The Virtual Designer – The Application of VRML in Collaborative Design

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Abstract. At present the architectural design process contains many inefficiencies. The tools of the collaborative design process tend to lack the high levels of interaction and communication required. All approaches in the modern design profession point to the utilisation of virtual space to maintain effective collaboration on all production levels. It is no longer relevant for outdated forms of physical communication to be expected to provide optimum collaborative work in the digital era. A new approach is needed. Rather than redesigning the process, the alteration of how communication between team members occurs is more appropriate.

1. Introduction

This paper looks at the process of collaborative virtual design, undertaken to improve online architectural communication. Through analysing the needs of designers and addressing their responses to collaborative design scenarios a clear process of approach to optimising virtual communication can be developed.

Over the past four decades, the realm of virtual reality (VR) has grown out of nothing more than a concept. Originally a nameless technology, VR is now perceived as a revolutionary form of technology in today's society, with an immense scope and variety of applications to which it is presently applied. The application of VR is a form of this technology but the essence of VR is essentially an experience. Recently, offshoots of virtual reality, have taken the limelight, becoming better known than the original technology. This has led to the creation of a false perception of what the meaning of virtual reality is.

By finding the essence of virtual reality, the relevance of its influencing factors can guide the technology to a relevant application. This application is focused on not only utilising the facets of VR in the most efficient manner, but to gain the maximum advancement for the design process in all areas of collaborative virtual design.

2. The Nature of Virtual Reality

VR is no longer just the high tech and futuristic technology, for specialised application, which it has long been categorised as. The development of Virtual Reality Modelling Language or VRML as it is commonly known, as

a hybrid of VR is enabling virtual reality to be utilised as the communication tool from which its full potential can be utilised.

VRML is a programming language, which enables a user to view interactive 3D reality. Accordingly to VRML specifications web site VRML is a file format for describing interactive 3D objects and worlds… designed to be used on the Internet, intranets and local client systems."(VRML 97) The development of VRML was borne out of the need to expand the usability of VR and the desire to turn the web into a 3d immersive environment. VRML unlike its predecessor VR does not require the external hardware, which stereotypically defines the technology. With the ability to connect to any computer in the world and share, display and communicate a 3D environment, gives VRML a very powerful advantage over existing technology. From this point the options for reproducing static or dynamic virtual models in a standard interacting format created the opportunity for a wide range relay of complete immersive worlds for both viewing and manipulation.

In order to understand what VRML can lend to collaborative design it is important to understand its relation to physical reality and to VR. When talking about computing and levels of interaction with physical reality there are several characteristics to compare. Professor Peter Thomas from the University of Western England sums this up quite well with his look at the paradigms of computing.

Prof. Thomas's (2000) paradigm shows there are four main types of human-computer interaction (shown in Figure 1a). The images of the GUI

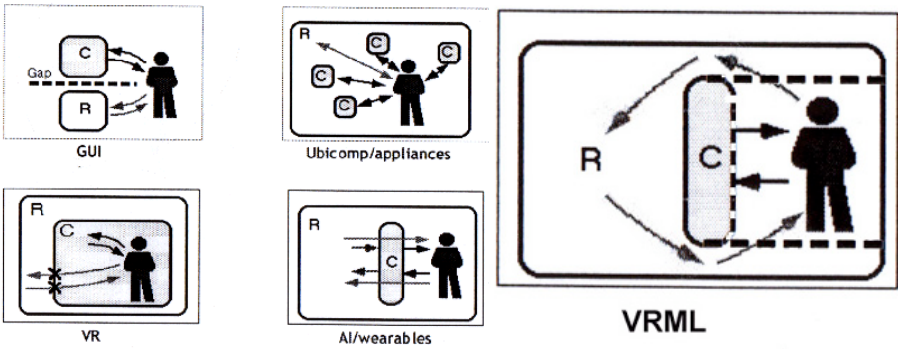

Figure 1a: Image of Prof. Peter Thomas representing types of computer interaction.
Figure 1b: Adaptation of Prof. Thomas's image showing arrangement of VRML.

and VR are most relevant to current discussion. The definition of VR involves the immersion of the user inside the computer. This is shown in Figure 1a where the user has access to reality only through the computer. The GUI on the other hand enables the user to interact with both the computer and physical reality simultaneously.

