Experimental Results in Immersive Virtual Reality (IVR): Searching Critical Design Factors within IVR to Increase Architectural Space Qualities

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The actual study in IVR (Immersive Virtual Reality) proposes a path which may provide meaningful information about the user’s behaviours and difficulties to articulate in immersive worlds. Beyond it, we are searching for parameters to improve design qualities in such an architectural space.

Our interest is to use IVR as a medium to research the quality of spaces in particular the atmosphere of such spaces, on the basis of people’s interest and eagerness. Therefore it is important to comprehend the special conditions of the perception and the behaviour of the user in virtual spaces. The purpose is to understand the influence of an IVR environment upon the human being and to develop motivation for a personal use of virtual space as a learning environment.

The aim of the analysis was to explore behaviour patterns in a simulated IVR environment. Moving from the dynamic of space, there arises a personal “space-time-system”.

Keywords: Urban planning; virtual reality; immersive; teaching.

Introduction

The physical laws of the “physical world” (real world) do not determine the possibilities of a world in IVR. Virtual Reality is a planning tool and not a replacement of reality. (Boytscheff, Kanacri, 2005). Our experience in IVR since 1999 has shown that in IVR it is possible to have real experience of space even though it is a synthetic space. “Everything perceived is also thinking, all reasoning is also intuition, all observation is also invention” (Arheim, Rudolf, 1979). For us the virtual space defines and initiates a new consciousness and understanding of architecture.

IVR versus Architecture

We assume that the architecture that can be discovered and developed in this growing area of IVR may provide new and as yet unimagined virtual environments and experiential worlds. It may be possible to assign the experiences made in IVR to the physical
world and it may be also possible to transfer the knowledge about an architectural space quality to the physical architecture.

Our basic principle is the human being and technology used as a detector or as a platform for the needs of the human being.

The immersive virtual reality (IVR) offers an unlimited possibility for the production and construction of room-space. For architectural planning, IVR has a very special value. No other medium comes close to providing an impression as close to that of the planned reality as does IVR. Even if the quality of the representation does not correspond to that of the computer animation, the perception can be much stronger as a result of the immersion effect.

Architecture does not have to do only with good function, but also with providing important immaterial qualities like “well-balanced design” and well-being by creating a positive effect on people. With the help of IVR, intangible spatial qualities can be experienced and learned (Boytscheff, Kanacri, 2004). Planning can thus be mediated in a more generally intelligible way. It has become for us a useful workplace to support the distinction between attractive or less attractive architectural virtual spaces or even to understand the well-being of a user in a physical architectural space.

Most users of immersive virtual spaces who engaged in certain productive space typology also engaged in spaces with no productivity, which are just accessible for diving around through the environmental effects of IVR. However, the current observations suggested the need to distinguish between their differences when establishing immersive virtual scenarios for tasks as serious games and other environments to access knowledge. Furthermore, our work in IVR since the early 1999 has shown that there is a need to deepen the understanding of how space quality and its atmosphere influence human behaviour. This drove us very early on to “learn” about the different kinds of human behaviours, attitudes and the neurobiological understanding of the mind.

Within this frame of questions, aimed to consider psychological and social features of a particular virtual environment, in 2003 we decided to use the IVR to find an answer to the basic questions concerned with understanding the relationship between the user and space quality and whether or not there is a predominant value that drives the behaviours of the user in IVR.

Methods

The Immersive_Room
Our research specified above, has been developed in a 4 sided CAVE™ system with user tracking and different VR software (see figure1). It presents the possibility of a user interaction having influence in the virtual architectural environment. This IVR-System is completely driven by us and only used for questions and related projects for a better understanding and development of new architectural spaces in the learning/teaching area.

Figure 1
The Immersive_Room and tested persons
Analysis of architectural space

We analyzed in IVR responses of acceptance through different examples of virtual architectural spaces, with different contents to explore and develop (new) spatial definitions. The worlds implemented are fairly intuitive and interactive: 1. Worlds as a simulation of the physical world (architecture buildings, city models, etc), 2. Synthetic worlds without any comparison to physical worlds and 3. A mixture between both.

Subjects - Participants and procedure

A total of 180 participants between 22-75 years, randomly selected, participated in this study. It took place over a number of years 2003-2007.

The tested persons were asked to dive naturally and interact as they wanted and to perform tasks in the virtual environment. It was expected that they could behave naturally, because any encumbering gear was and is an obstacle for us (see figure 1). The study involves, whether wanted or not, of course cognitive and motor abilities to dive in an interactive environment.

