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Towards Naturalistic Navigation Metaphors for Large Scale Virtual Environments

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Abstract

This paper looks at the background to the development of alternative interfaces to Virtual Environments and suggests a reappraisal of some of the early work which allowed a sense of presence in the 'real' world.

Initial work, the virtual exercise bike, is appraised, and new work is described which further develops the development of a low-cost interface system. Work in progress is described which is a combination of hard- and software. The solution described is a 'hands free' interface enabling the user to experience a VE in a similar manner to a physical environment, using movements of the head and feet for navigation. Whilst this is possible using expensive, proprietary equipment, the presented solution concentrates on a low cost approach. In line with this, the system uses a low cost gaming environment which is described and evaluated.

Resumo

Este documento introduce el desarrollo inicial de alternativas a las conexiones "interfaces" con Espacios Virtuales y sugiere una revaluacion de trabajos anteriores que ofrecen una sensacion de presencia en el mundo "real".

Trabajo inicial. La bicicleta virtual y otros nuevos trabajos son descritos para el desarrollo de sistemas de conexion de bajo coste. Trabajo en desarrollo "Work in Progress" es descrito como una combinacion entre hard y software. La solucion descrita presenta una conexion que ofrece al usuario la posibilidad de navegar por un espacio virtual usando solamente el movimiento de la cabeza y los pies. Aunque este tipo de sistema esta asociado a equipos de alto coste la alternativa presentada ofrece un sistema de bajo coste. En esta linea el trabajo usa bajo coste programas de animacion descritos y evaluados.

Introduction

Rendered building models tend to be very memory hungry and as a consequence interactive navigation around a rendered model puts considerable stress on the hardware used in the representation. However, it is not only real time animation that is the problem. If we are to move towards the idea of network or internet based collaborative design systems, then the memory problems referred to become exacerbated. In response, this paper describes a potential way forward in the development of techniques for producing architectural models that have both lower memory requirements and the capability of running in a common internet-based environment.

The work described here also leads to the development of alternative interfaces to Virtual Environments and suggests a reappraisal of some of the early work that allowed a sense of presence in the 'real' world. The phenomenon of sense of presence in virtual environments (VEs) is often seen as the real essence of Virtual Reality (Laurel, 1993) "*by changing space, by leaving the space of one's usual sensibilities, one enters into communication with a space that is psychically innovating…for we do not change place, we change our nature"(Bachelard, 1968)*

Much research has been carried out over the recent years into the interaction of the operator with a Virtual Environment (VE). The areas of interaction can be broadly broken down into the areas of interface, navigation and display and whilst there has been considerable work in the area of the design and navigation of the interface there is still considerable debate as to the best and most appropriate method(s) for interacting with the VE. The 'traditional' method of interacting with the computer and a virtual environment is though the mouse, a method that the vast majority of users feel comfortable with in a 2-dimensional environment, but which leaves a lot to be desired when using a 3-dimensional world.

Early attempts at providing a sense of location with a VE were based on specific need of the military with flight and tank simulators, firstly with physical models and latterly with computer generated models. In these, the physicality of the immediate environment was an essential part of the experience. Whilst this was driven by the limitations of the then current hardware, it offers us some important lessons. Whilst the viewable area was limited by the power and screen resolution available, it was the familiarity of the immediate 'real' environment that overcame the lack of detail.

It is also worth re-evaluating some of the early scientific VE experiments where there could be no user-based reality, as the scale being modelled was at molecular level. Grope-

Figure 1- Video Place.

III (Reim and Neilson, 1990) was developed to allow chemists to visualise the bonding patterns of complex molecules and 'feel' the bonding by means of feedback through the use of a remote manipulator arm. Even though this was patently an 'unreal' situation, the feedback felt through pressure on the hand was real. The method of navigation was through a natural analogy, in this case the hand which operated in a naturalistic way, the feedback giving the connection with the viewed scene.

In 'Video Place' (figure 1), Myron Kruger, an artist and computer scientist created an installation which, in one mode of operation, projected a shadow image of the participant onto a video screen which reacted to their movement. The specialised computing environment created by Kruger allowed the analysis of the participant down to the movement at finger level. A graphic object or 'critter' further interacted with this by attempting to climb over and follow the shadow. In this way the user had a sense of presence in the VE through the projected shadow and could directly interact with the VE. The shadow becomes an abstract form of avatar.

