Maintaining the Illusion of Interacting Within a 3D Virtual Space

Tim Marsh and Peter Wright
Department of Computer Science
University of York, YO10 5DD, UK.
tmarsh, pcw@cs.york.ac.uk

Abstract
It is widely thought to more or less a degree, that a sense of presence may be induced in users of new and emerging media technologies, such as, the Internet, digital television and cinema (supporting interaction), teleconferencing and 3D virtual reality systems. In this paper, it is argued that presence presupposes that participants are absorbed in the illusion of interacting within the visual spaces created by these media. That is, prior to the possibility of any inducement of presence, participants need to be absorbed in the illusion conveyed by the media. Without this, participants' attention is broken and the illusion is lost. Hence, the potential to induce presence in participants ceases. To encourage participants to lose sight of the means of representation and be drawn into the illusion conveyed by these media, this paper proposes the development of design principles to increase participants' experience. In an attempt to inform design principles, this paper focuses on another artificial although highly successful visual medium - film. By way of example, this paper concentrates on one medium, virtual reality, and proposes design principles that attempt to maintain the illusion of interacting within 3D virtual space. This attempts to provide a platform through the resourceful blend of hardware and software Virtual Reality (VR) enabling technologies on which to support a well designed virtual environment and hence, from which the inducement of presence in participants may develop.

Introduction
Many problems are associated with interaction of VR systems as identified in empirical studies of desktop VR (Kaur et al. 1999; Marsh and Wright 1999) and VR using a Head Mounted Display (HMD) (Marsh et al. 2000a). Traditionally, evaluation of applications running on a standard Graphical User Interface (GUI) referred to these as problems of usability and their existence reduced the effectiveness and efficiency of users' work-related tasks. This in turn has a detrimental effect on users' satisfaction (ISO 1997). However, tasks in VR are different from those performed with the GUI and therefore this paper will use the more appropriate term activities to describe them. As well as work-related, activities with VR systems can also be performed to acquire more knowledge, for fun or enjoyment, and in general fall in one of four main categories: work-related, informative, education and training, and entertainment. It is widely believed that performing activities within 3D virtual space has the potential to induce a unique experience in participants. However, this experience is broken by participants' awareness of the artificiality of the medium. The main causes of this are firstly, problems associated with the usability of hardware and software VR enabling technologies and secondly, participants' lack of interest for interacting within poorly designed 3D virtual space. Either of these will pull us out of the illusion of interacting within the 3D Virtual Environment (VE) and draw attention to its artificiality. Hence, the experience is broken. Regardless of how interesting, inspiring or well designed a VE is, if problems of usability exist with a VR system then they will make us consciously aware of the medium. Likewise, the most natural and transparent interaction in the world can not hold participants' interest in a poorly designed VE for long periods of time. Reducing usability problems through a resourceful blend of hardware and software VR enabling

technologies will help to achieve a more natural and transparent interaction, and additionally will provide a platform on which to support a well designed VE. This will lead to a greater experience of interacting within the VE. Although using criteria such as effectiveness, efficiency, and user satisfaction may well be satisfactory criteria to evaluate work-related activities, these are inappropriate to evaluate the goodness of all activities and their related experiences with VR systems. As an alternative this paper argues for the development of design principles as a way of achieving criteria for the evaluation of VR systems. These will inform the design of VR systems to maintain the illusion of interacting within a VE and so help to create an enhanced experience. In turn, the same design principles may then be used as guidelines to highlight inconsistencies in a VR system design and identify problems with usability and poorly designed virtual environments that pull us out of the illusion.

Background

A common belief held amongst VR workers is that increasing the fidelity of stimuli will lead to presence (Barfield et al. 1997). This implies that on reaching some level or threshold of fidelity that a sense of presence will then be induced in participants. Consider for a moment the stage at which this threshold may occur. Two design approaches are identified. Firstly, in the replication of the world in every conceivable detail (above that of the atomic level). This may provide participants of VR with the ultimate sense of presence nearing that obtained from the real world. However, this would of course introduce many associated difficulties. Consider for instance, the practical difficulties in terms of time, effort, complexity of models, memory requirements, not to mention the costs. Therefore, this is an unsatisfactory option, at least for the foreseeable future. Techniques from areas such as, fractal modelling, digital imaging (photographic and video) and computer vision, and those developed by the computer games industry could perhaps prove useful in the quest for ultimate fidelity, but some work is still required here. Secondly, consider if the threshold of presence experienced in a VE was determined by a resourceful blend of hardware and software, and judged according to participants' induced experience. Either one of two situations would arise from this. Firstly, that a scaled continuum of presence from low (threshold of presence) to high (the absolute level being the replication of the world in every conceivable detail) may exist. Manipulating the causes of presence shifts the level of participants' experience back and forth along this continuum. This implies that presence is multi-layered existing on many levels from low to high. In contrast, the second situation assumes that we are either present or not present in an environment. Although, whether or not there exists a threshold of fidelity that is required to be reached before a sense of presence is induced in participants, or whether or not presence exits on just one or many levels, remains to be seen. However, it is worth considering the potential outcomes that may arise from the two design approaches:

