A Portable and Natural Interface to Architectural Virtual Environments

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In previous papers the authors have described low cost, pragmatic interaction devices for architectural virtual environments, in particular the bike as a means of locomotion around a virtual urban environment. They have also been involved in work on portable systems for city navigation and representation, based around a personal digital assistant running pseudo 3d models of the city with an associated information database. This paper describes work that develops the two ideas of familiar real world interaction device and portability to produce a portable system for interaction with architectural urban models.

Keywords: *Virtual environments; locomotion; portable; interaction; navigation*

Background and context

In this paper we describe a current stage in the evolution of a real-world, low-cost interface for interaction, locomotion and navigation in Architectural Virtual Environments. This development is part of a body of research that has looked at real-world analogies for interfacing with virtual environments and the current phase of the development, that we will describe and demonstrate, is intended to satisfy our intentions:

- to improve the sense of presence in the environment;
- to allow better control and understanding of locomotion in the environment;
- to enable portability; and,
- to do all this in a cost effective way.

The sense of presence and ability to undertake tasks efficiently, that mimic real world events, in virtual environments (VEs) are often being seen as the real essence of Virtual Reality (Laurel, 1993). If we take it that sense presence and performance characteristics can be enhanced then appreciation and understanding of the representations in the environment should be improved. There are other aspects that influence our work such as that being undertaken by, for instance, Schnabel and Kvan (2002). Schnabel and Kvan have undertaken an interesting study of the 'understanding of spatial volumes within immersive, non-immersive virtual environments' in an architectural context. In addition Kalesperis et.al (2002) have looked at student perception and performance in virtual environments when using a low cost architectural VR system that the group have developed, called VR-desktop. Both of these studies suggest that there are indeed many

positive aspects to the application of Virtual Environments in a range of architectural applications as indicated would be the case, by Bridges and Charitos (1999).
When applied to a large scale urban VE, navigation methods such as flying are useful in the appreciation of the macro scale, but do little to engage the lay viewer with a scale that can be easily related to. When the idea of an appropriate locomotion and orientation device is taken to a logical conclusion, differing interfaces would be required for differing tasks. The means of locomotion, for instance would change; for example moving relatively large distances between buildings would be a an ‚assisted' task (using a mechanical device, such as bike or car) as opposed to moving around a building, which would be undertaken by walking or by wheelchair, for instance. Consequently our aim has been to develop an integrated set of interfaces that allow for appropriate navigation devices and interaction techniques, for different tasks. Such an approach was suggested as being useful and productive by Mallot-Hanspeter and Gillner (2000).

The Bike as a Locomotion device

The first locomotion interface that we described (developed in 1997/8 and reported by Knight and Brown, 1998) used a bike as the interface device with the physical connection and control from the bike being through the pedals (forward motion), handlebars (horizontal direction) and handlebar buttons (look up and down). The connections were all wired, and put simply, were direct translations from a mouse driver. The mouse was (carefully) destroyed and the mechanical movement within the mouse replaced by movement on the bike.
The system used a game level editor, Half-life, for creating the ‚world'. Problems arose from the inflexibility of the game platform for creation of the environment and scaling of movements on the bike so that for instance, angular displacement of the handlebars was correctly represented in the perceived angular displacement in the virtual environment. These have been subsequently addressed. For instance the Game engine that we moved to next, Virtools, allowed for greater customisation, that included scaling factors for input devices, so that pedal movements and handlebar movements were properly translated to the Virtual Environment.
In addition work on navigation in such environments (such as Darken et. al, 1998) gave useful indications of important factors to take into account in developing and refining such systems.
At the time of the development of our bike interface, it now transpires that others were working on parallel developments. In Psychological perception studies a team led by Frost undertook studies of performance in virtual environments where a bike was the locomotion interface (Tong et.al., 1995).

- Self-directed motion is sufficient for accurate spatial representation whereas passive movement leads to impaired spatial memory.
- The mouse interface produced less realistic virtual movement, however, it was as effective in promoting spatial learning as fully interactive immersion VR.
- Gross locomotion feedback, therefore, is not important for spatial memory formation.
- Decoupled locomotion feedback impairs spatial memory. This suggests that incoherent visual-motor information may distort spatial representation.
- Findings correspond to real world spatial memory studies (e.g. Foreman, Foreman, Cummings & Owens, 1990) which suggests that VR can adequately model certain visual-spatial aspects of reality.