As VRML is a hybrid of VR and in this sense it is more like the GUI, with a gap between the two worlds. VRML attempts to bridge this gap with immersion and focus that VR uses to draw the user into the environment. So VRML falls into a category of its own, somewhere between GUI and VR (Figure 1b). This hybrid tends to incorporate the idea of levels of immersion in VR, but with the freedom to return to reality at any time. So essentially it relies upon the focus of the user. Therefore the characteristics of VR are present. It is these elements that maintain the focus of the user.

The physical relationships to the GUI mean that VRML requires no more than an Internet capable computer to delve into the 3d immersed World Wide Web. The advantages of developing through VRML are its focus on its medium of transfer- the Internet.

The characteristics of VR that VRML draws upon also lend themselves to the collaborative interaction. The three I's of VR indicated by Michael Heim (1998) show these attributes clearly."These defining characteristics boil down to the 'three I's' of VR: immersion, interactivity, and information intensity. Immersion comes from devices that isolate the senses sufficiently to make a person feel transported to another place. Interaction…. comes from the computer's lightning ability to change the scene's point-of-view as fast as the human organism can alter its physical position and perspective. Information intensity is the notion that a virtual world can offer special qualities like telepresence and artificial entities that show a certain degree of intelligent behavior."

The ability to immerse a user in the experience presented, while supporting this experience with clarity of information and responsive information is paramount. These elements are inherently linked to the very structure of the software itself. The transferability across platforms through Internet browser, the synchronous nature of display maintained by relatively small file sizes, maintaining an immediacy of images. These attributes both in the nature of VRML and in its structure enable VRML to potentially be a powerful tool in design collaboration.

3. Application into Design

Design in any form is driven substantially by graphics. This is due to the importance of vision as a sense. As stated by McCullough (1996), "the eyes are the monopolists of the senses". But there is more to the issue that just this. The hand – eye co ordination of a designer is paramount to the production of graphics, as vision the key to the client viewing these designs. So essentially designers use graphics as a medium to communicate their design intention. It becomes clear that for VRML to be effective in its application, it must address a level of virtual design and communication adequately, by either expanding the parameters of what is achievable with the available tools or being more efficient than previous techniques

employed. To this end, the approach to implementing VRML into design development is rather simple. The intention is to gain the maximum advantage for the user with only the minimum impact and alteration to existing process.

The model for a collaborative design studio incorporating VRML is formed from the present day organisational structure. To highlight this point the modern architectural firm will be examined. The 1990's model of a design firm involves all team members having at least a basic level of computer skills. The diagram below (Figure 2) shows the high level of interaction between the members of all teams. The variation between the models of the two consecutive decades shows limited interaction between teams and CAD being used as an add-on tool rather than being highly incorporated in the design process. The 90's model tells a different story of high levels of interaction and computer/CAD usage. It becomes obvious that the design approach involves a more synchronous, virtually orientated office environment. It is this level of interaction and computer use that makes the proposal of incorporating VRML to improve communication skills relevant.

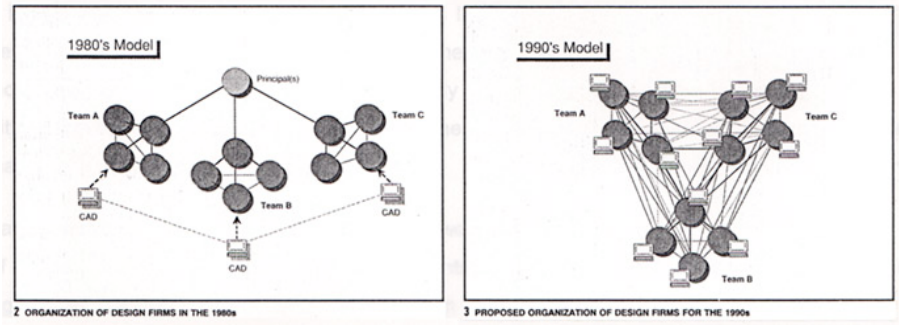

Figure 2: Design Firm Organisational Models (Young, 1992)

The proposed model still allows the firm to continue using the same approach to its projects as before, with VRML intended to be an additional application to save time and improve designs through better communication. The stage of establishing concept sketches and designs would remain unchanged; the main advantage would be during the design development and project documentation stages.

