Virtual Reality and Full Scale Modelling – a large Mixed Reality system for Participatory Design

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Abstract

What is the most effective way to help people gain access to tacit knowledge they have of the environment they work in and to communicate this to others with diverse backgrounds in a cooperative design situation? One idea is to use a process of active design with various tools to support, document and transfer abstract and concrete design ideas between participants. The tools we have chosen fulfil the needs of idea expansion and consolidation during different phases of the design process and have complementary roles. However, each tool on its own has limitations which can be overcome by tightly coupling them together. In this paper, we describe how a Full Scale Modelling environment of about forty square metres has been fitted with an optical tracking system to allow all the objects and people to be tracked and the information fed into a Virtual Reality model in realtime. The potential of this powerful combination is still being explored.

1. Introduction

The Envisionment Workshop is a collection of tools and methods to facilitate active involvement in a participatory design process [1]. These include; Full Scale Modelling, Virtual Reality, Drama and Democratic Meeting Techniques (such as brainstorming). The goal of an Envisionment Workshop is to discuss and design a personal environment, such as a workplace. The people involved in a workshop are both the workers and various designers; each expert in their respective fields. The tools are used to capture ideas, access tacit knowledge and facilitate discussion between these two communities of practice [5]. Our previous work [3] has concentrated on establishing the best combinations of the tools and methods of usage in various design situations (fig 1) through several real design case studies.

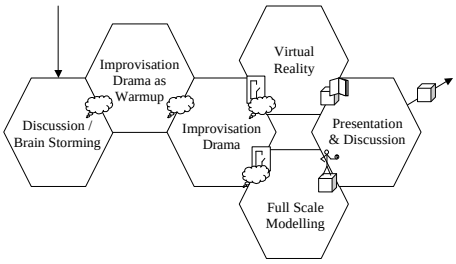

Figure 1: **A typical combination of tools in an Envisionment Workshop. This workshop took an entire day and was part of a longer process.**

2. Active, Participatory Design

One reason for using participatory design is to help the people from a workplace to identify problems in the existing environment and consider, with the help of designers, ergonomists, builders and architects, how to improve conditions. The participants come from a variety of backgrounds, each have useful knowledge, and need various means to help communicate these ideas with the others. Furthermore, the tacit knowledge they have of their environment can be difficult to gain access to and tools are required to move this knowledge into conscious thought.

An Envisionment Workshop progresses through idea expansion phases and idea consolidation phases so that new, crazy ideas may be captured which might lead to innovative solutions, and so that the multitude of ideas generated is filtered to find those most useful. Several such phases are normal, with periods of inactivity in between to allow ideas to mature and discussion with others.

Of particular interest in our studies has been how the various tools can be combined. Role play drama can bring life to a Full Scale Model, and Virtual Reality allows other aspects of an environment to be discussed than can be built in full scale.

Each tool has its strengths and weaknesses. Full Scale Models are heavy, non-portable and monotone, but excellent for active group design, lighting and obtaining a proper feeling for space with relation to one's own body. Full Scale Modelling can be used both to evaluate an existing environment in an idea expansion phase, and for testing a new environment suggestion (fig 2). Drama is useful for getting people active and relaxed, for testing a full scale model and for simulating various work situations, but can be difficult for some people to manage. Virtual Reality allows designs to be documented, colours and patterns to be added to objects, larger models to be included and is portable, but can be difficult for people to use in a group.

However a tight coupling of VR with Drama and Full Scale Modelling combines the best of all – people and object movements can be documented in the computer, real models can be augmented with virtual models, people can actively design together and appreciate the space in an environment, as well as cooperating with others at another location.

