THE VALIDITY OF COMPUTER SIMULATIONS OF URBAN ENVIRONMENTS FOR PLANNING AND DESIGN

I.D. Bishop

Centre for Geographic Information Systems and Modelling,
University of Melbourne, Parkville V3052, Australia

B. Rohrmann

School of Behavioural Science, Department of Psychology
University of Melbourne, Parkville V3052, Australia

INTRODUCTION

For over a decade people have been using computer graphics to simulate environments which are either too remote to visit directly or still being planned or designed. For most of this period there has also been a simmering level of uncertainty about the validity of the simulations being prepared. The early work on validity (i.e. realism in presentation and response) began with simple line drawings [KILL83] and then considered image manipulation at video resolution [VINI89] or in 8-bit colour [BISH89]. Recent studies have compared wire frame and rendered imagery of a campus building with photographs using semantic scaling [OH94]; reported on the validity of in-house software for generating forested landscapes [BERG95]; and considered the impact of scale accuracy on perception of infrastructure elements in the natural landscape [WATZ94]. In general, the results of these studies were encouraging but not conclusive.

This paper proposes several criteria for environmental simulations. It illustrates some of the options: those constrained by the processing capabilities of the technology (e.g. use of interactivity versus high quality rendering) and those choices of detail which are less directly constrained (e.g. the inclusion of sound, the atmospheric and lighting conditions). We then describe research in progress which is seeking to determine the effectiveness of the simulations as a surrogate for direct experience of the designed environment.

CRITERIA FOR ENVIRONMENTAL SIMULATION

The ideal is that each person should react in exactly the same way to a simulated environment as he or she would to the corresponding real environment. From a psychological viewpoint it is crucial that a simulation induces the same reactions as the real environment. In this study the assessed response variables were chosen to determine the perceived environmental qualities [CRAI82] and the emotional response of subjects [RUSS88] to the simulated environment. They were measured with respect to cognitive and affective aspects using psychometric approaches. The criteria for simulation validity thus become:, (a) similarity of recognition and recall, (b) similarity of mood or emotional response, and (c) degree of perceived realism.

TECHNOLOGICAL OPTIONS AND REALISATION

As suggested above, there are two levels of choice to be made in setting up environmental simulations. The first relates to the medium of presentation and is technology driven. The second involves issues of levels of detail, precision and additional presentation features which are not strongly constrained by the technology.

The Medium of Presentation

It is surmised that high levels of realism together with high levels of interactivity will give the best match of simulated to direct experience. Except on the very highest performance workstations it remains necessary to choose between high realism and high interactivity. We can

choose a very high level of reality in image generation - including shadows, reflections, antialiasing etc - using a specialised rendering package (such as RenderMan or the Alias/Wavefront products), or we can choose a high level of interactivity with the data using products such as Performer (Silicon Graphics Toolkit).

Choices in simulation detail.

The are a virtually unlimited range of options for the final presentation, even within the animation medium, of the urban environmental simulation. The choices depend in part of how much time is available for building the data base and added elements of detail - including cracks in pavement, litter and other general clutter. Some choices have lesser time implications but still require some extra work (e.g. increasing the levels of traffic movement or introducing static people). The final product is then the result of a series of trade-off between the possible and the practical. Research into the validity and effectiveness of various combinations can help in getting the best result for the resources available.

THE CURRENT PROJECT

A. General research plan

The project consists of several sub-studies: firstly, different versions of a computer simulation (e.g., regarding light, sound and shadows) have been presented to respondents; secondly, respondents are being asked to assess different modes of presentation, including computer simulations and photography-based versions, as well as the real environment. In each case, cognitive and affective responses are measured through a psychological questionnaire [BISH95a]. The general research aim is to identify which features of a computer-simulation of environments are crucial influences on perception and subjective appraisal.

B. Building the Data Bases

Most of this research has been based on Alias/Wavefront simulations of the streets and park-land adjacent to the Civic Centre in the Melbourne suburb of Camberwell [BISH95b]. New aerial photography was taken on a non-business day and at a time with appropriate shadow angles. Eventually 50 mm accuracy was achieved in the central retail area. Contours at 0.5 metre intervals plus spot heights were provided along with roof planes and verandahs and other major roof equipment. Building walls were created by extrusion of the roof planes.

The basic geometry of the environment is supplemented with texture mapped building facades and trees to give a more realistic appearance. We used video capture to record both the park vegetation and the facades of buildings within the parklands and along the adjacent streets. Portions of the images were captured or scanned into Adobe Photoshop where the relevant item could be separated from its background.