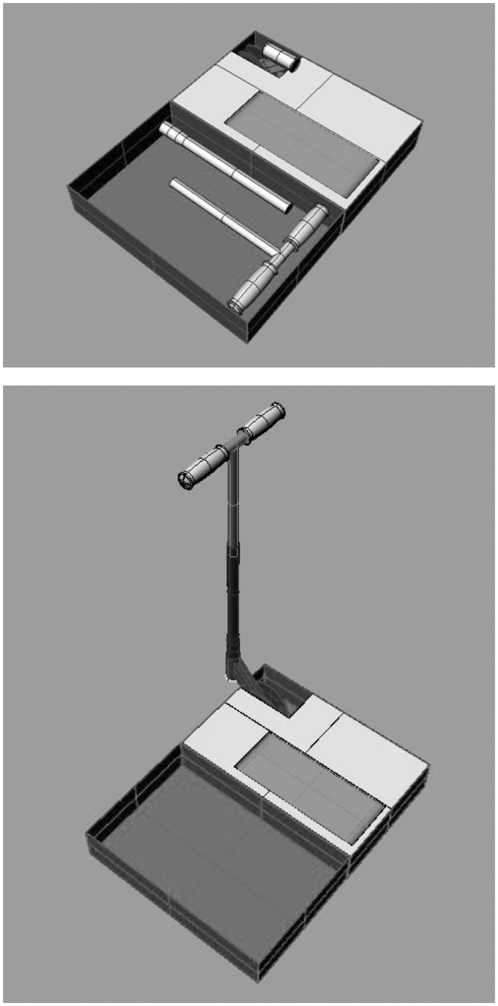
The Current Development

The physical interface and locomotion system now being developed, tested and applied, builds on previous experiences and concentrates on navigation, of a partial city model of the city of Liverpool. It also

aims to take in another of our research group's goals (Berridge et. al. 2002); that is, the idea of exploring portability of virtual environments constructed at minimal cost, since we believe that such systems have significant potential benefits in architectural applications.
The system is in two parts, the first is the use of a gaming engine for the creation and projection of the virtual world. This gives a suitable level of control over the various separate interaction elements of the physical interface. Reasons of cost and easy availability led us away from Virtools as the engine and towards Unreal Tournament as an engine worthy if further exploration.
The second part is the physical interface; it has been designed to be portable. For our purposes we define portability as being capable of being carried as aircraft hand baggage. We decided that a scooter was a device that we could possibly use to replace the bike, and worked on some sketch ideas and simple 3D models to mock up the kind of device that we had in mind (see Figures 1a and 1b).
In Figure 1 the scooter device as it was planned to appear on unfolding the case is show. The set up with the handle bars raised is shown in the working 3D sketch in Figure 1b.
Parallel work by the authors on perception of the rendered image has had a direct impact on the nature of the large scale VE used for testing the new interface. Reassessing the degree of detail required has suggested how the images that are seen can be both recognisable, and computationally efficient.
Initial experiences and analysis of user testing will also be presented and compared to previous work. In this evaluation we are aware of the fact that assuming that 'natural' is best may imply „questionable assumptions concerning distance and direction estimation and manoeuvrability" (Darken et.al. 1998). However, we have found that the approach was indeed generally appropriate (Knight et. al. 2003), but this issue is re-evaluated in the context of the new system.

Construction of the vr-scooter

In the development of the portable scooter device, as in previous work, the principle of developing a system at very low cost was a key driving force.
First we needed a sturdy case that could cope with the gentle attentions of airport baggage handlers, and the variety of mechanical destruction devices



Figures 1a and 1b
Sketch model of the scooter locomotion device.

used by airports to get bags from the airplane hold to the luggage carousel. This is a journey that is certainly more scary than most virtual reality games that have been produced using the games engines that we have been working with. We await the arrival of a VR game where you, as player act as a piece of luggage, and try to get from check in to the correct destination in one piece and without scars.

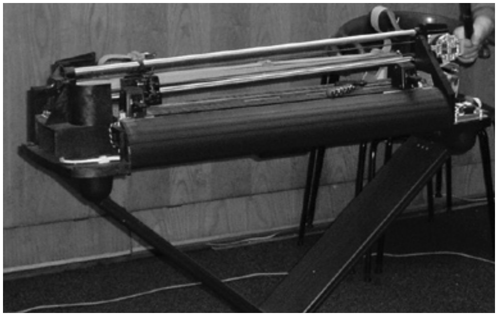


Figure 2
The Plotter before recycling.

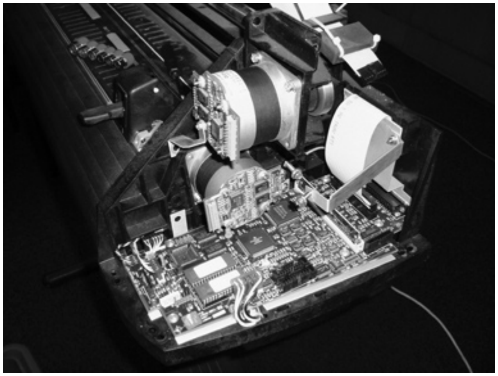


Figure 3
Stepper motor revealed.