By soliciting these participants to report their behaviour in virtual spaces, we focussed on the use of this technology only as a platform to verify the influence of space on a person. Their individual experiences were measured supported by: 1. observation of their reactions, 2. through the use of questionnaires asking their opinions and perceptions and 3. partly introducing Bio-feedback. Bio-feedback detects significant physiological changes in skin conductance parameters, so we wished to define, in a better way, the relationship and the influence of the architectural space on the emotions.
The use of Bio-Feedback was considered to be a more precise parameter to integrate the body senses of the users. This is a very exciting idea, but the main point of such an intention is the question of the influence of the physical incorporation on an understanding of the influence of certain spaces with the use of Bio-feedback (as a loop) so that the “impressions of the space” may return as an answer to the person and vice versa.

Analyses of skin conductance measurements and other values did not reveal a clear answer to the experienced situation. In a way, Bio-Feedback in IVR confused the people and the observer. Despite the fact that Bio-Feedback may support an objective analysis of behaviour, there are significant differences between the results and the observation. A visualization example was conducted to investigate the properties of such a Bio-Feedback procedure in the IVR. The results do not provide a clear help to understanding behaviour but to help the user to see and control his/her state. This is an on-going research. A different way of study was adapted and developed.

**Results**

**Bio-Feedback Procedure**

As a result we could develop a training form, a connection between speech and the user over the Bio-Feedback as a means of association between the state of the person and the task. The task was to deliver a speech through a PowerPoint presentation. The measured values were the skin conductance, the skin temperature and the heart rate (pulse). We choose this method because it is easier to connect, and does not have too much encumbering gear. In addition, the temperature sinks during excitation and rises during relaxation. With stress the skin reacts colder than in a calm mood. The pulse frequency (between 40 to 120 pulsations/min) sinks during relaxation and rises during excitation. This value oscillates with the breathing of the person (by breathing in the value rises.) Both, the PowerPoint presentation and the reached values were connected and dependent so that any difference in them caused a reaction in the presentation by changing the sheet at an accelerated tempo (very nervous). This process helped the user to see a response to his/her state. Through exercising by calming itself, it was possible to control the excitement and have a favourable experience when interacting with an audience.

**Responses of perception and behaviour**

The results obtained by the responses of acceptance through different examples of virtual architectural spaces in the Immersive_Room indicate that during the presence of the user in the nonlinear virtual environment the course of action and intention of their movement sequences are as well stored in their mind as the action sequences including their last interaction with the environment. The user tends to look for a path and try to understand the space and the next sequences. It was also shown that users have different learning styles and that they respond in very different manners. This study suggests that it
might be very important to give them largely space for interactions so they can have the opportunity to formulate their own course of action.

**Results of the effect of individual interaction**
The results we obtained at this time highlighted that users create a deep relationship with their virtual environment when they have the feeling that they may interact individually with the environment (84%).

An important motivation for the readiness to be in a synthetic world and to engage again and again was indicated by our empirical investigations and through experiencing several and antagonist worlds.
that participants strive for something new, something unexpected or where they become curious. All persons reacted and act very individually. They stay very gladly in the world when they can have new experiences and only so long as these are not actually evaluated and well-known by them (76%). They stay only where they can compare and assess, where they can develop interest. This is directly related to the need for more unknown rules which they can find out during their experience in the IVR world.

After an experience was already recognized, evaluated and experienced it became gradually less interesting and resulted in little or no activity or action. This study showed clearly that there is a connection between the person and the individual pre-experience and knowledge and the offered experience world.

Qualitative characteristics and cognitive knowledge are the two outstanding factors, which we could recognize so far as a very important formative control system in the design considerations of those worlds. These factors show up or are formed through: e.g. the atmosphere of the architectural worlds, their style and form of expression, the objects, the interactions, the orientation through known or recognizable elements, and the interest of content itself. Qualitative characteristics and cognitive knowledge certainly promote the interest to actively stay and learn in an IVR world. Qualitative experiences were perceived as providing a more useful experience than quantitative experiences.

The forms that are seen in the surroundings are the own entailments (predetermined order of succession) of the perceptual experience. There is indeed always a central question concerning physical architecture. The constant interaction between objects and subjects generates a permanent reciprocal agreement. That is why interactions in an IVR experience worlds are so important.

