

The Effectiveness of Artificial Landmarks for Orientation Tasks within a Large-Scale Virtual Environment

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KEYWORDS: Landmarks, Visualisation, Virtual Reality, Virtual Environment, Orientation

1 Introduction

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.

Teaching vignette A

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.

Teaching vignette B

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.

Teaching vignette C

You wish to teach students to sample particle sizes in a manner more lively than the traditional statistics lecture, while reserving precious time in the field for undertaking research as opposed to training in sampling. You decide instead to develop an immersive environment that can represent terrain based on underlying GIS data layers in a realistic way, in which students can point to features and include them in a virtual collection bag for later analysis. To your horror, you find that while students enjoy “collecting” virtual data samples in this way, their sense of scale as regards distance and height in the VE means that they find collecting a representative sample genuinely difficult.

Figure 1. Examples of complex space-time communication issues in a geomorphological teaching context

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 user 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, Sjölander *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).

The research presented here assesses whether introducing artificial landmarks into a large scale environment with little in the means of natural or manmade landmarks aids in orientation tasks. Further research is carried out in the form of dynamically colouring the landmarks depending on the distance from the user's location to ascertain whether colour can be used as an adequate distance scale.

2 Background and Methodology

2.1 Study Region

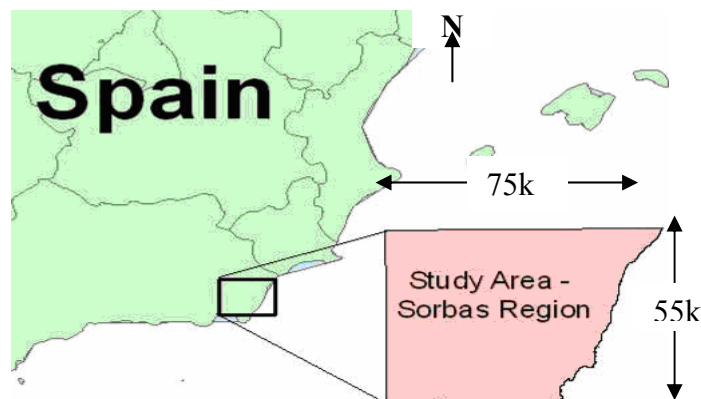


Figure 2 - Study area

The study uses a virtual representation of the Sorbas region in South-Eastern Spain, a relatively unpopulated inland area with a single coast line in the confines of this study area (Figure 2). The location (lower left corner) of the study area was at 542718.3 Easting and 4076991.2 Northing (using a WGS 1984 Complex UTM Zone 30N projection), and was 75 km wide by 55 km tall. This region was selected so that the VE could have a future use as a training environment for geography students at the

University of Leicester; each year, a number of students undertake field studies in the Tabernas and Sorbas regions.

2.2 Construction of the Virtual Model

The software used to construct the environment for the trials to take place in was the Bionatics Blueberry 3D geometry engine in conjunction with Paradis VegaPrime. Blueberry 3D geometry was used to create the terrain and VegaPrime to add the functionality required for the interactive analysis and stereo projection to take place.

2.2.1 Interactivity and Landmarks

The environment was created in the Bionatics Blueberry software using various datasets to create a realistic representation of the environment. Further functionality was then added to this environment using VegaPrime to allow the user to navigate and to include the artificial landmarks. 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.

2.3 User Trials

The user trials 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. 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.

2.3.1 Artificial Landmark Representations

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.

2.3.1.1 No Markers

At the first three locations the user was placed in, no additional information was provided about the environment other than the visual terrain (Figure 3).

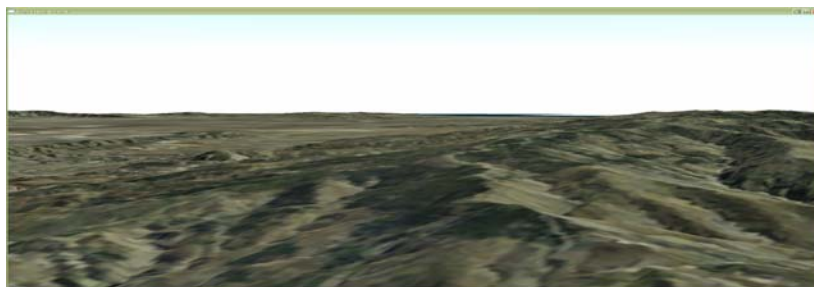


Figure 3: No markers

2.3.1.2 Plain Markers

At the next three locations, 10 markers coloured yellow were displayed in the form of a cone pointing down to an urbanisation. These markers were labelled to indicate the name of the particular town they were pointing towards, which also corresponded to towns marked on the paper map (Figure 4).