1. Replication of the world in every conceivable detail

The sensory information presented is such that, participants are presented with an all encompassing array of stimuli by which participants make a total switch from stimuli in the real world and attend only to sensory information from the virtual world. Identified are two situations that could arise:

i. natural switch in cues: participant's total acceptance of the stimuli from the virtual environment.

ii. conflicting switch in cues: no matter how accurate the stimuli appears participants know they are in an unreal environment in view of the fact that they can remember going from the real to the virtual world. A question to ask here is how long can participants remain in this situation -

will a point be reached at which participants feel detrimental or hazardous effects to health - such as those caused by the withdrawal from the real world, experience a kind of claustrophobic effect, paranoia or worse?

2. Blend of hardware and software VR enabling technologies

Participants receive sensory information from both the real and the virtual worlds. Identified are 2 potential situations that may arise from this:

i. suppression or blending of stimuli: suppress stimuli external to the VR system and attend only to stimuli from the virtual world. Or a blending of stimuli from the real and virtual worlds in some way to create new and balanced sensory information to the participant. e.g. most VEs use a participants' sense of gravity from the real world to inform their physical orientation in the virtual world.

ii. conflicting sensory information: participants are unable to suppress sensory information external to a VR system or blend information from the real and virtual worlds.

On examination of the above scenarios, common sense would advise avoidance of the design and development of VR systems that provide conflicting sensory information from both the real and the virtual worlds, such as the situations described in (1ii) and (2ii) above. Conflicting sensory cues will break any illusion we have for interacting in a 3D virtual environment, drawing attention to itself and make us aware of the artificiality of the medium. Additionally, for the reasons suggested above, e.g. the time, effort, complexity, memory requirements and costs makes the replication of the world in every detail, as in (1i) above, an unsatisfactory option. Trade-offs are required to be made and compromises reached. Therefore, this paper proposes the development of design principles that attempt to suppress real world stimuli or blend stimuli from the real and virtual worlds as described in (2i) above. To inform design principles for the design and evaluation of virtual space, this paper focuses on an another artificial although highly successful visual medium - film.

Film: Informing Design Principles for VR

Film is a highly successful visual medium. It is entertaining, educational, informative and provides an excellent story-telling medium. Its success is due to the experience that it provides spectators and this gives us the motivation to want to experience more films. A major goal of Hollywood mainstream cinema is to present the information or narrative in such a way that the artificiality of the medium remains invisible to the spectator. Hence, the spectator is encouraged to lose sight of the means of representation to capture and project the images. This grabs our attention, drawing us into the film and absorbs us in the narration itself. Thus, attempting to increase the spectators or filmgoers' experience (Messaris 1994). The most telling criticism of film editors, camera operators and actors work isn't that it's phony or crude, but that it takes spectators out of the picture - "when the audience is self-consciously examining its own responses, watching itself watch the movie, then all the razzle-dazzle in the world can't save the film" (Boorstin 1995). In the classical Hollywood style of film making, the experience that spectators get from viewing films comes from two main aspects. Firstly, the "invisible-style" that are cinematography and editing conventions that make spectators unaware of the artificiality of the medium and this supports the second aspect. That is, the making of films of "increasing complexity and power" [Laurel94]. This paper proposes the need for the development of design principles that like film will firstly, develop a kind of invisible style of VR in an attempt to draw participants' awareness away from the artificiality of a VR system. This will be achieved through the resourceful blending of hardware and software VR enabling technologies. Secondly, this will

support the making of 3D virtual spaces of "increasing complexity and power". Three broad design categories are proposed: voyeuristic, vicarious, and visceral, and it is anticipated that these will be used to inform the design of virtual environments for increased experience. In-turn, the design principles may be used as guidelines for the evaluation of VR systems.

