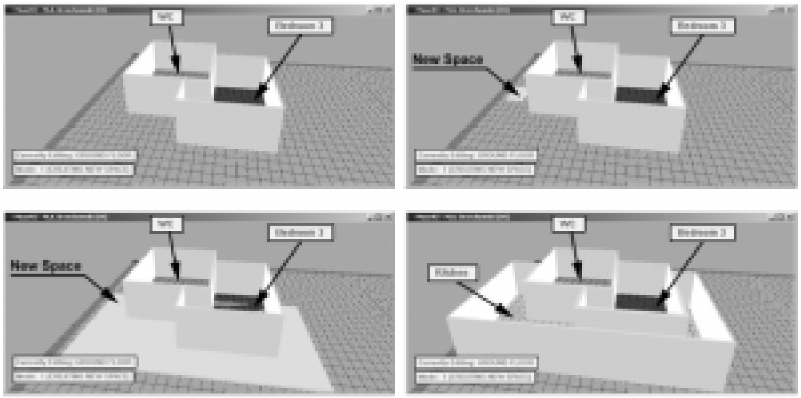
MuseV2 - THE VIRTUAL REALITY APPLICATION TO COLLECT USER PREFERENCE DATA



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Abstract

In this research project, we are creating an AI environment that helps architects to identify user preferences through a Virtual Reality Interface. At the current stage of development, the 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. To gather preference information, AI agents observe user-induced modifications in VR. The system that we envision should not become an automated design tool, but an adviser and viewer for novice users.

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. 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 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.

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.

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. 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).

Baseline design

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.

Each BLD represents a different layout of a building. Layouts are unique and they are distinguished from another by characteristic elements (for example: 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.

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		**Environment characteristics and location characteristics:**
7	Finishing of the interior	22	Type of extra outside space
8	Sanitary	23	Size of outside space
9	Facilities of the kitchen	24	Sunshine garden
10	Buying price	25	Type of district
11	Size of living room + dining room	26	Green/ playground
12	Size of kitchen	27	Location
13	Size of the bathroom 1		
14	Size of the bathroom 2		
15	Size of master bedroom		
16	Size of second bedroom		

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.

Presentation of Interactive Virtual Environments: Musev And Musev2

Our first approach was implemented in the application MuseV, which is a pilot for MuseV2, and a test for our new ideas. 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, constraints are very complex and require a lot of computing power (Kelleners [4]). Therefore we have used a different structure 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.

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 2; 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 Boolean matrix is a linkage between Muse and the outside world, e.g. an agent environment. 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 with one move of the mouse.

MuseV2 supports multi-storey designs, including connections between different stories. We are using the Boolean matrix to check the connections and collisions between elements of different floors.

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.

System Set Up - Desktop Cave.
MuseV2 is implemented in a Desktop CAVE to maximize the feeling of being inside a building (Figure 3). In this set-up we are using four projectors: three to display images 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 system traces the position of the user's head to obtain the correct rendered images in the Desktop CAVE.
For input we plan to use a large format tablet with a pen-like device. We are developing a gesture recognition system to eliminate the keyboard.

Future Work: Connection Between Musev2 And The Agents Technology
As mentioned 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 is processed and the preferences are 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 will arrive in an agent environment. Therefore we will be able to program 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 4). 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.

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 helps 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. In future work, the system needs to be tested against existing user satisfaction measurement techniques.

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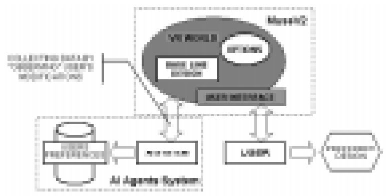

Fig 1: Two systems: MuseV2 and AI Agents

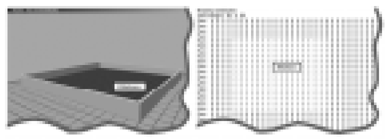

Fig 2: MuseV2: Double representation of a design (3D world; Boolean matrix).

Fig 3: Desktop CAVE – first experiences.

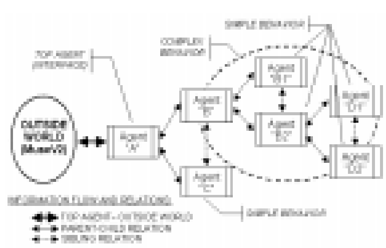

Fig 4: General overview: the agent environment and information flow.