Discussion and Conclusions

The present findings serve to guide us in the benefits of IVR. The results suggest that, while working with this medium a direct personal support is needed for a well-being of the user and that the considerations of interactions are very helpful in arousing positive results.

The majority of the users (80%) were enthusiastic about the possibility of experiencing alternate virtual worlds.

What determines how long people stay in a virtual world? IVR is an illusion machine. It depends on how much a person is willing to embrace such technology. By some estimates, a significant aspect is the sense of finding something “special” in it. But people are also looking for something exacting. The most interesting thing is that everything is searched and filtered through their particular perception. The characteristic criteria of what is “special” are different from person to person. They bring it along as their experience and own interpretation world. Objects and atmosphere stand like symbols, which have different meanings for each person. Therefore, the IVR world should provide the possibility of experiences and interpretations.

Each person carries a bunch of images, fulfilled with emotions. They constitute his/her abstract world. Some are conscious other unconscious. Their appreciation of the physical world is measured by their own history, emotions and the historical context in which they are inserted. That is why it is not important at all to have a realistic representation.

The subjective spatial quality is exactly the difference between these two conditions, between what they bring and what they find out. This rapport constitutes the experienced atmosphere which a person actively experienced in the IVR world.

The visual surroundings of a person are loaded with “meanings”. The objects exist because the sensorial experience has impregnated them with meanings. These are age, gender and cultural based. The real environment is constituted with continuous and complex transformations of special configurations. Therefore what is present in the experience world of IVR is a dynamic simultaneous visual stimulus. The
mind must be able to select the visual stimulus in a limited time (tediousness/excitement) and must develop the capacity to understand the structures, the orders and connections between the facts in a defined space-time (orientation). The perception must consider elements of change, of the simultaneous and of convergence. These are the guidelines for more or less realism.

Small noshes
However, we might like to think that more content is better but the facts conclude that the offers of contents should be given as snacks, till they are better experienced.

If the participants were chosen in preference to others, by a selective procedure before experiencing a certain synthetic world according to certain criteria like previous experience with IVR, or even with games consoles, PCs or similar technical devices, the study showed better results (68%). When this selection wasn’t done the “lack of interest” was soon experienced. Clearly better for us, was a selected small dosage of information, rightfully prepared for the user and without excessive demands.

The IVR technology
Some persons, not accustomed to the technology, were more attuned to the navigation forms in the world and to their own interpretation of the technology (32%). Although the lack of interest did not mean that this first experience was not helpful. As soon as certain conditions of habituation effect were reached (by support) they could perceive the qualitative characteristics and the cognitive knowledge, in which they were involved (66%).

Different behavior was observed by technology-experienced people. They reached an “ease” connection with the offered world. Their individual experiences were suited by the possibilities of impression of IVR. They tend to focus their energy on the concept, perceiving and judging the new information. A personal development, a personal learning thereby can be better promoted (83%).

Support
This study pointed out that different emotions may emerge in the case that two or several different persons are experiencing an IVR world at the same time. (67%) We can see a sense of motivation or a sense of fastidiousness. However, the danger is the monotonic feeling, which we want to prevent, of doing things too well known. All depends upon the personality traits of the persons, if this situation cannot be adjusted by personal support, then the session can be over. The session goes toward its end, if the individual feelings of each person are not being satisfied (88%). For collaborative work in IVR to succeed it is important to have few individual differences of personality traits. The persons can be engaged in promoting each other up to a certain point. A learning effect thus is that they can compare themselves in a mutual manner. With IVR the information can be achieved through a recreational world of experience, can be assigned as a portion and is individually experienced.

It may become a burden when using IVR as a platform for the user for favourable experiences in personal balanced growth and supported learning but its effectiveness may be dramatically dependent on the adequate development of this technology which was developed too early to be really understood and till now its benefits can only be profitable by developing it accurately. If the need is to invent or adapt new hardware in the course of further investigations, then we will support even that. For now the search for critical design factors within IVR to increase architectural space qualities must be continue in new case studies, which will be reported in later papers.

Acknowledgements

Our acknowledgements for their CAAD and VR work that helped these results to: Anjana Perera, Björn Lutze, Sebastian Dannecker, Leif Henning, Markus Fuerderer, Johannes Bader, Denise Fichter, Christian Klötzel. We thank Uwe Woesner and Joerg Scheurich for their VR assistance.
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