Early attempts at using a familiar and naturalistic interface were developed by Autodesk (Walker, 1991). Of these the second, the 'High Cycle' used a converted exercise bike to 'ride' through a virtual landscape (viewed through an early head-mounted display) and, if the user rode fast enough, take off and fly. Users reported that the familiarity of the interface allowed an easy assimilation of the experience, even it became 'unreal' as the participant flew over the landscape. The VE in itself was crude by today's standards, but contained sufficient 'clues' for the participant to make the connection with a real landscape. The HMD was constructed from consumer mini TV screens and the signals sent through a thick and unwieldy umbilical cord from the two PCs (one for each eye image), but to an audience with lower expectations than today, it worked very well. The importance of a sense of orientation in a VE has been noted before (Bridges and Charitos, 1997). In this case, the bike is fundamental in the realisation of this.

Figure 2 Osmose.

An important attempt at a non-realistic environment that used a 'natural' interface was 'Osmose' by Canadian artist Char Davies (Davies, 1996). By using a navigational metaphor based on a scuba diving breathing technique, coupled with an immersive headset projection, Davies allowed the users of the VE to navigate in a very simple, easily assimilated manner, quite literally as easily as breathing; breath in to move up, breathe out to go down. The ease with which users could learn the system was crucial to its success, even though the VE being experienced was totally unreal, the users felt a sense of belonging and connection, the ease of navigation being central to this. (figure 2)

Coupled with an increase in the power and availability of cheaper computers for home use has been a rise in expectation of the quality of computer graphics, the majority of which has come through the demand of the gaming community. It is now recognised that games development is a major force. The rise in popularity of 'first-person' view, role playing games has risen out of this. These games (such as Half-Life) are virtual environments in the true definition of the term. Players have free movement and are faced with foes that are programmed with a basic AI behavioural pattern. The development of these is aimed at achieving a 'realistic' environment at as higher resolution as possible and at as higher frame rate as current graphics cards will allow. The designers quickly realised that the sense of realism can be heightened by both lighting, atmospheric and sound affects that serve to give the user a sense of 'belonging' and presence in the VE. However, the controlling mechanism is still, for home use, the mouse or joystick.

In tandem with this has been the availability of software for users to create their own levels of the game. The architectectural contribution and content of the games can be recognised in the frequency of job adverts for games designers in the architectural press. In many cases the software used in the original game creation is the same as for many architectural simulations (e.g. Kinetix 3D Studio). Unfortunately, what is missing from many level editors is the ability to import 'standard' CAD or modelling data into them. This is due to the different audiences that the software is targeted at, i.e. level editors at home users who cannot afford to spend £3500 on 3D Studio. Once this has been realised, the way will be open for architectural VEs to be quickly realised.

Proposal

It has been demonstrated that the method of interaction is a central part in the users immersive experience in a VE. Both the Legible City and Osmose used a consciously non-realistic environment through which the experience was heightened by the use of a naturalistic navigational metaphor.

The importance of retaining a sense of orientation in a VE has been noted (Bridges and Charitos, 1997) and the problems of scaling and scalelessness (Boudakis, 1997) in the movement of the navigation method.

What is proposed is the development of a generic navigational metaphor, adaptable to a variety of natural or naturalistic navigational methods. We have started to develop an architectural VE using a commercially available gaming engine and, initially, we have revisited the use of a bike for navigation. The experiences of the bike have been documented (Knight and Brown, 1999), in particular the difficulties of differential scaling. Our aim is to progress this towards with the aim of a hands-free interface.

With a large scale urban VE, differential scaling becomes more problematic. If the naturalistic metaphor is taken to a logical conclusion, the exercise bike would be used to move over large distances. For building interiors or where a 'bike' would be inappropriate, a system that uses foot movement, such as a treadmill would be more appropriate.

