Summary: This paper deals with the architectural aspect of virtual environment design. It builds on precedents from the areas of architectural, urban design and environmental cognition and attempts to suggest an architectural way of thinking about designing the spatial elements of a virtual environment. A taxonomy of the objects and the spatial elements that a VE consists of is presented as the main hypothesis. Finally, a method for evaluating this hypothesis is suggested.

Keywords: Virtual environment design, virtual reality, architecture, information visualisation.

1. INTRODUCTION

This paper documents a research project which deals with the architectural aspect of virtual environment (VE) design. It aims at developing an architectural way of thinking about designing space in a VE through studying the significance spatial elements in a VE may have with respect to wayfinding behaviour. In order to achieve this, precedents from the disciplines of architectural, urban design and environmental cognition have been used.

The predominant use of virtual reality (VR) technology in relation to architecture, so far, has been as a means of visually simulating architectural designs. In fact, VR may be considered as the ultimate medium for producing representations of architectural designs, as it is the only technology capable of simulating the experience of being and moving within a designed environment prior to its construction. This paper, however, is concerned with how architectural design may contribute to the design of VEs.

It specifically refers to a particular class of VEs, named in a World Design Inc report (1993, p.12) as abstractions, which support interactive access to information that has no physical representation.

This paper does not refer to simulations, where the aim is to realistically imitate real objects and events. In the real world, architectural form is often dictated by physical constraints (gravity, friction, weather conditions etc.). As such constraints are not easily implemented and often quite unnecessary in a non-simulation VE, objects or elements of space do not necessarily have to resemble any real-world elements. However, in the generation of new methods of composing form in order to define space in VEs, designers may build on what is known about space in the real world while avoiding the imitation of real world forms without a specific purpose.
It must also be stressed that this paper does not refer to dynamically evolving representational environments. It is understood that the three-dimensional visualisation of a data set would have to support the nature of a dynamically updatable database. Accordingly the re-arrangement of data in a dynamically evolving three dimensional environment can be seen as the ultimate goal of this research in the future. However, as experienced from existing examples, such dynamic VEs are usually little more than sparse constellations of abstract geometric primitives. Therefore, this research currently focuses on VEs which are not dynamic but have been designed as a static visualisation of a pre-determined database, affording limited addition or subtraction of data.

Such VEs may consist of several auditory and/or visual entities and events which have no real-world counterparts and which accommodate human activities such as navigation, interaction or communication within this three-dimensional, representational context. To this extent, the spatial design of a VE is an architectural problem and this paper considers architecture and urban design as appropriate precedents for informing VE design.

2. HYPOTHESIS

When we navigate in real environments, we find our way by utilising environmental information conveyed to us directly (signs, maps, etc.) or indirectly (architectural and spatial characteristics of a setting) (Passini, 1992, p.90). Similarly in VEs, the setting defined by a certain arrangement of objects may indirectly inform us of forthcoming events or direct us towards significant spaces. If we want to design VEs where the arrangement of spaces aids the users’ spatial awareness, we firstly have to investigate which are the objects that we may find in a VE and what types of spaces these objects define.

Earlier work (Charitos, 1996, Bridges and Charitos, 1997) has attempted to develop an architectural way of thinking about designing VEs, based on the phenomenological aspect of thinking about space in the real world. These views were in need of support by more objective evidence. Accordingly, the second phase of this research focused on how we think about and remember space when navigating in our environment, as seen from an environmental cognition perspective. This lead to a better understanding of the characteristics that make environments more memorable and to a definition of objects and spatial elements which may be identified within a VE. As a result of these two phases, a hypothesis about the nature, significance and structure of the possible spatial elements that a VE consists of was introduced.

Following Deleuze (1983) a VE may be seen as a closed system. Within this system, framing is the art of choosing the elements which become a part of a set (a relatively closed system), which includes everything which is present in an image. These elements consist of props and characters. The architectural design of a VE may be then seen as the determination of this closed system which includes all elements which are present in an image. However, this project focuses on the “inanimate” and relatively static props and the sets which they define. Characters, which are the dynamic, animated objects that may inhabit a VE are not being considered in this project.

2.1 Props

According to the hypothesis, the spatial design of a VE involves the composition of props which are visual and auditory “inanimate” objects that define space, by virtue of their formal qualities and their arrangement within the VE. Three types of props are identified here:
2.1.1 Landmarks: When we navigate in a VE, we firstly recognise those landmark objects, which are predominant within the context of the VE, as seen from our subjective point of view (behaviour, social aspects, experiences, etc.). Lynch (1960, p.48) defines landmarks as point-references within the urban environment which may vary widely in scale. Their use involves the singling out of one element from other alternatives in a VE, because of their form or function. They are mainly static but may also be mobile, if their motion is sufficiently slow and regular. When designing landmarks, Lynch (1960) and Appleyard (1969) have suggested certain criteria which affect their significance within the context of an environment. According to these, a landmark would be easily identified if:

- it has prominent physical features or
- it contrasts with its background, in terms of form and other characteristics (meaning, style) or
- it is visible from many locations or
- it is being used frequently or performs a symbolic function.

