University of Leicester

SPLINT
SPatial Literacy IN Teaching

Where am I?

The effectiveness of artificial landmarks for establishing location in an immersive virtual environment

The issue

A primary use of virtual environments is to allow people to explore and interact with an environment that they either do not have access to, or as a training facility for tasks that they will perform in the real world. In many of these uses, it is essential that the user can successfully navigate this environment and to do this, they need to know where they are (both location & orientation). Further to this problem, it is also important that users can successfully perceive distances and scales to allow them to perform these tasks accurately. In Figure 1, we outline a number of scenarios where difficulties in navigating and spatial perception within a virtual environment could compromise their effectiveness in a variety of applications, including those related to teaching and learning and public engagement more generally.

Vignette A

Data: Co. Junta de Andalucia

Interface: Virtalis/SPLINT Geovisionary

You are aware that students have a tendency to 'switch off' on coach journeys between stops on orientation days in the field. However, it is really important that they gain a sense of direction relative to the coast and mountain ranges in order to understand particular landforms and processes at different locations in your field area. As one measure to try and overcome this difficulty, you build an immersive virtual environment to enhance the students' sense of scale and location before they go into the field. However, it soon becomes clear that students find it exceedingly difficult to locate themselves in this environment relative to a map and further that difficulties estimating distances in the VE are contributing to this problem.

Vignette B

Image: G. Priestnall, University of Nottingham

You wish to demonstrate a real-time virtual environment in a public participatory context, looking at the potential impact of wind turbines both in terms of visual and sound impact in a natural landscape. You would like groups of the "local public" to be able to place potential wind farms in the region and debate their impact in relation to places of particular emotional significance for them in the area. However, for this process to work, the participants must be able to find both locations of personal significance and to place the wind turbines in the landscape. Both prove much more difficult than you expected, as participants keep getting "lost" in the VE.

There has been extensive research into the cognitive processes of navigation and orientation, and how different features aid in the construction of cognitive maps. However, one of the main problems discovered is that people do not often perceive many features in the Virtual Environment (VE) as they would in the real world. They tend to get disorientated easily (Wiener 2007) and lack the spatial judgement that is easily perceived in real environments when calculating distances (Interrante et al. 2007) and avoiding obstacles (Suma *et al.* 2007). For navigating large scale virtual environments it is essential that the use can orientate themselves accurately (Juan-Espinosa *et al*. 2000).

From a geographer's perspective, the use of a top-down overview map as an inset is a common orientation device and a potential means of assisting the user to navigate in a broader landscape context. Such an overview map is implemented in the Google Earth interface, and indeed we use a very traditional example below in Figure 1. However, Sjölinder *et al.* (2005) suggest that the use of an overview map is of little use when learning an environment as it aids in the construction of route knowledge rather than survey. As the information is directly presented to the user they tend not to learn that information, and so using an overview map in an application aimed at aiding in the learning of an environment ready for visiting that location seems of little benefit. It has also been found that in other applications that require navigation, such as alternative route determination, survey knowledge presented in the form of an overview map is generally not used and route knowledge is used instead (Janzen *et al.* 2001).

Interrante V., Ries B., Lindquist J., and Anderson. L. 2007; Elucidating Factors that can Facilitate Veridical Spatial Perception in Immersive Virtual Environments; IEEE Virtual Reality Conference 2007; Charlotte, North Carolina, USA

Janzen G., Schade M., Katz S., and Heermann T. 2001; Strategies for detour finding in a virtual maze: the role of the visual perspective; Journal of Environmental Psychology 21, 149-163.

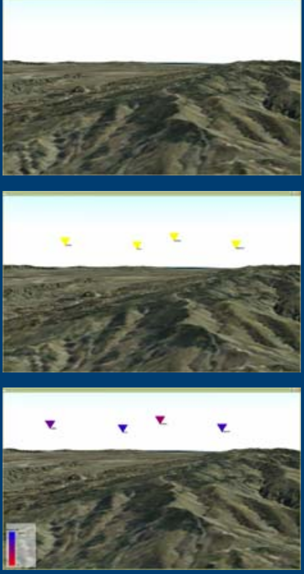
Juan-Espinosa M., Abad F. J., Colom R., and Fernádez-Truchaud M. 2000; Individual differences in large-spaces orientation: g and beyond; Personality and Individual Differences 29, 85-98.

Sjölinder M., Hook K., Nilsson L. G., and Andersson G. 2005; Age differences and the acquisition of spatial knowledge in a three-dimensional environment: Evaluating the use of an overview map as a navigation aid; Int. J. Human-Computer Studies 63, 537-564.

