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MuseV2 - THE VIRTUAL REALITY APPLICATION TO COLLECT USER PREFERENCE DATA.

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Abstract

Virtual Reality (VR), and Artificial Intelligence (AI) technology have become increasingly more common in all disciplines of modern life. These new technologies range from simple software assistants to sophisticated modeling of human behavior. In this research project, we are creating an AI agent environment that helps architects to identify user preferences through a Virtual Reality Interface. At the current stage of development, the research project has resulted in a VR application - MuseV2 that allows users to instantly modify an architectural design. The distinctive feature of this application is that a space is considered as a base for all user modifications and as a connection between all design elements. In this paper we provide some technical information about MuseV2. Presentation of a design through VR allows AI agents to observe user-induced modifications and to gather preference information. In addition to allowing for an individualized design, this information generalized across a sample of users should provide the basis for developing basic designs for particular market segments and predict the market potential of those designs. The system that we envision should not become an automated design tool, but an adviser and viewer for users, who have limited knowledge or no knowledge at all about CAD systems, and architectural design. This tool should help investors to assess preferences for new community housing in order to meet the needs of future inhabitants.

1. INTRODUCTION

The measurement of user satisfaction has been the subject of continuous research endeavors in many disciplines, including architectural and urban design. Information about user satisfaction is critical in assessing alternatives design options and to predict potential market shares. If the current trend towards user-centered design will continue, a valid and reliable understanding of user satisfaction is paramount to designers and to the development of products. Over the last decades, many different approaches to measuring user satisfaction have been suggested, ranging from simple direct questioning of respondents to sophisticated measurement approaches such as conjoint analysis, which allows the researchers to test the assumptions underlying their measurement approach (e.g. Timmermans, 1984; Louviere, 1988; Katoshevski and Timmermans, 2001). None of these approaches are necessarily error-free. There is no definitive answer to the question how to measure satisfaction. Even in a face-to-face discussion, an architect might have problems establishing user satisfaction as users may not be able to articulate explicitly their preferences or may be induced by the situation to express their preferences in a certain biased way. The central question for our research project is whether virtual reality may be an alternative to traditional questionnaires, using paper and pencil representation, to collect user preference data. The main potential advantage of using VR is that respondents can experience the new product. Moreover, if the virtual environment can be changed, respondents can actually create the profile that would maximize their preference. VR has the ability to present solutions and ideas in a straightforward manner by creating an almost real world situation. The user "feels" the space, and is present in that environment. Virtual reality gives us the opportunity to show interactively a design to a respondent. This is very useful to present a large number of design elements in order to create design alternatives. Moreover, because of the large interactivity he/she can generate new solutions, instead of reacting to design alternatives, controlled by the designer/researcher. In this paper, we will not position our approach against more traditional ones as this has been discussed elsewhere (see Orzechowski, Timmermans and de Vries, 2000). Instead we report on the development of a virtual reality system MuseV2 that together with AI agents can be used to measure user satisfaction in an unobtrusive manner. By allowing users to change particular components of a design, and observe that changes, the system can derive user preferences and evaluations. This paper is organized as follows. First, we will present the main concept of the VR system (MuseV2) and the AI System. Next, we will discuss the characteristics of two prototypes of the virtual systems that were developed. We will look closer to MuseV2 technical aspects and the system set-up. This is followed by a brief exposition of our ideas to link MuseV2 with the agent technology. Finally, we will draw some conclusions.

