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Walking participants through a virtual model: how we got there and its implications

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Background to project

In the context of urban redesign and public participation, this research aims to establish what differences are afforded between active navigation of a desktop computer model of the built environment, compared to passive observation of a walkthrough of that same model. The motivation for the research is to establish an improved method for architects and urban designers seeking to convey design ideas to their audience.

Findings from the research literature on whether active navigation of desktop virtual environments offers advantages over passive observation are equivocal in many areas. For example, there are contradictory findings in relation to wayfinding, spatial orientation and scene recognition (e.g. Wilson 1999; Christou and Bulthoff 1999; Gaunet et al. 2001). However, there is greater agreement on the issue of memory for spatial layout, with researchers confirming that this is enhanced with active navigation compared to passive observation (e.g. Brooks et al. 1999; Foreman et al. 2005).

Within architecture, there is evidence to suggest that the presentation of moving images (in, for example, a walkthrough) does lead to better understanding of design proposals, but at present the viewer is precisely that, a viewer of a predetermined display. In the research described here we have incorporated 3D CAD (Computer Aided Design) models into a computer game engine in order to give people the ability to actively navigate themselves through an architectural model that would previously only have been accessible to them in the form of a predetermined walkthrough.

We designed a between subjects experiment to investigate what differences, if any, are to be found between active and passive navigation of our desktop virtual environment. Two groups of subjects are asked to navigate/view two different versions of a cityscape, with the explicit goal of choosing the version they like the best. One group of subjects (the Active group) is invited to navigate a route around a cityscape, using mouse and keyboard, directed by the researcher. The other group (the Passive group) is shown pre-recorded walkthroughs of the same route. As the subjects navigate/watch, they are asked to comment on what they see, what they like and what they dislike, using a 'think aloud' protocol. After navigating/viewing one version of the model, the subjects complete a number of perceptual rating scales, and answer questions about their impressions and memories of the model. The task is then repeated for the other version of the model. At the end of the study subjects are asked which version of the model they preferred, and how easy they found it to make this decision. Voice commentary is recorded, as is navigation behaviour.

This paper describes the process we went through in order to establish an effective experimental task.

Design of experiment: issues encountered

Our study used a photorealistic 3D computer model of Tinganes, the historic headland at Tòrshavn, the capital of the Faroe Islands. We used a computer game engine (UnrealEngine2 Runtime®) to convert all the 3D data and digital textures from a CAD model of Tinganes into a real time rendering that enables users to move around the environment using mouse and keyboard. UnrealEngine2 Runtime allows a designer to create a detailed and accurate environment with little scripting knowledge and is also free to use for non-commercial purposes.

The base model consists of a full representation of

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Tinganes' built environment in terms of buildings and street layout, but it does not portray any attributes such as benches, street lights, flora etc.

For our experimental purposes, we needed to produce two noticeably different versions of our model. (It should be noted that it was not our intention to create two versions where one would automatically be preferred over the other, since it is not the preference per se that we are interested in, rather the process of arriving at the preference decision.) The first stage of the process involved the 'furnishing' of the base model with various realistic environmental attributes, such as flowers, trees, benches and people. By positioning these attributes in different parts of our model, we were able to generate two versions of the virtual model.

A key aim in piloting our experiment was to ensure that both Active group and Passive group participants were able to perceive and remember differences between the two versions of the model. In order to encourage wide exploration of the model, we needed a task for participants to perform. Determining this task was far from straightforward. Since the Active group participants needed to cope with the additional task of moving themselves around the environment, we focused on establishing a task that could be reliably performed by this group.

Our initial pilot task asked Active group participants to freely search for four targets distributed within each version of the model. They were asked to tick checklists as they found each target, while at the same time following a 'think aloud' protocol, describing what they saw and their impressions of the environment. We believed that this task would 'force' participants to explore the model and visit all the areas we wanted them to see. However, it became clear that this task placed too great a cognitive load on participants since they rarely reported noticing changes between the different versions of the model. The demands placed on them in terms of exploring the model, thinking aloud as they did so, looking for the targets, remembering routes and areas and answering questions between versions were too onerous. Participants were focusing on locating the targets and not absorbing the environment around them.

As a result of these observations, the experimental design was changed such that the second pilot focused on keeping participants in areas where changes had been made for longer, in the hope that the changes were therefore more likely to be noticed. By placing words beneath the targets, we created a situation where participants would have to get closer to the targets to read the word underneath and would therefore spend longer in a particular area. We made our attribute alterations most obvious within these areas. However, despite these changes, the end result was similar to the first pilot i.e. differences between the versions were not picked up on.

Since it was key to our experiment that participants focused on the 'look and feel of the environment' such that they would pick up on differences between the models, decreasing the cognitive load was imperative.