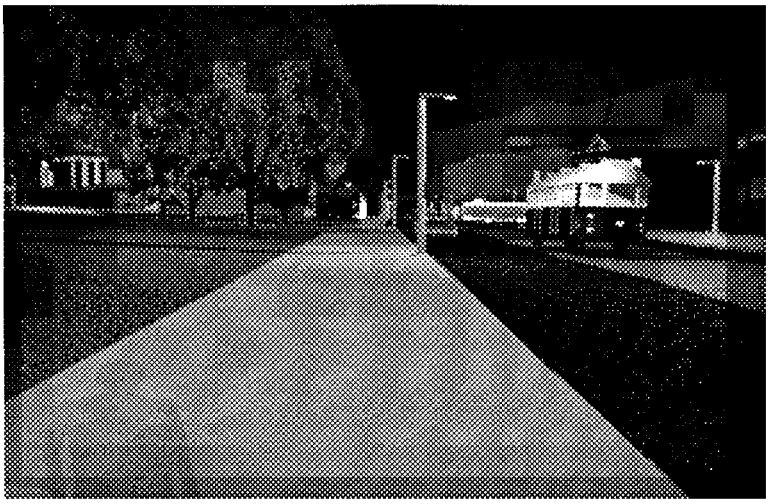

Figure 2. Night-time rendering of the environment with personal shadow and animated tram.

C. Experimental Variables

In a coordinated series of experiments, the influence of several factors, related to the medium and to physical features of the presented environment, is being studied.

1. The Medium of Presentation

Five modes of presentation are to be compared:

- direct experience of the environment
- the computer animation (Advanced Visualizer)
- a 'walk-through' captured with a video camera on the same route as the animation
- a series of still simulated images taken along this route
- an interactive computer based exposure to the environment (Performer)

2. Sound. Conditions are:

• no sounds • daytime urban sounds • late night urban sounds

These were recorded in the represented setting itself and dubbed into the final animated simulations.

3. Shadow. Personal shadow as cast by a person (not identifiable by sex) at the viewer/camera location:

• without personal shadow • with personal shadow.

4. Lighting. The separate lighting/atmospheric conditions will be:

- sunny daylight - single light source
- foggy daylight - ambient lighting
- clear night time - artificial lighting in street and park

To date a total of ten (10) experimental simulations have been prepared. In each case an animated sequence representing a two and half minute walk (1250 frames at 8.33 frames per second) was created on video-tape.

D. Measuring Responses

Based on the criteria for simulation validity identified above the following aspects were measured:

1. Cognitive responses

- identification and retention of main objects and structures; measured through a recall task
- perceived "legibility" , i.e., the recognition of main features of the environment
- rating of naturalness (vs. designed/built/shaped by humans)
- assessment of realism of simulations: overall and for features such as shapes, light, shadows etc

2. Affective responses

- aesthetic evaluation according to subj. criteria for "beauty" and congruity [NASA94]
- affective environmental qualities: to be measured through the semantic scaling procedure [RUSS88]. It is based on 20 adjective pairs which relate to a two dimensional psychological space defined by the factors of pleasantness and arousal versus boredom.
- perception of safety (for people travelling through the environment)
- liking (overall) of the place (how much and why).

E. Data Collection

Six audience groups were established each being shown a different visual simulation. Each audience was shown first the simulation without sound and then the same simulation with sound. To control for sequence effects, for one simulation the no-sound/sound versions were presented in both orders.

CONCLUSION

The use of environmental simulations for urban planning and design depends upon our ability to produce such simulation in a timely and cost effective manner and to be assured that public response to the simulations matches the responses that will eventuate should the proposed project proceed. The development of digital data bases for urban areas and the increasing availability of affordable computer hardware capable of producing realistic simulations suggests that environmental simulation will be increasingly used in this context. The early indications from this work are encouraging in that the overall evaluation of realism for most versions is quite positive. It is also clear even from preliminary analysis that sound is an important issue. The results which are still to emerge from this interdisciplinary study will further develop our understanding of the potential of computer graphics as an importance component of urban planning and design.

ACKNOWLEDGMENTS

The simulation component of this work has been supported at certain stages by the (then) City of Camberwell. The simulation studies themselves are supported by two grants from the Australian Research Council. Alan Nash and Mark Shurey have carried out much of the hard work.

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