2. MAIN CONCEPT BEHIND THE TWO SYSTEMS

The key characteristic of the project is that every user can compose his/her preferred design by modifying some of the elements of a so-called baseline design. A user is using the VR application MuseV2 to view and modify that design. The functionality of MuseV2 is limited to a set of simple tools that allows a user to learn fast how to perform all basic modifications to a baseline design. On the other hand there is an invisible AI system, that observes that modifications done to a baseline design, stores these changes and derives preferences (Figure 1). What is a base line design? This can be explained using the following example. The task of a researcher is to find out the preferences for a housing company that intends to build a social housing district. In the preparation stage of the experiment, an architect is creating a number of design alternatives for the given project. During discussions over the project certain elements of the buildings are pointed out, as important issues for the company. In the evaluation part of the experiment, the design alternatives become base line designs (BLD), and the pointed elements - options. The BLDs are the same for all respondents. The evaluation experiment shows how the user would modify the BLD in order to create the preferred design. Please note: to know what is the preferred design we need to know which BLD was modified, plus the changes that were made. Each BLD represents a different layout of a building. Layouts are unique and they are distinguished from another by characteristic elements (like: type and location of stair-case or bearing walls) that cannot be changed directly. A user can indicate his/her wishes to relocate one of those elements, what will cause the system to "move" to a different BLD. From this point onwards, modifications that will be performed by a user will be applied and stored with the new BLD. At the beginning of an evaluation experiment, a user is prompted to specify some preliminary characteristics (see table 1). Based on his/her choices the matching BLD and the set of options are selected and presented to the user. The user is prompted to re-arrange that design, choose from different options and interact with the design, using the VR application.

Table 1. List of attributes (characteristics of a building):

House characteristics:	
1. Type of house	17. Size of the storage facilities inside the dwelling
2. Type of architecture	18. Size of the storage facilities outside the dwelling
3. Roof form	19. Garage
4. Height house	20. Technical state of the outside of the dwelling
5. Surface ground level	21. Heating facility
6. Number of bedrooms	
7. Finishing of the interior	**Environment characteristics and location characteristics:**
8. Sanitary	22. Type of extra outside space
9. Facilities of the kitchen	23. Size of outside space
10. Buying price	24. Sunshine garden
11. Size of living room + dining room	25. Type of district
12. Size of kitchen	26. Green/ playground
13. Size of the bathroom 1	27. Location
14. Size of the bathroom 2	
15. Size of master bedroom	
16. Size of second bedroom	

3. PRESENTATION OF INTERACTIVE VIRTUAL ENVIRONMENTS: MuseV AND MuseV2

Our intention is to build a system that is easy to understand and easy to use by respondents who have limited knowledge or no knowledge at all about CAD systems, and the architectural design. Our first approach to virtual environment is implemented in the application MuseV, which is a pilot for MuseV2, and a test for our new ideas (Figure 2). This system was developed to proof that it is possible to build VR software that is easy to learn and can be used by inexperienced users. When developing the software, we learned that (i) building elements have to be linked, (ii) at least two representations of design information (graphical and numerical) is required, (iii) the menu has to be very simple, and (iv) the modification process has to be intuitive. When developing MuseV2, these learning experiences were kept in mind. In this second prototype, the building elements are linked together. Normally, the constraints are very complex and require a lot of computing power (Kelleners [4]). That is why we have used different structures for such linkages. The core of MuseV2 is a grid that represents not occupied space (no function is assigned). The size of a single grid cell is 30x30 cm (as this is the smallest significant size to observe changes). Each cell has the following properties: location, function, walls, and openings. Space (an occupied grid) is the most important element in MuseV2. It contains all necessary information to represent a design. To speed up and simplify the modification process the system automatically generates a wall on the border between those cells that have a different function. Each space (a group of the grid cells with the same function assigned) is surrounded by its own walls (Figure 3). In terms of numbers we can say that each space carries a half of the wall's width. From the user's point of view, editing the building is simple and relies on adding a new space (Figure 4), deleting or changing the function of existing spaces. For example to create a building with two rooms a user needs to make three operations: create three spaces - two for the rooms, and one for a roof. To create another space around this simple house - one needs one more space operation (Figure 5). MuseV2 has two representations of a design. One is the visual part (3D world and 3D objects); the second one is a Boolean matrix (Figure 6; left - 3D world; right - Boolean matrix: 0 - non space, 1 - numeric code for space function type - "Kitchen"). Both of them contain all necessary information to store a complete design. The user is using only the 3D world and 3D objects to interact with the design. The reason to use the double representation is that MuseV2 has been developed not as self-standing application, but we have used the environment of World Up (from Sense8). The Boolean matrix is a linkage between Muse and the outside world, e.g. an agent environment. Also the algorithms to create and edit spaces are using the double representation: the creation and selection shape is a box, the double representation allows us to create more complex spaces (Figure 5) with one move of the mouse. MuseV2 supports multi-floors designs, including connections between different stories. This connection refers to common building's elements, e.g. staircase, bearing walls. We are using the Boolean matrix to check the connections and collisions between elements of different floors. For a rendering performance the usage of boxes to represent sophisticated shapes is a good solution - it keeps low polygon count. MuseV2 has an optimization method, which reduces the number of boxes that represent a space. This helps to keep a design clean and the rendering fast. The optimization process is done every time a space is edited.