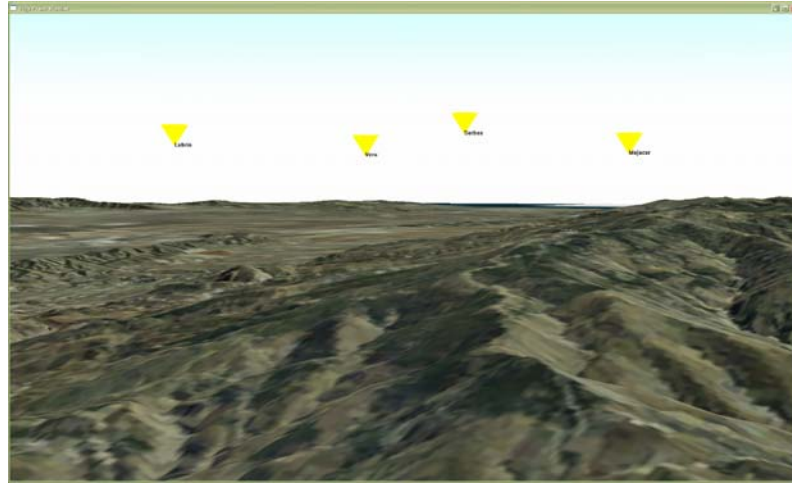


Figure 4: Plain markers

2.3.1.3 Dynamically Coloured Markers

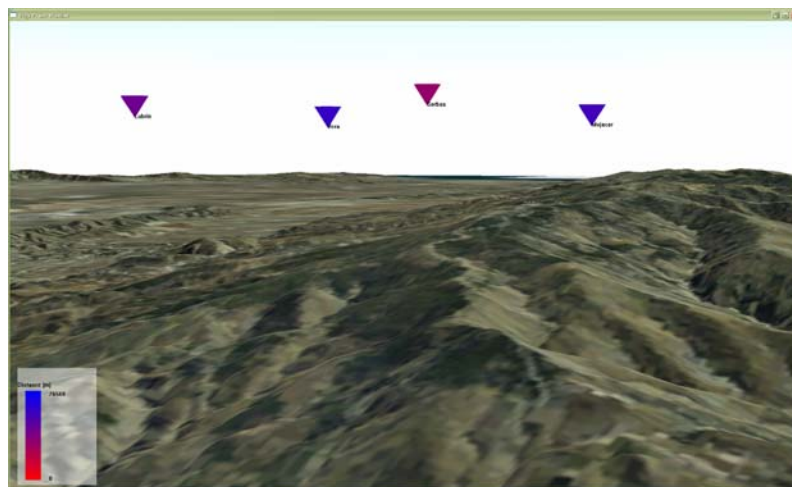


Figure 5: Dynamically coloured markers

Finally, the remaining three locations also had the same markers displayed, but here the markers were dynamically coloured depending on their distance from the user's location. If the marker was close to the user then it appeared red, and if it was far away it appeared blue. In between these extremes a graduation of colour was used going from the red through to magenta and then to blue. A legend was provided to the user on the display showing that this was the case (Figure 5).

2.3.2 Post Trial Feedback

Once all locations had been plotted on the paper map, the user was asked a series of questions about their 3D stereo landscape experience and to ascertain what methods they used to determine their orientation.

3. Results

The results presented here were gathered by measuring distance values on the paper maps between perceived locations as marked by the participants and their actual geographical locations. Additionally, aural feedback was collected from the participants both to provide additional qualitative indications as to the orientation techniques users employed in the study, as well as to provide support when analysing the quantitative findings.

Numerical results, in the form of distance error from the actual point, were measured (1 cm = 3.3 km) and analysed using the R statistical package. A t-test was performed between each of the groups of data obtained (no markers, plain markers and colour markers). The results from these trials are indicated in Table 1. The P- value from this test represents the probability of the two distributions in fact being the same distribution.