Figure 1: Vaguely defined boundaries.

2.1.2 Boundaries: According to Ching (1979, p.108), space is “inherently formless; its visual form, quality of light, dimensions and scale depend totally on its boundaries as defined by elements of form”. These boundaries generally define all spatial elements by binding them, in varying degrees of explicitness. Similarly, a VE consists of boundaries, visual and/or auditory, which bind and subsequently define virtual space and the spatial experience in the VE.

2.1.3 Thresholds: A third intermediate type, the threshold, is an object which signifies the transition between spaces, while navigating in a VE. Thresholds still define spaces by binding them but at the same time afford movement through themselves. Unlike real environments, the “solidity” of an object in VEs depends on whether collision detection is “on” or “off” and consequently a threshold does not have to be void to afford passage.

Figure 2: A threshold signifying the beginning of a path
2.2 Elements of a Set

The four types of spatial elements which constitute the sets that the VE consists of are defined in this section of the paper, in terms of their spatial qualities and significance:

2.2.1 Place: Bell et al. (1996, p.79) refer to place as a component of spatial knowledge and describe it as a spatial unit to which we attach information like name and function and perceptual characteristics such as affective quality or affordances. Norberg-Schulz (1971, p.19) defines place as the “space where particular activities are carried out”, while stressing that these activities are meaningful only in relation to their corresponding places. When a place’s boundaries and consequently the relation between “inside” and “outside” are clearly defined, then the user may feel secure enough to engage in an activity there. The character of the place is therefore dependent on how explicitly this place is defined by its boundaries as well as on its form and volumetric proportions.

A place may be:
- a goal, or
- a focus for an event or
- a point of departure towards the rest of the environment.

2.2.2 Path: A path is a kind of space which implies movement and within which directions are always evident, due to the formal qualities of its spatial arrangement.
When navigating in a VE, after identifying certain landmarks within the environment we begin to think of the routes which connect these landmarks. During this stage, we acquire the second type of spatial knowledge, route knowledge. The physical expression of a route is the path. It is important to take into account that active engagement in navigation enhances the generation of route knowledge, considerably more than passive viewing does. (Gale et al., 1990, p.21)

A path consists of:

- a starting point,
- a direction to be followed through a sequence of places and events and
- a final destination

2.2.3 Intersection: An intersection is the space of interaction between other elements. When acquiring route knowledge, more information is coded at intersections, where choices are made as opposed to between intersections. These spaces are the main decision points for wayfinding in an environment, as they afford viewpoints to actual and potential navigation choices and generally provide the user of the VE with richer and more complex environmental information. In addition, the novelty of having fresh visual stimulus where new views are first seen may contribute significantly on focusing attention and encoding information. (Gale et al., 1990, p.21)

![Image of an intersection]

Figure 5: An intersection.

2.2.4 Domain: A domain is a subset of the whole VE which consists of a system of paths and places. Domains are mainly thought of rather than directly experienced, as a whole. It is necessary to structure a VE by means of domains, in order to be able to conceptualise it as a whole. In real environments, domains expand in two dimensions, due to physical constraints. In virtual environments, which are devoid of such constraints, domains may expand in three or more dimensions.
3. EVALUATION

In the last phase of the project, the hypothesis is being evaluated by means of an experimental study. This phase consists of the following stages:

- A VE has been created which closely follows this hypothesis and which functions as a three-dimensional interface to a repository of image and sound objects.
- A set of experiments are being conducted for the purpose of evaluating the effectiveness of the hypothesis as a framework for the spatial design of VEs. Users are required to undertake simple wayfinding tasks, involving exploration and search for particular objects within the VE. User feedback is provided by means of questionnaires, focused interviews, sketched production of a cognitive map and other performance measurements. It has to be stressed, however, that the focus of documenting the users’ experience is on the qualitative rather than on quantitative aspects of their performance. (i.e. task execution times are considered as less significant than the quality of their spatial memory of the VE).
- Further objectives are to resolve more specific design issues. These issues have mainly emerged during the process of designing the VE, while attempting to adapt an architectural way of thinking about designing real environments to the particularities of designing space in VEs. For this purpose, parts of the VE have been designed so as to direct subjects towards situations, where their particular behaviour provides answers to these issues.

REFERENCES

BIOGRAPHICAL PROFILES

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- Currently a research fellow in ABACUS – University of Strathclyde, he has undertaken a three-year research project, supported by the Commission of the European Communities, under the Training and Mobility of Researchers Programme. The project deals with the architectural aspect of virtual environment design and during the 96-97 period he has published on this subject in conference proceedings, academic journals and magazines.
- Awarded the degree of MSc in Computer Aided Building Design from the University of Strathclyde.
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