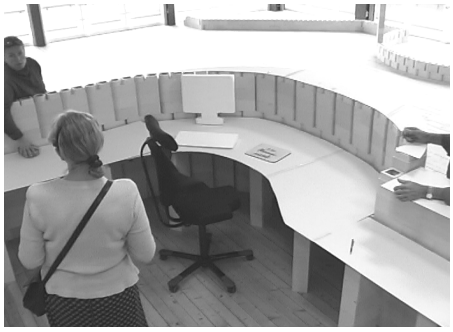

Figure 2: **A model made in the Full Scale Laboratory using large plastic bricks and cardboard.**

3. A forty square metre, multi-user computer interface

In many of the previous case studies, it became apparent that the interface to the Virtual Reality tool was the weak link for group design [2] due to the single user interface having to be shared by several people.

In these early studies, VR and Full Scale Modelling where used separately, with sketches and drawings being the main means of transferring information from one to the other. However, modelling in the Full Scale Laboratory has been found to be an activating and engaging method and supports active participatory design [4]. Thus it was decided to combine these two so that the active design benefits of Full Scale Modelling could be added to the portability and large-environment visualisation benefits of VR modelling.

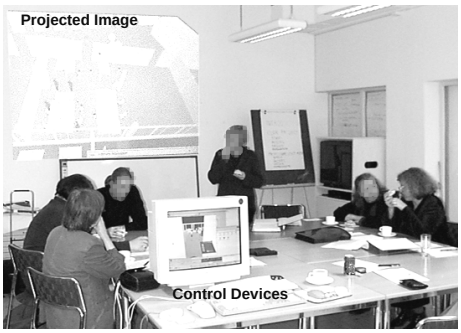

Figure 3: **A group using the basic VR tool for discussing workplace design**

To this end, a VICON optical tracking system was purchased. This system uses a number of cameras with attached light sources to track the positions of reflective markers in 3D space. From the 2D images from each camera, the system reconstructs the positions of the markers, and then looks for patterns in a predefined configuration that might represent a person or building element. The system is traditionally used for tracking people for both analysis of gait and for recording action for movies. However, we decided to instead turn this into a large input device for transferring, in realtime, models made in the Full Scale Laboratory to the Virtual Reality System (figs 4 and 5).

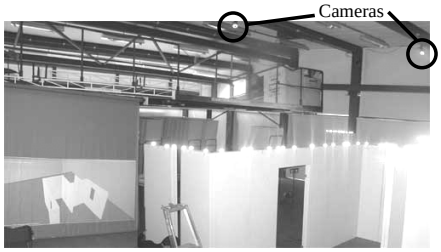

Figure 4: **Building elements with reflective markers are tracked optically with object type, position and orientation fed into the VR system in realtime. The cameras can be seen in the ceiling and the VR image to the left hand side.**

Figure 5: **The model from the real environment can be complemented in VR with other objects and set in context.**

These models can then be further modified in VR, perhaps colours changed, other objects added, copies made and put beside previously modelled rooms or put into context of a larger environment. Furthermore, people can take part from a remote location by following the modelling process in VR and communicating with the people in the laboratory by internet telephone (fig 6).

4. The system

The system consists of 12 cameras (with visible red light sources) placed in the ceiling of the Full Scale Laboratory, which are connected to a VICON 524 datastation. This is in turn controlled by a computer running the VICON workstation software where the object marker pattern relationships are defined which are in turn sent to the VICON realtime computer. This computer then analyses the camera information from the workstation looking for the object patterns and generating a database of object types, positions and rotations. This information is sent by network to the VR system running Sense8 WorldUp Virtual Reality software. The participants see the VR image in stereo on a nearby screen using a passive stereo back projector system.