Table 1: t-test results

t-test	P value
No markers & plain markers	1.548e-05
No markers & coloured markers	7.443e-06
Plain & coloured markers	0.8167

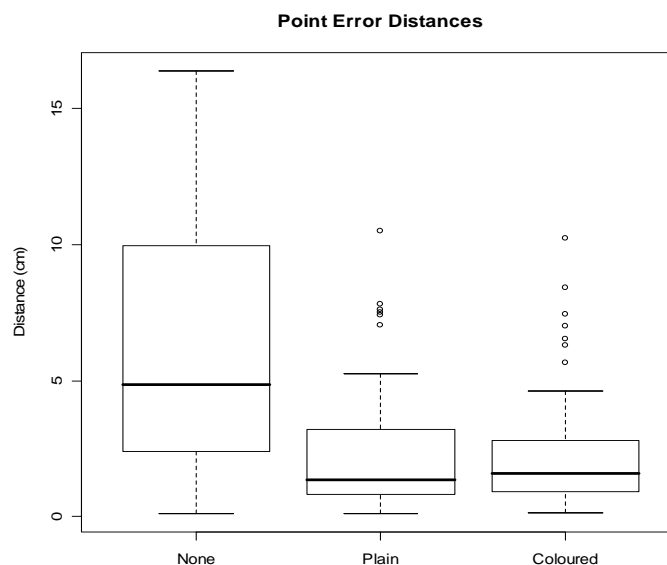


Figure 6: Box plot of error distances

From these results, it is evident that whilst both the plain and coloured markers show a distinctly statistically 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 in Figure 6

This suggests that in fact, knowing the distance from the landmark was not needed by the test subjects when determining their orientation within the environment.

Qualitative feedback suggested that the features used by participants for the orientation tasks were 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. The artificial landmarks were used mainly as global features, owing to their method of implementation.

4 Discussion

From the statistical analysis of the distributions of the error, it has been found that whilst the addition of artificial landmarks into the environment greatly increased the accuracy of the orientation tasks, the further addition of distance information in the form of a colour scale had negligible impact.

A further feature found from the results was that the accuracy of orientation tasks greatly varies depending on the location. For example, trial locations that did not have any distinguishable visible features such as buildings or roads were much more inaccurate in terms of orientation tasks.

Owing to the similarity of results between the trials using plain markers and coloured markers, and post trial feedback given by the users, it was concluded that in fact knowing ones distance from the landmarks makes no difference to accuracy. Topological relationships between the landmarks are determined and this information then used to derive a user location.

However, the main item determined from this research was that in large scale virtual environments where there is little in the way of visible landmarks, it is essential that the user is provided with navigational assistance. Perhaps to a geographer, this may seem self evident, yet in the virtual reality literature much emphasis have been placed on the problem of spatial perception and less on potential solutions. This is particularly the case in regard to open and, to less an extent urban, landscapes; extent work largely focuses on internal environments.

The usefulness or otherwise of style of artificial landmarks presented in this paper, in particular their location in the sky, clearly has a scaled component related to longer distance navigation and a fly-through perspective. At shorter distances, selected man-made landmarks of a more familiar type such as signposts at road junctions are likely to prove of generic value while the highlighting of distinctive buildings may especially benefit those with prior local knowledge of an area. Equally, a mapped inset showing a small scale top-down overview of the area may be beneficial. While as we reported above, initial experiments using map insets by others have been less than successful, it may be that a spatial literacy component to their effectiveness will prove important and that familiarity with topographic mapping is a necessary pre-condition if such insets are to improve spatial navigation and wayfinding. Further research is underway to investigate these matters in the context of geographical, regional landscapes in particular.

Acknowledgements

Data was obtained from Instituto de Cartografía de Andalucía, which was gained access to from the University of Leicester. Acknowledgement is also deserved for NERC who funded my Postgraduate University studies.

5 References

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Biographies

Adam Rousell: *Having just completed my studies at postgraduate level of GIS (MSc), I am currently working as a web developer. My research interests include virtual reality and geographical visualisation, with the intention of doing a PhD in these fields.*