14 del 2 al 5 de Diciembre de 2008 CONVENCIÓN CIENTÍFICA DE INGENIERÍA Y ARQUITECTURA

44 ANIVERSARIO cujae 2008

Congreso SIGraDi Cuba 2008 — Gráfica Digital Integración y Desarrollo — La Habana 1 al 5 Diciembre 2008

The implications of Virtual Reality project practices: ergonomic aspects of interactive virtual immersive environments

Humberto Malard Monteiro, Rodrigo Peronti Santiago, Marcus Soares, Vanilson Cosme

Escola de Arquitetura da Universidade Federal de Minas Gerais

Abstract. The objective of this work is to discuss some applications of Virtual Reality (VR) in the field of Ergonomics and Architecture, and how these applications can contribute to facilitate the conception of architectural projects, the designing of technical systems as well as the user-designer interface. Virtual Reality through the Immersion Environment of Low Technology can also facilitate the conception of project that provide clients with an easier handling, thus reducing recurrent user's manual consult and consequently making use more comfortable.

Through virtual reality a support to the designer in the interface with the costumer is expected, providing the first with a better explanation of his idea to the last. Under the perspective of the designer VR could be used as an excellent teaching tool, since it allows the interaction with certain aspects (complexes ones) of the project that are difficult to be translated into ordinary terms.

It is believed that VR could be a valuable and useful tool in the conception of new technical systems because could avoid waste and rework, thus saving money and time because any setback in the stage of design means waste of time and money – changes in the design phase may result in a partial or even complete destruction of the system.

The aim of the study is also to assess the conception of products with regard to the costs of maintenance and repair – as it is the case of some automobiles – which you it is necessary to destroy some components in order to fix others. This increases the costs of maintenance. It is expected that Virtual Reality may be helpful to support designers and professionals who work with maintenance to solve problems related to mounting, dismounting and maintenance of machines due to the possibility of visualizing objects in 3D and from different angles.

Key-words: Ergonomics, Project, Virtual Reality, Designer, User.

I. INTRODUCTION

The Virtual immersion has become the aim of a systematic study since the diffusion of the computer in the seventies. The CAVE (*Cave Automatic Virtual Environment*) was a project developed by the artist Daniel Sadin and the engineer Thomas DeFanti at the Laboratory of Electronic Visualization of the University of Illinois, Chicago, between the period of 1970 and 1991. Since then, the idea of using three-dimensional stereoscopic models to simulate the interaction between persons and objects or between persons in different places has gained importance in several researches. This may be seen as a perceptive evaluation of new and old buildings, urban environments, automobile and aircrafts as well as a collaborative work between groups of research, teams of inter-institution or a partnership among companies.

The CAVE, archetypes of immersive environment [1] presents significant limitations related to the assembly cost of its components and the diversity of application.

Conceived in the School of Architecture of the Federal University of Minas Gerais by professors and researchers of the Department of Projects, "the Virtual Immersion Environment of Low Technology" (in Portuguese: Ambientes de Imersão Virtual de Tecnologia Simplificada - AIVITS) has the aim of developing, defusing technological resource

locally, and supporting the scientific development of secondary schools and universities.

The creation of the AIVITS has the purpose of developing and diffusing this technology in the state of Minas Gerais. This will be accomplished by gathering the scientific expertise of the Federal University of Minas Gerais (School of Architecture/Department of Projects and ICEX/Department of Computer Sciences) and from Technological Center of Minas Gerais – CETEC – (Scientific Visualization Group/ Chemical Analysis Sector).

Based on the idea of using stereoscopic three-dimensional models in which the relationship between the presence of objects and persons are simulated, the AIVITS has a range of applications in several working areas, for example: in the perceptive assessment of built environments; in urban environments; in the automobile and aerospace industry; and finally in the collaborative work among research groups and corporative partnership.

Although VR is a technology that already exists, the aim of the AIVITS project is to develop an Immersion Environment of Low Technology, that is to say, a Virtual Environment at lower financial cost. The reason is quite simple: it will be implemented in Brazil which is a developing country and where the budget for research and technology is short (the government budget) and the private sector is not always willing to spend high amounts of money on something that will not give a profit in short term. So, in this country cost is a variable that must be taken into account in every aspect of research due to the sponsor`s limitation, specially, when it comes to developing a project which implies in the purchase of expensive equipment.

The aim of this study is to facilitate the interface between user and machines by developing technical systems that puts human needs and capabilities at the focus of the design stage. So, it is expected that through an immersive environment it will be possible to display a technical system, project, etc. in a way that the user (layperson) is able to understand it thoroughly without much difficulty.

II. Applications of the AIVITS in Ergonomics

2.1. A brief definition of Ergonomics

Ergonomics is an approach which puts human needs and capabilities at the focus of designing technological systems. The aim is to ensure that humans and technology work in complete harmony, with the equipment and tasks aligned to human characteristics.