Design development and documentation are generally the most time consuming in the project life-cycle stages according to Zwart (1995), "traditionally sketch design is 12%, design development is 13% and design documentation is 35%" of a project's length. From these figures VRML can potentially assist close to half of the average project's lifetime. By focusing upon design development and documentation, issues of technical computer constraints hampering design creativity in early stages can be assisted and in some cases avoided.

4. Implementation Approach

While many studies have been conducted into utilising virtual reality can be used to replace how design development and communication occurs, none have been focused on aiding the design profession in their present form, with limited impact. This is a feasible approach due to the nature of the design process, which can at times be highly personalised.

To create a highly developed communication tool, which stifles creativity and hinders the design process is counterproductive. The aim of this tool is to maintain the design process while improving communication and understanding of all parties. Rather than using VRML to reinvent the wheel, the advantage of the technology can come from its ability to make the wheel run smoother and more efficiently.

Through analysis of the advantages and comparison to the present collaborative tools of the design industry, support for the use of VRML as a tool for the enhancement of the collaborative design process in architecture is provided. These were standardised into three streams, aimed at encapsulating the elements beneficial to the virtual collaboration process, while attempting to address issues of online design. The first stream is focused upon gaining a realistic mimicking of physical communication utilising real time video conferencing and a synchronous shared 2D sketch workspace. The second looks at extending the boundaries of collaboration beyond the standard two-dimensional interfaces used in online collaboration by incorporating VRML as an intuitive, synchronous 3d tool that affords use. Thirdly, the integration of seamless transitions between of overlaid 2d workspaces for images and sketches as would occur in a physical environment.

Through analysis of three strands of virtual collaborative work relevant to design, support for a process of applying VRML was established. By integrating the utilisation of VRML seamlessly into the existing architectural design structure in this format, familiarity of physical discussion and maximised usability of incorporating VRML in the design process were achieved. Furthermore, through the use of a typical computer aided design (CAD) tool such as ArchiCAD the creation of VRML files from the initial virtual design are merely a change in file format. Integration with the existing design structures of an architectural firm are sustained and enhanced through greater functionality.

The prototype involved a video conferencing system that allows VRML model display with a collaborative translucent overlaid whiteboard. The system needs to be multi-platform and enables users to exchange control over objects and applications. A high level of continuity between applications and movement while providing the designer with video, audio and graphical interface as an effective level of communication.

In order to test these theories an initial study was conducted. This was aimed at testing the feasibility of such an approach to adapting the design process, rather than obtaining conclusive results. The results that were produced did provide future direction for further research to occur.

Through testing this adaptation of the design process to virtual collaboration through qualitative analysis, the integration of collaborative streams identified as relevant for the nature of virtual design collaboration where supported. The experiment was recorded and analysed through video taped analysis, questionnaires of the study participants and the design outcomes at the end of the study.

5. The Results

The study resulted a considerable design progression during the study. Analysis and agreement upon the nature of the existing design occurred initially with little confusion. All parties were able to understand the details of the model with minor hassle; development of particular zones in project was the aim of the exercise and within the time required.

The design objective was achieved and the system was successful, but this does not show that the tools for collaboration were the best for the job. What it does show is the use of VRML in collaboration can assist designers. The following points support this through comparison of findings to focused aims of collaboration. The findings of the questionnaire and the video footage revealed the following points:

- The communication focus of the system occurred with the audio connection and the whiteboard. The video was only used for initial connection and introduction between users.
- There where consistently high levels of interaction occurred between the two parties and also between the applications
- Intuitive interfaces for applications enabled fast learning curves for all parties involved in studies. This enabled the users to become familiar with the interfaces within a matter of minutes with the design collaboration rapidly progressing from an early stage.
- Simple quality of sketches was appropriate to the level of design discussion. The sketches and the same quality of those, which traditionally occur in a physical design meeting.