4. SYSTEM SET UP - Desktop CAVE.

We decided to use a Desktop CAVE to maximize the feeling of being inside a viewing building. Figure 7 present our first experience with the Desktop CAVE. In this set-up we are using four projectors: three to display images at the level of user eyes (the front, left, and right), and one to project an image on the tabletop. The last projection allowed us to create a virtual desktop. The virtual desktop is the place where users can make notes, browse catalogues, edit floor plans, or project the floor view of the 3D world. The last option is mainly used for walking through the model. The system traces the position of user's head to obtain the correct rendered images in the CAVE. A user can make changes through both 3D view and on the virtual desktop. As input device we plan to use a large format tablet with a pen-like device. We are developing a gesture recognition system to eliminate keyboard from the experiment.

5. FUTURE WORK: CONNECTION BETWEEN MuseV2 AND THE AGENTS TECHNOLOGY

As mention earlier the MuseV2 application has two representations of a design. The information about changes that are made in a design is sent in a message packet (the Boolean matrix, or part of it) to an agent environment, where it will be processed and the preferences shall be derived. The information that will be received by agents strongly depends on the user's tasks (like arranging office shapes, or colors) or on what a researcher would like to investigate in a design. The complexity of the information forced us to divide it into simple problems. We know what kind of information we can expect to arrive to an agent environment. Therefore we will be able to preprogram simple rules (behaviors) for agents to search for a specific part of the information. For example there can be a SpaceProportionAgent that searches the input information for the dimensions and function of a space to check if the proportions are correct. For more complex behaviors, agents can be arranged in parent/sibling relations. Agents can send and received messages to and from their siblings and their parent. Parents are responsible to forward messages to other parents. Single agents that are arranged in sibling relations create a strong team to derive user preferences. As we can see the agent environment is organized hierarchically (Figure 8). The sibling agents are communicating with the parent agents, which are communicating with a top agent, which is an interface between the agent environment and the outside world - Muse V2. Example: using agents to check if space proportion is correct Here we define only three levels of agents: top agent, parents, and siblings. The system uses spaces to determinate new arrangements. Therefore most of the rules will refer to the characteristics of a space. Let's have a look at how the agent system should process the input message that contains the following information: Element type - "space" Function - "kitchen" Type of change - "resized" Value - "2,1,5" The top agent receives that information packet, and distributes it to all parents, which are sending the same information to all siblings. Let assume that we are observing only the SpaceProportionAgent. This agent is searching the input information for the element type - "space". If it did not find it, it means that there is no need for the agent to process that message. In our case the changed object is a space, the function is "kitchen", type of change "resized", value "2,1,5" (means x, y, z; where y represents height and x, z length and width). The agent knows the right proportions for a space of the type "kitchen" (it is one of the predetermined rules, or constrains), checks if the changed values are within the allowed limits. Let assume it is true. Then the result of that process is send back to the parent, then to the top agent that tells MuseV2 that this operation can be preformed. If the check is false, then a user will receive a message to inform about the consequences or the operation will be prohibited.

6. CONCLUSION

The aim of this paper is to sketch an outline of a virtual reality system - called MuseV2. The first experiences with the system suggest that it is possible to create an application that is simple to use by novice users. Using a space as the base for all modifications and connections between all design elements, has simplified the modification process. Double representation of the design helped with creating a link between the VR application and the agent system. Furthermore some basic ideas, about an agent environment that could be used to collect information about user preferences and to predict user satisfaction, are explored. Theoretically this may be a good approach to solve a complex problem like measuring user satisfaction. But at this point it is difficult to make any judgment about its significance as this part of the system is still under theoretical evaluation.

7. BIBLIOGRAPHY

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8. ILLUSTRATIONS