2.2 Virtual environment as an interface between designers and users

The AIVITS project will provide ergonomists and architects with a tool that we expect it will enable them to make a better understandable interface between themselves and the costumer or final user. One of the main challenges Architects and Designers have in the process of conception and design of buildings (or any other device) is how to get their point across to a layperson since professionals, in general, tend to use technical vocabulary to explain their work. However, designers and architects seem not to be fully aware of this fact, specially, when it comes to the presentation of their work to people who are not experts in their field of knowledge. With the implementation of the AIVITS, a reduction in the workload [2] for the expert as well as the user is expected to occur, since this interface will be eased by simple and intelligible concepts which put communication at an ease and intelligible level for everyone.

It has been noticed that the blueprints of some projects are not clearly represented in the perspective. Due to this situation ergonomists believe that there is a gap between knowledge designers have and how to put this knowledge into intelligible figures to a layperson [3]. Normally when a device is developed the characteristics of users are not taken into account – since devices such as computers, calculators, telephones, watches, etc., are projected considering the knowledge designers have in their mind, which is much different from the ones ordinary people have (a reason why we find ourselves reading instruction manuals in order to make simple operation more often than with other appliances we had in the past, eg.: blender, vacuum cleaner, electric grills and even the old television set) - this gives room to the development of products that do not fully meet the demand of the costumer, which lead the to misusage or maybe failure to accomplish certain tasks [3]. Another reason is that machine normally are made with only a few buttons that perform many operations, that is to say, if you hold a push bottom during 3 seconds it will give a determined response, and if you hold the same button again for a shorter period (2 seconds) the response might be completely different. This is very common in digital watches that are produced nowadays.

2.3 How a virtual environment of low technology can contribute to Ergonomics

As it was mentioned in item 2.1 the human needs and capabilities must be put at the focus of designing technological systems, thus the VE with low technology has a lot to contribute to facilitate decision making process in the phase of design review in the following aspects:

- It will reduce the production of a physical mock-up since it can be replaced by the virtual one, which makes the creation process cheaper.
- It will reduce the time consuming during the stages of creation, since a virtual model can be easily and quickly restructured at a zero cost.
- It may reduce the psychic workload of the designers, since the great deal of responsibility they have during

the decision making process is due to the high amount of money involved to make a prototype; making a wrong decision at this stage means having to build a new mockup, and as a consequence, a loss of time and money [4].

- Companies will save money by not having to make mock-up in order to display the product to the client. This can be applied specially to those companies such as the Real State that need scaled models to show their product to clients.
- It requires equipments that are readily available in the market.

III. Applications of VR in Architecture

3.1. Application of the VR in Architectural research

In Architecture, the perceptive evaluation of buildings and urban environment in addition to collaborative work, has an application not only in research centers but in the development of subjects in the graduation and post graduation courses of Architecture. Subjects that approach predominantly expositive contents could benefit significantly in terms of quality as well as in passing information on to students, though the most notorious benefit is seen in subjects dedicated to project development because they cover not just the production and transmission of information but they can become feasible, consequently providing a better use of time and better condition for the development of ideas.

3.2. Application in the Architectural working field

In the architectural working field the AIVITS has a potential application as a tool for project representation as well as a mean of project development, thus substituting resources commonly used such as physical mockups and photorealistic images.

One type of application, part of a *mechanical* paradigm also called *perspective* (Baltazar, 2001), has been developed in most Architecture offices, nevertheless other architectural practices worldwide already incorporate to a certain extent, a vision of the technology of information in addition to the representation tool.

IV. Applications of VR in the Cultural Heritage field

The application of VR in the cultural heritage field, with an emphasis on building heritage is a result of the storage of stereoscopic electronic models of works in which not only formal information would be stored (as images, blueprints and cuts) but also sensorial information (like the idea of space and time of the work). The application also reaches the possibilities of visualization of the works with a difficult access to research, or the ones that have already been destroyed, for example: *Cine Metropole Building* (dated from the 1950s) located in the city centre of Belo Horizonte and the *Pantheon* in Rome – Italy.

V. Contributions of VR to Collaborative Project Development

The collaborative project development is supported by computer tools that allows the proposal of broaden solutions, thus decreasing the difficulties of communication [5]. The development process shows enhanced ideas and solutions, since there are many collaborators, and many are the approaches and interpretation that could be proposed for the solution of problems.

When partially or fully immersed in virtual worlds, the users can discuss and develop critical sense about the strategies and definitions of project adopted, as opposed to when it is represented in blueprints. The identification of reduced functionality operational areas (residual areas), idea of proportion among elements (footing, sheathing, vault, frames) and the performance of the structure and constructive elements in addition to animated studies of flux (related to the shift of persons and equipment from one place to another), are examples of useful applications specially to facilitate the dialog among technicians and non-technicians who are collaborating with the development of the project.

VI. Conclusion

It is believed that the collaborative aspect of immersive environments means a high level of interactivity among users and these environments. The AIVITS aims are the search of new technologies of interaction among users and virtual reality (VR) so that it could be manipulated and navigated in an effective way.

In relation to Architecture the ways of interaction could be focused on specific contexts and situations. One example is the use of a bicycle in order to simulate a ride throughout a historical city. As far as project is concerned, the ways of interaction could be focused rather on the changing of the physical space that is being created, followed by the use of common tools in software for virtual modeling as the zoom in/out, extrude, line and others.

