ON ARCHITECTURAL DESIGN IN VIRTUAL ENVIRONMENTS

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1. INTRODUCTION

This paper discusses precedents for the design of virtual environments (VEs). The domains investigated are architectural design and film theory. It is suggested that these domains may form the background for the consideration of possible metaphors for the design of VEs.

Firstly, the paper considers the use of architectural design knowledge in the design of VEs. Differences between VEs and PEs are also considered, for the purpose of identifying the limitations of such use.

Secondly, the paper investigates the use of film related studies for enhancing our conception of movement and time in a VE. Through this analysis, it is also indicated that humans can cope with spatiotemporal discontinuities, which are inherent in VEs.

2. DRAWINGS AND VIRTUAL ENVIRONMENTS

2.1 Drawings and virtual environments as simulations.

Computer drafting and drawing in general play a major, if not entirely decisive, role in the creation and development of architectural ideas. Drawing has provided a way for architects to explore their concepts about built form, free from the constraints of construction. The power of drawings lies as much in their power of suggestion as in their power of description.

Robin Evans (1986, pp 3-18) points out that: "Recognition of the drawing's power as a medium turns out, unexpectedly, to be recognition of the drawing's distinctness from and unlikeness to the thing that is represented, rather than its likeness to it, which is neither as paradoxical nor as dissociative as it may seem". Certainly for a particular group of architects (Daniel Libeskind, Lebbeus Woods, Wolf Prix, Zaha Hadid, Rem Koolhaas, Frank Gehry and others) the drawing is almost more important than the building for it is only relatively recently that these architects are being commissioned to build.

Libeskind (1991) elaborates on how drawings have assumed the identity of signs. They are now considered to have an existence of their own. Indeed they may be seen as the major output of architectural design. Once the idea of a drawing as an instruction for building is dispensed with, drawings may be seen as a coherent formal system in themselves. Drawings may thus exist as independent systems without any reliance on the potential existence of any building. They have their own coherent set of rules and conventions and, furthermore, can carry meaning and serve as subjects for interpretation.
Drawings are abstract representations of designed environments and so may be considered a subset of the class of virtual environments (VEs), in the sense that they both are simulations of mental models of environments conceived by the designer. VEs, however, may also be directly experienced as three-dimensional spaces, due to the enabling technologies which support them. As such, they may serve as an alternative platform for design exploration.

The advent of related technologies has led Baudrillard to argue that: "Abstraction today is no longer that of the map, the double, the mirror or the concept. Simulation is no longer that of a territory, a referential being or a substance. It is the generation by models of a real without origin or reality: a hyperreal" (Baudrillard, 1983). VEs can accordingly be seen as "hyperrealities" carrying experiential qualities, existing independently in their own right and not necessarily as simulations of real objects and phenomena which constitute PEs.

A VE does not necessarily need to imitate any reality, as in the case of a simulation of a real-world task. It may communicate to the operator a synthetic experience which cannot happen in the real world. This is due to the fact that a VE is being experienced via the same perceptual processes employed for perception in the real world, so if the patterns of information, which are being perceived are accurately constructed to simulate the perceptual mechanisms inherent in the subject, a non-realistic synthetic environment still comes across as convincing and effective for a specific task (Carr and England, 1995). The relationship of architecture and VE design is investigated from this viewpoint.

2.2 Architecture and Virtual Reality

There is a two-way relationship between architectural design and virtual reality technology:

- architectural design can employ virtual reality techniques for evaluation, communication and documentation purposes and
- virtual reality can employ architectural design, as one of the disciplines, which may contribute to the design of virtual environments.

This paper focuses on the latter aspect of this relationship.

Jean-Louis Gasee defines the interface as: "the cognitive locus of human-computer interaction"(1990, p.226). Humans participate in on-line networked communities (MUDs, MUSEs) and interact with computers via HCIs, in ways that give the interaction experience a predominantly three-dimensional spatial character.

In graphics user interfaces (GUIs) the screen can be seen as the barrier between the users and the "world" of the computer which they are trying to explore. The same can be said about cinema and since the beginning of the century filmmakers have been trying to find ways to engage the viewer and surpass this barrier. Walker (1990, p.444), suggests that VR technology takes us to the next generation of human-computer interfaces, where the user can surpass the screen and "enter" the computer. He defines "a cyberspace system as one that provides users a three-dimensional interaction experience that includes the illusion they are inside a world rather than observing an image."

These developments contribute to the notion of the HCI as having a three-dimensional spatial character. More so a virtual environment, by definition, is experienced by the user as a kind of three-dimensional space.

Whenever we need to represent, dynamically and visually, some abstract concept or when we need to employ some type of metaphor, not intrinsic to the nature of the task, we
need to design a VE which comprises several spatial entities and phenomena, which have no real-world counterparts. These entities and phenomena accommodate human activities such as navigation, interaction and communication. To this extent, the design of a VE is an architectural problem as well, so it may benefit by making use of architectural design knowledge. The limitations imposed on how we can apply such knowledge to the design of VEs will be better defined when the differences between VEs and PEs are clarified.

3. THE DIFFERENCES BETWEEN VEs AND PEs

The operator of a VE system perceives the VE through the same perceptual processes involved in the perception of the PE. However similar VEs and PEs may be in the way that they are being manifested to the human, they are, by nature, significantly different as well. These differences may be seen as problems which are due to the limitations of current VR technology and which may be overcome as the technology evolves. They may also be seen as intrinsic characteristics of VEs, causally related to VR technology again, but essential in helping us to understand the individual nature of VEs as a medium.