While the above are relevant, the true results in response to the collaborative aims are addressed in the following findings.

5.1. CREATING THE REALISM OF A PHYSICAL INTERFACE

The first of these is the input devices. When discussing design, in a physical meeting, a pen or pencil would create graphical discussion. For the virtual system, using a device like a graphics tablet would greatly improve the similarity to the physical process. The mouse does not have the same ability to control when compared to a graphical device, such as a pen, which is

second nature to most designers. The nature of graphics interface heightens the quality of the development of 'efficient' graphics. This is supported by the argument that design is essentially driven by graphics as a medium for communication.

The model interface would benefit greatly from a system such as the ComsoPlayer VRML viewer interface. This would enable the system to be even more intuitive and immersive. The interface on the tested system relied more upon three forms of movement, while CosmoPlayer enables six directional movement with more intuitive commands such as the seek function, the ability to undo a move and to reset view to the horizon. This adaptation would assist the future use of such a package. This would enable real-time movement and adaptation like can be achieved with a physical model.

5.2. CONTINUITY BETWEEN PHYSICAL AND THE VIRTUAL

An approach which was desired but not possible to test due to technical considerations was the ability to lay the transparent whiteboard over the model, just like butter paper or trace would go over a 2d or 3d drawing to add changes of locate points. The need for a transparent whiteboard to overlay the VRML model is supported by the actions of the participants in the initial experiments.

In the process of design discussion an image was cut and paste onto the whiteboard and acted as a template for the design discussion. The implementation of a transparent/translucent whiteboard would allow the model to be moved to the required position with the whiteboard acting like the tracing paper. Rather than just providing the plans and elevations to sketch off the VRML model provides the ability to change the model appearance in 3D also. The virtual model also allows the opportunity to access details in the model from positions, which cannot be achieved, in a physical model.

The dual use of sketching in both 2d and 3d further indicates a need to use the model and the whiteboard as one. The need for the view to be updated while synchronised with a designer speech and movements requires a simple interface for image change and also a highly usable navigation system for the VRML as mentioned in the first aim.

5.3. PRODUCING AND MAINTAINING EFFECTIVE COMMUNICATION

When working in a physical meeting the sketches and images produced can be taken with you. When documenting in a virtual meeting all notes and sketches are either in the whiteboard or a text box. This indicates the need to have a note keeper. In a virtual meeting the role of this individual would be to keep the points of verbal discussion linked to the appropriate sketches and screen shots of the VRML models location. It is very important for this to occur as the data is dynamic and the relevance of sketches can change due to

modifications and different versions of ideas. As found with the user study conducted substantial data was verbally communicated, acting as linking and explaining the images produced. The images themselves were of a sketch like quality as often occurs in design meetings, seeming to contain limited meaning to the casual viewer, but with high relevance for those involved in terms of reminding and image recognition. It is for this linking that a note keeper would assist greatly, documenting for future communications.

6. Conclusion

In conclusion the initial study shows that the collaborative approaches utilising VRML were successful in conducting design development. While these results are not conclusive, they do provide a stepping-stone for further studies to occur, in order to establish a comparison of the level of effective communication when compared to physical collaboration methods. All these approaches will assist in making the system more like the physical meeting space, without losing the power required to visualise the full details and volumes of the virtual models, with the realism of the physical world. Above all, this will assist virtual communication. In light of the findings established above, the proposal envisaged for application of VRML is highly appropriate and proved against the three aims of collaboration.

7. Future Work:

Currently further exploration of the nature of collaboration required for design development is in progress. A prototype focusing upon the three streams of collaboration is under development to further establish the relevant aspects of design in the virtual realm. User testing of this approach will hopefully lead to a clear understanding of the issues of involved in user orientated virtual design collaboration.

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