Suma E. A., Babu S., and Hodges L. F. 2007; Comparison of Travel Techniques in a Complex, Multi-Level 3D Environment; IEEE Virtual Reality Conference 2007; Charlotte, North Carolina, USA

Wiener J. M. 2007; Can People Not Tell Left From Right in VR? Point-to-origin Studies Revealed Qualitative Errors in Visual Path Integration; IEEE Virtual Reality Conference 2007; Charlotte, North Carolina, USA. *Educational Psychologist* 41, 75-86.

Study area: Almeria, SE Spain



Landscape with plain & coloured artificial markers

Immersive stereo rig for user trials

Adam Rousell (MSc GIS, 2006/7)

Project Supervisor: Dr Claire Jarvis (chj2@le.ac.uk)

This dissertation was presented in oral format at GISRUK 2008.

Adam Rousell will be returning to the Department in October 2008 to take up a 50th Anniversary Student Scholarship on the subject of navigating & wayfinding in virtual environments.

Research overview

Aim: To develop & evaluate methods to support users of virtual environments to gauge their geographical location correctly

Objectives

- To assess whether introducing artificial landmarks into a large scale environment with little in the means of natural or manmade landmarks aids in orientation tasks.
- To ascertain whether dynamically colouring the landmarks depending on the distance from the user's location can assist the user in interpreting geographical distance.

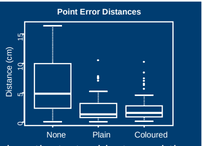
Methods

Software: Bionatics Blueberry 3D geometry software was used to create the terrain and VegaPrime to add the functionality required for the interactive analysis and stereo projection to take place.
Landmarks & interactivity: A new movement model was added to the environment using VegaPrime to allow the user to observe the landscape from particular locations. Artificial pointers (landmarks) were added to the environment using VegaPrime. Code was also implemented to change the colour of the landmarks dynamically, as well as to allow the use of multiple viewports so that the images could be projected in stereo using specialist equipment.
User trials: These consisted of a brief fly around the environment by the user, before they were placed in nine different virtual locations without the ability to move forward and backwards within the scene. Once placed at these sites, the triallists were required to plot the location they believed themselves to be in at within the virtual environment on a paper map. This map comprised of the basic features within the environment such as buildings, roads, contour lines and the coastline. Urban features were also marked on the map which corresponded to the landmarks shown in the environment.

To ascertain the effectiveness of using artificial landmarks to represent the towns, each test subject undertook nine trials at three different locations. One third of these trials had no artificial landmarks, another third had the artificial landmarks displayed but in one colour, and the final third had the same landmarks shown but they were dynamically coloured to represent distance. The order of locations in which users began the trials was altered to avoid geographical bias in the results.

Subjects: In this experiment, 15 trials were undertaken consisting of test subjects between the age of 21 and 42, and comprising of 11 males and 4 females.
Analysis: Both quantitative and qualitative methods were used:
1. Location - Distances between actual and estimated position tested for statistical difference between experiments.
2. Kernel density surfaces of estimated positions, by site, for all participants.
3. Qualitative analysis of discussion material using urban image theory.

Main findings



Location: From the results, it was evident that whilst both the plain and coloured markers show a distinctly statistical different distribution from the no marker results, there is no statistical significance in the distribution of the results between the coloured and plain markers. This can be seen when viewing the box plots of each distribution, as shown here.

The most probable cause of this similarity of distributions is how the test subjects used the markers; post trial discussions identified that rather than using the user's location with each marker to triangulate their position, they in fact used the markers relationships with each other. This topological approach meant that knowing the distance from the user to the marker had no direct influence on the determination of location and so was not used.

Kernel density

The kernel intensity function of estimated locations made by the trial subjects was a very good way of visually determining which trial locations people were most accurate at determining. A selection of the most interesting of these is shown in above. Just in this selection it is clear that some locations had a far higher concentration of points close to the actual location than others, indicating that these locations had a higher accuracy. The results showed, unsurprisingly, that ground features are used to aid in orientation techniques, but also that these features are used more effectively depending on their type. Once the artificial landmarks were placed, the coastline and terrain were used less as a general location identifier, but buildings and roads were still used to localise the user. We can see that the features used within the orientation tasks are associated with the same representations as used in the Urban Image Theory, in that for larger scales, boundaries and zones (coastlines and terrain covers) are used for general locality, and then paths and nodes (roads) for more local determination. Landmarks were used as mainly global tools, owing to the method of implementation.