Using Cinematography Conventions to Inform Guidelines For the Design and Evaluation of Virtual Off-Screen Space

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Abstract

Many usability problems are associated with navigation and exploration of virtual space. In an attempt to find methods that support navigation within virtual space, this paper describes an investigation of cinematography conventions. In particular, this will focus on conventions that suggest to spectators the existence of additional space other than that contained within the confines or borders of the projection screen. Referred to as off-screen space, this paper builds upon these conventions and proposes guidelines to inform the design of visual cues to suggest virtual off-screen space. 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 Field-Of-View (FOV) of the display screen.

Introduction

The 3rd dimension of a Virtual Environment (VE) creates a space. Within navigable VEs participants are permitted to move around and explore this space, and this has been identified as the central and most frequently performed action in a VE. For example, Kaur, Maiden, and Sutcliffe (1999) found that participants would return to navigation following any activity in a VE, and Persson (1998) identified navigation as the "fundamental cornerstone" in user interaction of digital spaces, including virtual spaces. However, many usability problems are associated with navigation in a VE. For example, a common and recurring problem is disorientation, often resulting in participants becoming completely lost in a VE. Probably the main cause of participant disorientation is the restrictive Field-Of-View (FOV) of the display screen, including that of the Head Mounted Display (HMD) and desktop monitor. The effects of a truncated FOV in the real world are well documented and include, the under-estimation of sizes and distances, and difficulties in constructing an accurate cognitive map of the surrounding environment (Dolzeal 1982; Alfano and George 1990). Similar effects to these have been experienced in the virtual world with FOV restrictions in HMDs (Osgood and Wells 1991) and desktop monitors (Neale 1997). Additionally, and for the purposes of this paper, two main problems in the design of VEs are identified that are a major cause of participant disorientation. Firstly, is the lack of navigational or wayfinding cues to guide participants around rooms, buildings, or through the VE itself (Darken and Sibert 1996). Secondly, the whole display screen turns one colour. The cause of this being participants getting too close to objects or walls, facing in the direction of an object, etc. with no additional visual cues to indicate their position within the VE, or walking through virtual objects when collision detection is not implemented (Kaur, Sutcliffe, and Maiden 1998; Marsh and Wright 1999, 2000).

One way forward might be to examine and then mimic, or borrow from, the methods employed by people to move around or navigate in the real world. Probably one of the most important methods employed by people is through the use of visual cues. The world around us contains a considerable and varied source of shapes and objects, patterns, textures, and detail, from both man-made and natural forms. These provide us with information or visual cues that trigger the knowledge and experience that we have for our environment and the objects within it. This is essential to guide us in our everyday interactions and movements within our world. Using similar levels of detail as that found in the real world, in the design and construction of 3D computer generated graphical or virtual worlds will likewise trigger knowledge and experience in users, and thus, support their interactions and navigation within the virtual environment. However, an increase in detail in the virtual world would of course, mean a corresponding increase in time to process the larger amounts of data. This may have a noticeable effect on the graphic update rate and subsequently, introduce lags in response to a participant's movements through the VE. Therefore in order to get round this problem, methods are required that will provide sufficient visual cues from small sets of data. Thus, maintaining processing times at levels that will support the illusion of smooth and continuous animation in response to a user's interaction and movement through the virtual environment or space.

In an attempt to find methods that support user interactions within virtual space, an investigation of cinematography conventions was carried out. In particular, this focused on conventions that suggest to spectators the existence of additional space other than that seen on the projection screen. This helps spectators to construct off-screen space implying that additional space and action exists beyond that shown within the confines or boundaries of the screen. Building on these conventions, guidelines are proposed that will inform the design and evaluation of virtual environments to suggest off-screen space to users. This will imply the potential for further action within a virtual space, provide visual clues that will help to guide the user through the virtual space, and will thus, overcome some of the usability problems associated with navigation within virtual space. Additionally, it is anticipated that the guidelines and the VR enabling technology to support the guidelines will appear transparent to the user, thus, re-enforcing the illusion of interacting within a virtual space, and possibly having a positive effect on a user's experience.

Background

Prior to the development of cinematography conventions to construct and/or articulate time and space, films were shot with the camera fixed in one position, usually mounted on a tripod, and the narrative took place within this fixed frame captured by the camera. That is, the actors, props, objects, and scene, and the spatial relations between them are explicitly represented within the still frame. Therefore, they are unambiguous to the viewer. This style is referred to as the long-take style. It maintained the illusion of "theatrical" or real space, in which, the viewer has "an immediate and constant sense of orientation" (Burch 1983). The development of editing techniques provided cinematography with a way to escape from the restrictions of a still long-take style, and introduced a system whereby the space of a scene can be altered from shot-to-shot to create an artificial or "cinematic space" (Burch 1983). In "cinematic space", shots are taken from different camera angles or even different locations (more than likely, these have been shot at different times), and present fragments of the total space to the viewer (Kepley 1983). The fragmented shots are edited together to create the overall space of the scene, and these appear natural and transparent to the viewer; that is, they add up (Kepley 1983).