The final pilot design therefore shifted radically from the previous two. To create a more 'interactive' experience, the 'search for targets' task was eliminated and the participants were verbally directed to three target areas within the two models whilst using the 'think aloud' protocol. The target areas featured dramatic differences between the two versions in terms of missing buildings, different paving and absence of trees, as well as different placement of environmental attributes (see Fig. 1). When participants reached each target area, they were told the number of the target area, asked to look around and give their impressions of the space. As such, our task effectively changed from one of exploration to one of guided navigation, but with the desired result that

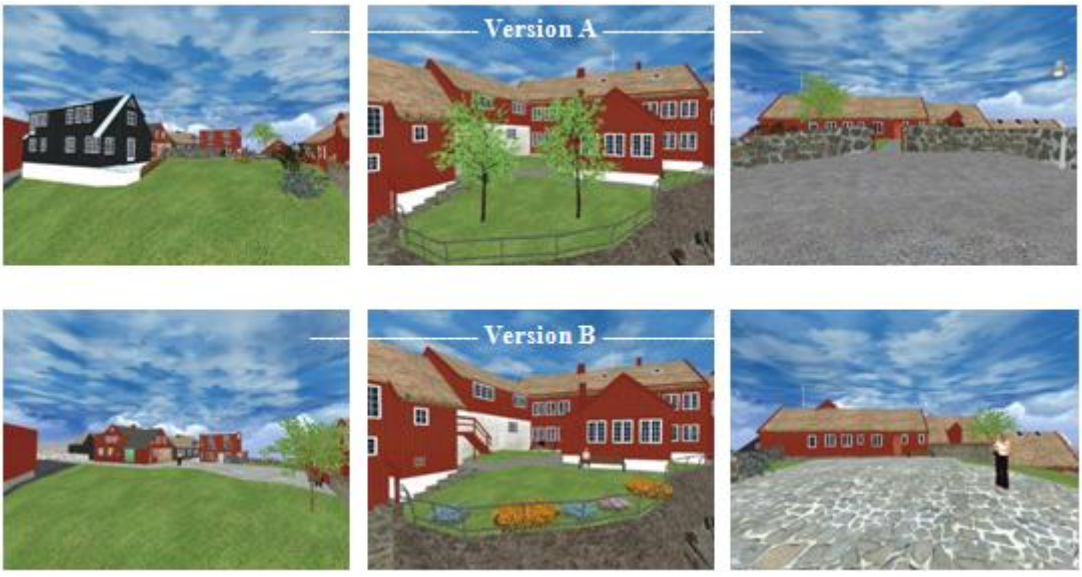

Fig. 1 Example differences between the two versions of the cityscape

participants were identifying differences between the versions of the model.
The Passive group task is to observe a walkthrough of visits to each of the target areas in turn. They are invited to give their impressions of each space in the same manner as the Active group participants.

Technical issues and limitations

In addition to refining the task for participants, we encountered a number of technical issues that merit attention.
The manner and speed at which people move through the model had to be controlled. We took the decision to restrict movement to walking only i.e. no running, jumping or flying, to keep the experience as 'natural' as possible and similar to the manner in which people might normally be expected to explore a new environment. Walking speed needed to be slow enough to ensure that there was enough time to take in details of the environment, yet quick enough that participants did not become frustrated and lose interest. After testing a variety of different speeds, we settled on a speed equivalent to 5.39 km/h. The method for moving through the environment was by mouse only or mouse and keyboard (participants' choice).
The field of view displayed on the screen also affects the performance and experience of the virtual environment (Bishop et al. 2001; Lessels et al. 2004). Based on previous literature and current trends of the video game industry, it was decided that a field of view of 90° degrees for one single monitor was an adequate size for the display, since this is wide enough for an enriching perceptual information experience, does not over-distort the viewed content and is less likely to cause motion sickness than wider or narrower displays (Czerwinski et al. 2002; Lin et al. 2002).
There were a number of other factors caused by time and resource constraints inherent to the desktop computing technology used and the Unreal Runtime® modelling package. The fact that this modelling package license is free for non-commercial and educational purposes meant that some parts of its core are not fully customisable (e.g. height of person, movement of people populating the environment). There is an inevitable trade-off between level of detail in the model, and rendering demands placed on the graphics card, processor and RAM.

Implications for the real world

The issues we have encountered in the design of this experiment have implications for how architects and planners might choose to represent their designs within computer models. For example, we have seen that it is necessary to artificially focus people's attention within our model on particular features or routes, so as to ensure that potential problems connected with lack of clarity and respondent boredom can be avoided.
With many designs pertaining to real world urban planning, public buildings or open space, issues might be less related to specific physical features within a space, and more concerned with the overall atmosphere created by a design and potential, as yet unrealised, uses for a space. This begins to raise questions concerning the extent to which areas and buildings neighbouring a proposed development should also be modelled, but also suggests directions for future research.
Previous research has established that the presence and natural movement of people can have significant effects on the perception and use of a space, including feelings of safety, security and attractiveness. Foremost among future research agendas, therefore, should also be a need to recognise that the kind of interactive 3D model used in this study intrinsically lends itself to the simultaneous navigation of virtual spaces by multiple users.

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