In Ergonomics the application of the AIVITS could contribute to relieve the work load of conceptual teams by providing tools that allow rapid changes in project without having to spend huge amounts of money and time.

Acknowledgements

The authors would like to acknowledge the financial support of FAPEMIG and also their scholarships from PRONEX.

REFERENCES

[1] A. P. Baltazar and J. S. Cabral Filho, *Tenda Digital/Digital TENT (Technological Environment for Negotiated Topology) e suas possíveis implicações em contextos sociais*, artigo publicado no X *Congreso Iberoamericano de Grafica Digital* – X SIGraDi, Santiago, Chile, 2006.

[2] C. Dejours, E. Abdoucheli, C. Jayet, *Psicodinâmica do Trabalho: contribuições da Escola Dejouriana à análise da relacão prazer, sofrimento e trabalho*, São Paulo, Brasil, 1994.

[3] D. Norman, *The Design of Everyday Things*, 1988, originally under the title The Psychology of Everyday Things, Newprint, 2002.

[4] G. Moreau, P. Fuchs, P. Stergiopoulos, Applications of Virtual Reality in the manufacturing industry: from design review to ergonomic Studies.

[5] A. P. Baltazar, *E-futuros: projetando para um mundo digital*, artigo publicado no portal Vitruvius, 2001. http://www.vitruvius.com.br/arquitextos/arq000/esp077.asp

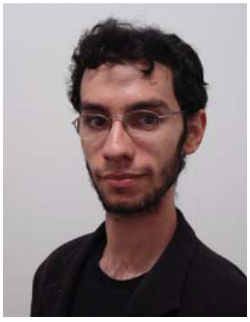
AUTHORS

Maria Lucia Malard is Professor at the School of Architecture, Universidade Federal de Minas Gerais, Brazil, where she heads EVA (Estúdio Virtual de Arquitetura / Virtual Studio of Architecture). She is a qualified architect and obtained her Doctorate at the University of Sheffield, UK, in 1992. She has been involved in practice, research and teaching for most of her professional life. Her research has been mainly concerned with the design process, low-cost housing and the interactions between people and spaces. She has several publications and has held research grants from Conselho Nacional de Pesquisas (CNPq), Financiadora de Estudos e Projetos (FINEP) and Fundação de Amparo a Pesquisa de Minas Gerais (FAPEMIG). She has supervised over 30 Master students and 65 undergraduate students.
Contact: pirapora@arq.ufmg.br ; http://www.arq.ufmg.br/eva.

Humberto Malard Monteiro is a Brazilian qualified Psychologist, MSc, Production Engineering. He is currently working as a researcher at EVA (Estudio Virtual de Arquitetura / Virtual Studio of Architecture) and has worked at RSV research project (Residencial Serra Verde) at the School of Architecture, Federal University of Minas Gerais, Brazil. His main interests are on Production Engineering, Ergonomics of conception, the role of ergonomists as an interface between designers and users, the conception of products that puts human needs and capabilities at the focus of design, task analysis, enhance production processes in order to improve productivity and workers wellbeing. He lectures on Ergonomics and worker`s health at universities and enterprises in Belo Horizonte – Brazil.
Contact: hmmalard@hotmail.com ; <http://www.arquitetura.ufmg.br/eva>

Rodrigo Peronti Santiago, Brazilian qualified Architect, MSc, studied architecture and urbanism at the Universidade de São Paulo (USP), Brazil, and did his master about social memory and cultural heritage in virtual environments at the same university. Between 2005 and 2007, he was researcher in Nomads.usp (Center of Interactive Living Studies), at Department of Archictecture and Urbanism, USP. He currently is involved in research for developing a low-cost immersive collaborative environment using stereoscopy (AIVITS), at School of Architecture, Universidade Federal de Minas Gerais (UFMG), Brazil. His main interests are on Design of Knowledge Spaces, Digital Inclusion, Cooperative Work through new midia, Ubiquitous computing, Digital Art and History in Mixed Reality Applications.
Contact: peronti@sc.usp.br ; <http://www.arquitetura.ufmg.br/eva>.

Marcus Soares is a brazilian graduate student of architecture at the School of Architecture, Federal University of Minas Gerais. He develops project apresentations with 3D models and rederization. He already worked with project developing in private architecture offices and at the Departament of Architecture of the Faculty of Medicine of Universidade Federal de Minas Gerais. Nowadays, he works on development of an Imesrive Environment of the AIVITS project. Contact:
marcao_arquiteto@yahoo.com.br ;
<http://www.arquitetura.ufmg.br/eva>.



Vanilson Cosme is a graduating student of Archictecture and Urbanism at School of Architecture of Federal University of Minas Gerais. His graduation project is an ocupation plan for a 5ha area, at Ribeirão das Neves suburbs, near Belo Horizonte city, including housing design, enhancement of the installations of a communitarian center and the architectural design of a center for production of ornamental plants. Since 2006, he has been involved in research for housing and computer aided design in EVA (Virtual Studio of Architecture). Contact: vanilsoncosme@yahoo.com.br ; < http://www.arquitetura.ufmg.br/eva>.