness" (Small, 1996) can be seen as an opportunity of positive interaction for disabled children. Thus the light and colour landscapes, despite their abstractedness, provide the user with a visual pleasure that can be associated to 'aesthetic resonance' - a situation where the response to an intent is so immediate and aesthetically pleasing as to make one forget the physical movement involved in the conveying of the intention (Brooks et al, 2002).

Passages is an artistic interface that goes beyond icons, symbolism and constraining human-computer interface metaphors to become both fluid and embodied. This approach builds on a recent trend in philosophical and cognitive models of the human mind that understands all linguistic and iconic knowledge as “embodied” action (Lakoff and Johnson, 1999, and Valera et al, 1991). This interaction paradigm expressly avoids traditional mouse/keyboard usage, allowing accessibility by children with physical disabilities who are unable them to perform fine motor movements such as those required by most computer interfaces.

5. CONCLUSIONS

In the future, improvements to the *Passages* installation itself will be incorporated and evaluated through further scientific research. Given the predictions of experts today (MacIntyre and Feiner, 1996; Cadoz and Wanderley, 2000), the efficiency of gesture learning and expression is likely to have widespread implications on the future of human-computer interaction. For rehabilitation environments in particular, performed data could be mined by an intelligent system to understand which aspects of movement are similar and how patients' gestures evolve through use. Opportunities incorporating real time machine learning and interactive human/system interface didactics will be fascinating to apply in a networked environment where a variety of users collaborate to teach the system how to structure an abilitation environment that surpasses the capacities of the individual therapist.

Passages is an ongoing project exploring the expressive potential of multimodal environments. In conclusion, it is an artistic user-friendly interactive environment that encourages and motivates social interaction and spatial exploration. The added value of being “fun” to interact with (as noted by the majority of the users who experienced it), could well be a deceptively simple yet remarkably valid resource for special needs patients (Lakoff and Johnson, 1999) and rehabilitation in general.

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