Invisible Style of VR

"Invisible style" is one of many terms used to describe Hollywood mainstream cinema. The term is used to describe the style of filmmaking that encourages spectators to lose sight of the means of representation and become absorbed exclusively in the represented act itself (Messaris 1994). That is, the conventions or artifice support the translations of the people, places and events, etc., of the narrative into a sequence of visual images in such a way as to hide or make us unaware of the underlying artificiality used to capture and project the images. Awareness of the conventions or artifice breaks the illusion of film and draws attention to its artificiality. That is, spectators become aware that they are spectators of a film presentation and hence, the illusion is broken. For an in-depth treatment of the "invisible style" of Hollywood cinema and its manipulation of time and space the reader is referred to Burch (1983) and Messaris (1994). Using the "invisible style" of film, this paper describes on-going work that attempt to inform design principles to draw participants' awareness away from the artificiality of interacting with a VR system. This will be achieved through the blending of hardware and software VR enabling technologies to create a natural, transparent and seemingly invisible form of interaction between a participant and a VR system. Hence, develop an invisible style of VR. In this short paper we describe an example of ongoing work that attempts to overcome some of the problems of interaction and navigation within a 3D virtual space that are caused by the restricted Field Of View (FOV) of the VR system display screen. See for example Neale (1997). The restricted FOV is the most likely cause of participants' disorientation and getting lost in a VE as captured in empirical evaluation studies of desktop VR (Marsh and Wright 1999) and VR with a HMD (Marsh et al. 2000a). In an attempt to overcome problems associated with a restricted FOV, we focus on cinematography conventions that suggest off-screen space to spectators of film. The purpose of these conventions are to support the fragmented shots of the "classical Hollywood" style, and so imply that additional space and action exists beyond that which is shown within the confines or boundaries of the screen. These have been used to inform the design of visual cues to suggest virtual off-screen space in VEs. It is anticipated that the visual cues will appear natural and transparent, they will help to guide participants through the smooth and continuously animated VE, and thus maintain the illusion of interacting within a larger 3D virtual space than that contained within the restricted FOV of the display screen. See Marsh and Wright 2000b. There are three main conventions used to imply off-screen space in cinematography: *exit and entry points, partially out of the frame, and points of view* (Burch 1983). Building on these conventions, guidelines have been proposed to inform the design and evaluation of virtual off-screen space (Marsh and Wright 2000b). In this paper we restrict our discussions to the former two. The first of these is *exit and entry points* where characters exiting or entering through one of these points will suggest to the spectator that there is space off-screen that leads to another area not shown on-screen. Theatre uses similar techniques to help audiences construct off-stage space that is additional to that seen on-stage. For example, as a play progresses and the story unfolds, the audience learns that the door to the left of the set leads to the kitchen and the door to the right to the back yard. Although the spaces contained off-stage are purely imaginary, the audience will however, construct a cognitive map of the off-stage space and this is essential for the

development and understanding of the theatrical production. Implementation of exit and entry points in VEs can be achieved by the use of graphical models or representations of: doors, paths, roads, etc. Their existence will trigger a participant's knowledge and experience. They imply that by taking this pathway a participant can reach other spaces that are not contained within the confines of the display. Secondly, *partially out of the frame* is a convention used to capture a character or object in such a way that some part of a character's body or section of an object protrudes out of the frame to infer the space out of the screen. For example, an object that is only partly seen on-screen constantly reminds spectators of the off-screen space where the rest of the object is contained. In the design of VEs, similar techniques could be employed using only part of a familiar object shown on a display screen. This object's part is recognized as being only a section of the whole object and thus, implies that the rest of the object is in off-screen space.

Informing Design Principles to Promote the VR Experience

Finally, this paper introduces ongoing work that attempts to find criteria for the design and evaluation of participants' experience of interacting within 3D virtual space. No matter how resourceful or invisible the blend of hardware and software, if the VE is uninspiring, dull or boring to use, it will not hold participants' attention for any long periods of time. So how do we design virtual environments for increased experience to grab and hold our attention and maybe provide the motivation to want to interact with more VEs for long periods of time? To answer this question we need to find out just what we mean by experience? Hassenzahl et al. (1999) provide informed arguments for the need of alternative and/or additional design and evaluation criteria to that which has been used traditionally, e.g. effectiveness, efficiency and user satisfaction (ISO 1997). Hassenzahl et al. (1999) argue for criteria to promote fun and enjoyment, and cite the many approaches that have been taken in an attempt to analyze how computer games achieves this. In particular, Malone (1981) identifies three broad design categories: "challenge", "fantasy" and "curiosity" and each consists of recommendations for designing appealing computer games. However, VR has the potential to provide a greater wealth of experience than just enjoyment and fun, and therefore, again this paper looks to the example of film. Consider how we rate a good film? Maybe by the story, plot, script, acting, images, and so on, delivered at a pace that doesn't lose or break spectators' attention. Another way is through individual subjective experience. Boorstin (1995) states that we don't watch films in 1 way but in 3 ways. He identifies these as:

Voyeuristic: is the "prying observer" and the its pleasure is the joy of seeing the new and the wonderful.
Vicarious: experienced imaginatively through another person, being or object.
Visceral: "Point Of View (POV) is the gateway to the visceral". POV puts us in the scene. It's a gut reaction - sensations rather than emotions.