Conventions to Articulate Time and Space

Cinematic conventions to represent time and space arose in order to communicate experience and to serve as syntactic elements in the construction of meaning (Laurel, Strickland, and Tow 1994). Referred to by many names including, "classical cinema" and "invisible style", to a large extent this style emerged from Hollywood in the 1910's, 20's and 30's and eventually came to dominate commercial narrative cinema (Kepley 1983). The main reason for the style's adoption is as Laurel et al. (1994) explain, that it was successful in forming a language that supports the creation of films of increasing complexity and power. Film unfolds in time and space (Burch 1983). To a large extent, the conventions to represent time and space in cinema are inseparable. They are intertwined. An editing technique to represent or articulate one of these, may also have an effect on the other. Take for example, an edit which is used to represent a transition in space between scenes in different locations, using say a wipe, fade or dissolve. This may also infer a temporal transition, to denote, going back in time or flashbacks, the passing of time or that time has elapsed, or traveling forward in time or flash-forwards.

In contrast, virtual environments or spaces unfold in real or continuous time in response to particiapants' interaction within the virtual space. That is, instead of passively receiving information or narrative as a spectator of film, in VR your contribution determines the outcome. Participants in a virtual environment create their own journey or narrative through constant time and within virtual space. Or as Laurel et al. (1994) state, "the experience of VR hinges on human action and the environments response", and "in VR one is not done unto but doing". The additional interactive component of VR is what sets it apart from cinema and this is shown simply and effectively in the hierarchical Framework of VR developed by Marsh et al. (1998). This interaction occurs in real time, and thus, it is the interactive component that dictates the unfolding of virtual space in real or continuous time. As a result, it is difficult to envisage how edits that represent temporal transitions can be applied in the design of VEs. That is, can VE design make use of conventions to suggest flashbacks or the passing of time? Future developments may well devise ways in which temporal transitions will be applied in the design of virtual environments, and these may feel natural and transparent to the user. Although, this is an area of further research, and its outcome remains to be seen. Additionally, it is difficult to envisage how to apply the same on-screen editing techniques (including: wipes, fades or dissolves) to support transitions in virtual space. Although, it is easier to imagine the use of these edits as jump-cuts. That is, to relocate or teleport a user from one location to another location in virtual space. Pausch and Burnette (1995) proposed a similar technique that allows a user to view the virtual environment or world in miniature, select a location within that environment, and then be teleported to that new location. The central concern with this, and similar techniques to that of teleportation, is that of user distortion. Thus the work presented here will focus on conventions that support the smooth and continuous animation of a participant's interactions within and through a virtual space, and will therefore attempt to alleviate user distortion.

Design of Virtual Off-Screen Space

The work described so far has focused on conventions for the construction and articulation of space that is contained within the pictures that are framed by the borders of the projection screen. This is referred to as on-screen space. There is however, another kind of space in cinematography, the space that exists outside that of the projection screen and is referred to as off-screen space. Off-screen space is more complex than on-screen space and includes everything out of the frame, or not shown on the screen. In most part, this is purely imaginary. Off-screen space is divided into 6 segments. The 1^{st} to 4^{th} segments are determined by the edges of the screen. The 5^{th} segment is the area behind the camera, and the 6^{th} is the space that exists behind the set, the outer limit is beyond the horizon (Burch 1983). Cinematography conventions have been developed that suggest to spectators the existence of off-screen space. The purpose of this, is 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. There are three main conventions used to imply off-screen space in cinematography: *exit and entry points, points-of-view, and partially out of the frame* (Burch 1983). These conventions provide a means to inform the construction of off-screen space in VEs in present and continuous time, and this is consistent with the smooth and continuously moving animation within a VE. Building on these conventions, guidelines are proposed to inform the design and evaluation of virtual off-screen space.

The first of these is *exit and entry points*. Refer to table 1. In cinema, 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 which is 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 leads 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 in the VE 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 screen. An example of a typical guideline for exit and entry points is shown in table 1 and this can be used to inform the design and the evaluation of virtual environments. Exit and entry points such as paths and roads are a special case or sub-group of partially out of the frame. See description below. This is because only part or a section is shown on-screen.