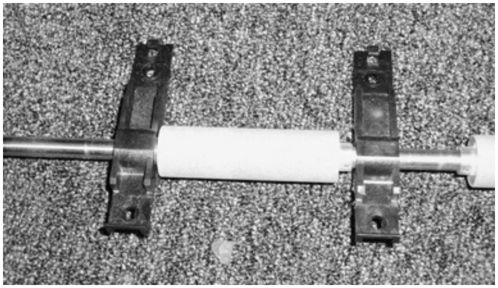


Figure 4
Roller bearings.

We needed roller bearings for the belt drive that would be operated by foot by the operator to achieve forward motion. We also needed a motor to provide haptic feedback, such as resistance as the operator pushes the scooter up a hill. In the corner of the computer room sat an old pen plotter that had been donated to the school by a local architectural practice. Fortunately, we were too polite to say it was of little use to us. We later realised that these old pen plotters (Figure 2) had a stepper motor (Figure 3) to move the pen holders around the page, and roller bearings (Figure 4) to shuffle the paper backwards and forwards. By dismantling the plotter we were therefore able to obtain a couple of key parts for the scooter interface. In doing so we obtained parts for free and satisfied our wish to support sustainability through recycling: a double success.

As for the bike interface the means of connection and control was to be through the modification of a mouse driver. We also needed a scooter that could be dismantled into component parts that were useful to us. Handlebars and stem with a joint at the base of the stem would be needed. A running board would also be possibly needed. But wheels were superfluous since this was to be a virtual scooter where the scooter was to stay still and the ground would move, in the form of a belt drive that the propelling foot would move forward. A student had a suitable scooter with worn out wheels and wheel bearings that was donated to the project for free: another success in terms of cost and sustainability.

Thus all the main component parts to be contained in the case were brought together and the task was then to undertake the mechanical fabrications, and make the electrical connections. This was to be done in such a way that all the components fitted inside the sturdy case, with, for instance, the handle bars and stem folding into the case for transportation.

In the bike-vr project one of the problems that we noted was that buttons on the handlebars had to be used to look up or down. This was clearly an unnatural way to change viewing direction and was

one of the issues that we hoped to improve on in the scooter-vr system. We had experimented with controlling viewing direction with electrical sensors on the muscles controlling head movements (Knight and Brown, 2000), but the practical problems in making this work proved to be too troublesome to warrant extensive refinement of this system.
We then found that we could purchase a second hand, good condition, vr headset, to control viewing for both horizontal and vertical panning, at a very low price (£5, or 8 Euros; or not very much). Hence we had obtained the components that could give the portable locomotion and control that we needed for the scooter-vr interface.

Conclusion: the acid test

In the development of the portable scooter device, as in previous work, the principle of being pragmatic and cost effective, whilst being well founded and useful have been our aspirations. To what extent we have been successful will be revealed partly in testing as in Knight et. al. (2003). But partly the success could be proved by the authors managing to get the device from Liverpool to Copenhagen, by means of transport that include a plane. Once at Copenhagen, if the device works, and is seen to work, then the transportability issue will, at least, have been addressed.
Consequently our conclusion is, as yet, unwritten. If the scooter interface arrives at eCAADe 2004 and works we will be able to claim some success, at least. So we wait to make our final comment on this stage of development in spoken words rather than written ones.

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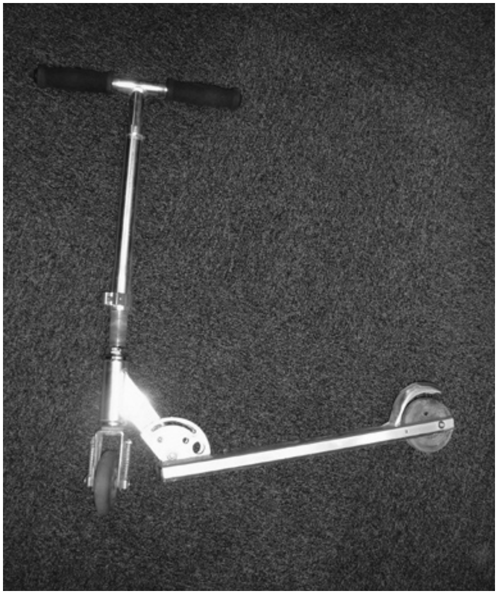

Figure 5
Scooter before modification.

Figure 6
Head mounted control of direction of movement and up-down viewing.

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