Boorstin (1995) states that as we watch a film the three compete in us. Perhaps then, it is possible to use these broad categories to develop criteria to rate or evaluate film? From this, it may be possible to provide a rating according to individual subjective experience. Hence, evaluate a film through the criteria provided by the broad categories of the voyeuristic, vicarious, and visceral (3Vs). Could then, the responses (3Vs) that are triggered in spectators of film also be used to inform design criteria for the development of virtual environments? This may inspire the making of VEs of increasing complexity and power, grabbing and holding participants' attention,

maintaining the illusion of interacting in 3D virtual space and hence, design for increased experience. In turn, the same criteria may be used as guidelines to evaluate for the experience of interacting within 3D virtual space.

Acknowledgements
This work was carried out in-part at the Human Interface Technology Laboratory (HITL), University of Washington, Seattle, WA. Thanks to Tom Furness, Don Parker and members of the Presence Group, HITL. Funded by, UK EPSRC INQUISITIVE (Grant GR/L53199).

References

Barfirld, W., Hendrix, C., and Brytrom, K. 1997. Visualizing the structure of virtual objects using desktop virtual reality displays, Virtual Reality Annual International Symposium (VRAIS), IEEE Computer Society.

Boorstin, J. 1995. Making Movies Work: Thinking Like a Filmmaker, Silman-James Press, Los Angeles.

Burch, N. 1983. Theory of Film Practice, London: Praeger Publishers Inc.

Hassenzahl, M., Platz, A., Burmester M., and Lehner, K. 2000. Hedonic and Ergonomic Quality Aspects Determine a Software's Appeal. In Proceedings of CHI 2000, ACM Press(in press).

ISO. 1997. Ergonomic requirements for office work with visual display terminal (VDTS), DIS 9241-11, International Standards Organization.

Kaur, K., Maiden, N., and Sutcliffe, A. 1999. Interacting with virtual environments an evaluation model of interaction, Interacting with Computers, Vol. 11, No. 4, Elsevier.

Laurel, B., Strickland R., and Tow R. 1994. Placeholder: Landscape and Narrative in Virtual Environments, Computer Graphics, vol. 28, no. 2, ACM SIGGRAPH.

Malone, T. W. 1981. Toward a theory of intrinsically motivating instruction. Cognitive Science, no. 4.

Marsh, T., and Wright, P. 1999. Co-operative Evaluation of a Desktop Virtual Reality System, Workshop on User Centered Design and Implementation of Virtual Environments, King's Manor, University of York.

Marsh, T., Wright, P., Smith, S. 2000a. Usability and Spatial Evaluation of a Stereoscopic Head Mounted Display Virtual Reality System. Forthcoming.

Marsh, T., and Wright, P. 2000b. Using Cinematography Conventions to Inform Guidelines For the Design and Evaluation of Virtual Off-Screen Space, AAAI Spring Symposium Series "Smart Graphics", Stanford University, CA, March.

Messaris P. 1994. Visual "Literacy": Image, Mind and Reality, Westview Press, San Francisco.

Neale, D.C. 1997. Factors Influencing Spatial Awareness and Orientation in Desktop Virtual Environments. In Proceedings of the Human Factors and Ergonomics Society 41st Annual Meeting, Albuquerque: Human Factors and Ergonomic Society.

-

-

-

-

Authors: Tim Marsh and Peter Wright

Presenting Author: Tim Marsh

Phone: +44 (1904) 432748

Fax: +44 (1904) 432767

Email: tmarsh@cs.york.ac.uk

* this paper argues that presence presupposes that participants are absorbed in the illusion of interacting within 3D virtual space

* however, problems of usability or a poorly designed virtual environment (VE) make participants aware of the artificiality of the medium used to support the VE and hence, break the illusion

* in an attempt to encourage participants of VR systems to lose sight of the means of representation and be drawn into the illusion conveyed by a VE this paper proposes the development of design principles

* examples of design principles that attempt to reduce usability problems through a resourceful blend of virtual reality hardware and software enabling technologies are described. Additionally, this paper introduces broad design categories by which recommendations can be developed for the design of VEs for increased experience

* it is anticipated that the design principles may then be used as guidelines to evaluate 3D virtual reality systems

* to inform design principles this paper focuses on another artificial although highly successful visual medium - film