The second of these is *points of view.* In cinematography this convention is used frequently. Off-screen space is suggested to the spectator by a character on-screen looking somewhere off-screen, for example, either to an object, location, or talking to another person located off-screen. Persson (1998) suggests using this in VR by employing an avatar to look at something that is not contained within on-screen space and so suggest that space exists off-screen. A typical guideline for this might be as contained in table 1. The use of this guideline will be especially useful in multi-user environments, such as, collaborative VEs and in video teleconferencing.

cinematography conventions	**cinema**	**virtual reality**	**guideline**
exit and entry points	• character passing through door / corridor • character moving out of the frame • up / down stairs or in a caged lift	• doors, hallways, paths, windows, roads, etc.	• wherever possible, it must be clear to the user that there exists the option to exit the area contained within the confines of the display screen (HMD / monitor)
points of view	• talking to someone off-screen • looking off-screen	• avatar gazing at / talking to, something / somebody off-screen	• where applicable, avatars should have the ability to look to space contained off-screen
partially out of the frame	• sticking part of body off-screen • object partly on-screen	• familiar object shown partly in frame (HMD, display monitor)	• the placement of objects in the virtual environment should be such that there is always more than one object partially in the user's FOV

Table 1. Guidelines for the design and evaluation of virtual off-screen space

Finally, the third is *partially out of the frame.* In cinematography, a character or object is framed in such a way that some part of a character's body or a part or section of an object protrudes out of the frame to infer the space out of the screen. For example, a character sticking their head off-screen, say through a door or window to find out what is going on in the space we cannot see. Or 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, techniques such as this could be employed by having 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 imply that the rest of object is in off-screen space. Persson (1998) suggests using a similar technique to trigger users' recognition of familiar objects. For example, using part of a human body as the background for a web page to suggest the potential to scroll to view more of the human body in off-screen space. Hence, implying that there is a larger web page than that seen through the restricted FOV of the display screen. An example of a typical guideline for partially out of the frame is given in table 1, and the design of a virtual room using this guideline in shown in figure 1 below. Figures 2 to 5 show a participant's FOV whilst panning around the virtual room at eye-level. These guidelines attempt to increase a participant's awareness of off-screen by continually having a partial object within the FOV, as shown.

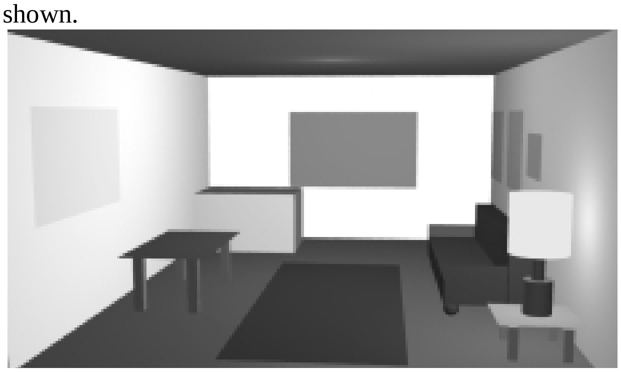
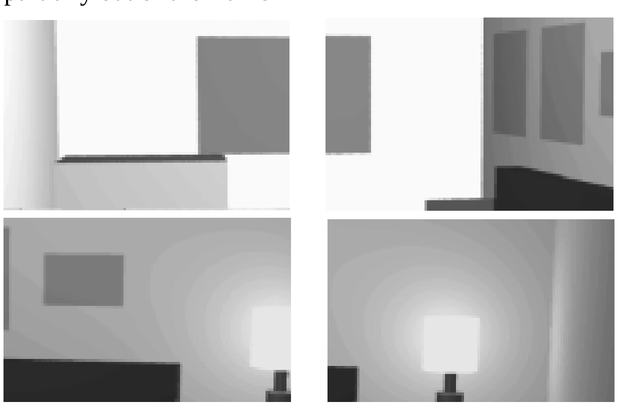


Figure 1. Virtual room designed using the guideline for partially out of the frame



Figures 2 to 5. Participant's FOV whilst panning the virtual room

Further Work

Future work will be concerned with guidelines to inform the design and evaluation of virtual off-screen space. For present purposes, this work is concerned with single user virtual environments and therefore, will concentrate on two of the three conventions: *exit and entry points*, and *partially out of the frame*, and investigate the interplay between the two. Studies are planned that will test the effectiveness of these guidelines in the design and the evaluation of virtual off-screen space. It is expected that this will be an empirical study of two groups. One group will be required to carry out tasks in a virtual environment with the design guidelines implemented and the other in the same virtual environment without the guidelines implemented. A comparison of the two results will then be performed. It is anticipated that the use of guidelines in the design will reduce the number of usability problems. Additionally, it is expected that the guidelines will appear natural and transparent to the participant, thus, re-enforcing the illusion of interacting within a virtual space, and possibly having a positive effect on a user's experience.

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