The experience of using the bike has allowed us to learn a great deal about naturalistic navigational metaphors. While users adapt very quickly to unnatural and in some cases slightly surreal situations (riding a bike down stairs to the sound of footsteps), a more natural metaphor is still the goal. To his end, the use of head movements is currently under investigation. Whilst this is used in commercial products such as the 'Flock of Birds' motion tracking, it does not comply with our low cost aim. We aim to use the body's natural resources to provide the signals necessary for navigation.

To continue to use the games software for the VE environments, the navigation needs to be mouse or joystick compatible. To use head movements, the game is configured to 'mouse follow' which means that the mouse X and Y movements correspond to the left/right/up/down movements of the view. Forward/backward movement is achieved with the keyboard arrow keys. This means that two axis of movement are required of the head, the X and Y, both positive and negative. A straight-ahead gaze would be 0,0, a look up would be a positive Y, a rotation of the head to the left would be a negative X.

Whenever a muscle is activated a small electrical charge is generated, the size of which is dependent on the type of muscle movement. Muscles that control the head are in a state of constant activation to maintain posture. Movement of individual muscle fibres is evidenced by a small level of electrical activity, whereas in a large muscle movement involving all the muscle fibres, a much higher level of electrical activity is generated.

This activity can be detected using surface fixed EMG sensors (figure 3) similar to those used in detecting other bodily activity such as ECG heart monitoring. We propose to use these as indicators of head movement. These would be amplified using a high quality signal amplifier, interfaced to the PC by an analogue to digital converter and processed to provide the necessary information to the mouse driver.

Experimentation will be necessary to determine the threshold value that determines posture correction and conscious movement. The exact placement and method of fixing the sensors will also need resolution. The centre point of the muscle provides the strongest muscle signal, but is also subject to the greatest amount of surface distortion.

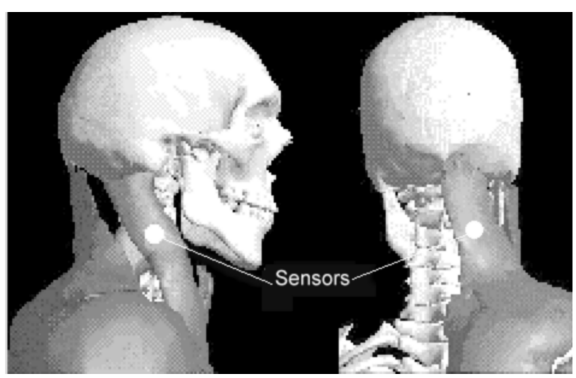

Figure 3 sensor positions on the neck.

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The human head has three axes of movement, up/down (flexion and extension), left/right (rotation) and tilt. The muscles involved in the two required, (flexion/extension for the Y-axis and tilt for the X-axis) are both large and near to the surface. The sternoceidomastoid muscle is present on each side of the neck, movement of the head to the left involves the right side muscle and visa versa. The trapezius muscle at the rear of the neck determines tilt. Muscles rarely work in isolation, for example, if both sternoceidomastoid muscles contract together, the head would tilt to the front, and in this case the trapezoid muscle would be inactive. It should be possible, through a series of logical conditions (by processing the combinations of signals received) to determine the head movements.

The table below shows the muscle movements with the corresponding axial movements.

		Sternoceidomastoid Left side	Sternoceidomastoid right side	Trapezoid
-X	Left	-	X	O
+X	Right	X	-	O
+Y	Up	-	-	X
-Y	Down	X	X	-

X above signal threshold

O below signal threshold

- static (no signal)

There are several potential problems with this approach. As with the rest of the body, the muscle structure of the neck is several layers deep and there will be conflicting signals as each is triggered. By establishing a threshold level it should be possible to filter out extraneous noise and leave the relevant signal. Coupled with this is the variation in signal strength that varies according to the size, age and build of the user. The software that interprets the signals must be capable of being calibrated to compensate for this. With using a projected screen, the view will move in a manner that may prove initially unsettling for the user. Experience of use will etermine the extent of this.

In experiencing architecture, we use our head and eyes to direct our view, and our feet to move. The aim of this work is to allow designers and others to experience an architectural VE in a naturalistic way with a minimum of layers between the user and computer, using a desktop PC or laptop and a minimum of specialised equipment.