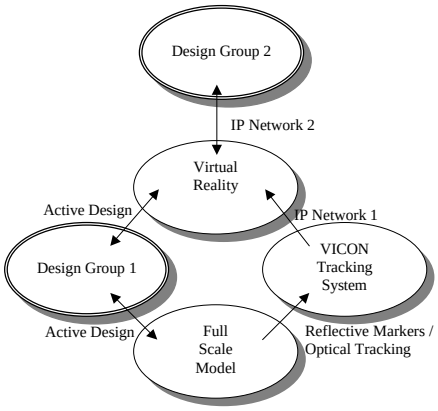

Figure 6: **The components of the Full Scale Model Tracking System**

5. Making a usable VR tool for novices

Even though the main intention is to use Full Scale Modelling as the primary means for moving objects in VR, the resulting models must then be manipulated, saved, adjusted, continued and combined with other models in the VR system. The users of the system are people from a workplace, and are taking part in a Participatory Design process. Thus, they have very little time to spend with the system since they have a task to perform and a problem to solve. They must, indeed, be able to use the system directly. Standard usability issues must be considered, for example, that the interface is intuitive, that controls are obvious and visible, that feedback is adequate and direct and that experimentation is encouraged through the ability to undo. Various prototypes have been tested in real design situations leading to the current system.

The current prototype uses direct manipulation of objects (with the mouse), allows clicking and dragging of objects around a design environment, enables new objects to be loaded from files (for example as designed in a CAD program), allows designs to be saved and combined with others at a later date and has intuitive object behaviours, for example objects can be placed on others (eg, cup on table) and when the base object is moved, those on top also follow along. The state of the system and all options are shown on-screen (fig 5). As yet, an undo function is not implemented. The current version of the prototype has yet to be fully tested in a real design situation.

6. Challenges

There are a number of challenges yet to be addressed which form the basis for our continued research.

Limitations in the tracking system. At some point, the system will reach the limit for the number of markers it can process at a time. A faster realtime computer would extend this limit. Normally, a VICON system deals with perhaps 30 or 40 markers. Ours will need to manage 300 too 400. Furthermore, there will be a limit in the amount of information that can be sent over the network. This will limit the number of objects that can be taken into the design space.

Occlusion of markers. When markers are hidden, the system might mis-recognise objects or place them in peculiar positions. The cameras have been placed to try to obtain the best view into rooms built. Temporary occlusion is not really a problem since when the marker reappears, so does the object to the system. However, when building small rooms, low-down objects may need markers on poles to be visible.

Marker definition patterns must be identified. These must be sufficiently unique for the system to differentiate one object type from another and non-symmetrical so that the system can determine the orientation of the object. Furthermore, when object are placed in close proximity to one another, the resulting patterns of markers must not look like another object type.

Obtain as large a work space as possible. Ideally, we would like to be able to use the entire laboratory for modelling, however, with

the limitation of an optic system and the fact that there is a platform that covers half the laboratory, this means that, in practice, only half the lab can be covered with cameras placed up high. Different lenses might help.

Usability of the system as a whole must be high. It must be possible to design naturally without having to break to account wait for the system. A continuous flow of ideas and group work must be supported. Furthermore, the location of the VR component in the laboratory needs to be considered. Sometimes the VR design should be a continuation of a physical design, otherwise it is a parallel work place.

How to manage multiple parallel designs and multiple documents. Many documents are produced during a Participatory Design process. These must be archived in a manner that is both transportable and retrievable at a later date. Furthermore, it should be possible to go through a design from start to finish, copy designs from a halfway point to include in other designs, etc. This will be difficult to achieve since there will be a large amount of information which must be visible to the participants, but at the same time manageable.

Large plastic bricks and cardboard. In the design process, not only large building elements are used, but plastic bricks, cardboard and polystyrene. How should these be measured and tracked by the system?

7. Conclusion and Future work

We have successfully managed to produce a collection of tools and usage protocols for participatory design. These include Full Scale Modelling, Virtual Reality, Drama and Democratic Meeting techniques. Now our goal is to tie these more closely together so that participants can easily switch between one tool and the other and share information between tools, each other and over networks. Our current and future work is to continue on these lines, investigating new and exciting amalgamations of technology and traditional design in the hunt for usable systems that go beyond the everyday design tools and allow the imagination to roam free.

8. References

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