Firstly, due to limitations of VR technology:

- VE systems cannot approach the resolution and complexity of experiencing a PE,
- output devices provide feedback (visual, auditory, tactile) for only three of the five senses and
- users do not receive enough visual, auditory or tactile kinaesthetic information from the representation of their bodies in the VE.

3.1 The human body and its avatar.

In reality, one sees the environment not only with the eyes but with the help of a system consisting of the eyes, which are positioned in the head, which is positioned on the body, which is resting on the ground. An observer perceives the position of "here" as being relative to the environment and also to the body which is "here". The occupied point of observation is constantly in motion, so observers always see their bodies moving relative to the ground or see that part of the environment toward which they are moving. These are all cases of visual kinesthesis. (Gibson, 1986, pp.205-208)

Piaget also understands perception of space, as an activity which cannot be dissociated from the very subject and the surrounding environment: "space is the product of the interaction between the organism of the subject in which it is impossible to dissociate the organisation of the universe which is perceived from that of the activity itself" (Piaget, 1955, p.217). Humans, therefore, have evolved while perceiving themselves as parts of the environment and have accordingly developed space schemata for existing in this environment.

McLellan (1994, pp.33-35) describes "avatars" as the only representations of the operators' bodies, which are being displayed to them in an immersive VE. If the avatar is only a three-dimensional cursor or a glove, as is often the case, operators cannot perceive the "here" and "there" of the surrounding environment as relative to their body being "here", and this reduces their sense of presence. They do not receive the visual feedback needed for informing them of their own movements relative to the VE. There is experimental evidence (Smets, in Carr and England, 1995) which suggests that the coupling between our own movements and shifts in the optic flow allows us to estimate where things are in space relative to ourselves and this coupling causes a sense of telepresence.
The sense of presence (Steed, Slater, 1994) increases when there is a direct visual consequence of each of the operator's movements and when there is an obvious mapping between the operator's movements and the movements of the virtual body. There is experimental evidence showing that kinaesthetic sense, which includes proprioception, is just as important as the increasing quality of the visual and auditory channels for increasing the sense of presence and for this reason the representation of the body in the VE is an essential feature of the system.

A basic aspect of a person's being in the world is movement along a path, in the environment. Schulz (1971, p.35) suggests that we move because we want to "take possession of the environment" and we can achieve that by running, strolling, marching or dancing. In VEs operators cannot move in these natural ways but are limited to the forms of interaction, defined by the input/output devices, which determine the metaphor for movement; i.e. walking on a treadmill, flying where the virtual finger points, etc.

The avatars used as representations of the operators' bodies in VEs do not provide them with the visual kinesthetic feedback needed for informing them of their constantly changing position in the environment. Consequently, their sense of presence and their overall sense of space is limited.

We have to design VEs in a way that helps operators establish spatial schemata, which can be coordinated with the ones they have established in their existence in PEs. The fluid innate nature of VEs, as identified by Novak (1991, pp 248-251), may hinder the establishment of these schemata. The assumption that a mobile, wholly-changing environment can be disorientating is strongly suggested by Schulz (1971, p.34-35), who quotes Piaget's words: "a mobile world would tie a man to an "egocentric" stage, while a stable and structured world frees his intelligence". Spatial anchors should be carefully incorporated in the experience of a VE.

An operator of a VE system "dwells" in the VE, in the sense that Heidegger speaks about "dwelling" (1971), even if that is the case for the few minutes of being immersed. If we want this experience to come across as meaningful and convincing, we should design a VE which helps operators define the topological relations of "inside" and "outside", so that their experiences and memories are located, and the inside of space becomes the inside of their personality (Bachelard, 1964, ch IX).

### 3.2 The intrinsic characteristics of VEs

VEs are, by nature, very different from PEs in that:

- there exist no physical constraints to dictate the dynamic, spatio-temporal nature of a VE,
- there is no scale consistency,
- space is non-contiguous and multidimensional and self-reflexive,
- time is not necessarily continuous, may be reversed and its pace may be altered (slowed-down or speeded up).

A fundamental characteristic of VEs is the lack of any physical constraints, similar to the ones which dictate our existence in a PE. One cannot speak of gravity or friction in a VE unless we design and implement them.

Although all geometrical models of objects are designed in three-dimensional Euclidean space, we are not limited to three dimensions in a VE, because any 2D plane or point may
unfold to reveal other environments. VEs also allow for the interactive visualisation of data sets represented by 4D or higher-dimensional spaces. (Feiner and Novak)

The scale of the environment, relative to the operator, may be altered at will. We may transform our size in relation to each level of the environment, and this way experience all levels in a very direct way, as we can experience the level of things in PEs.

Space in not continuous or contiguous as real space is; the structure of spaces within a VE may be more of a hypertextual nature. In general, the principles of real space may be violated in VEs (Benedikt, 1991, pp.119-224) and the characteristics and constraints are only determined by the specifications which define the VE.

Understanding how these differences are being experienced may lead to useful insights into the problem of designing VEs and may also define the limitations of using architectural knowledge in such a design.

3.3 Architectural elements in VEs

Openings (doors and windows) should exist in VEs only when the "walls" or surrounding surfaces do not permit the passage through them; that is only when collision detection is supported. This gives a meaningful and consistent identity to the door. If we were able to enter a place by passing through a wall then the door would lose its significance.

A window may afford viewing through, or even passage through itself; we may enter a place by flying through a window, according to the mode of navigation within the VE. There should also be a functional differentiation between events which correspond to the two states that a door can be found in; that is being opened or closed. Otherwise the door would simply function as a gate. This fact influences not only the opening itself as an object, but the relation of the enclosed place, through the direction directed by the door, to the outside and vice versa.

Such consistencies help operators establish an existential foothold in a VE, because they correspond to familiar space schemata and real world actions. A cupboard, for example, in a VE should afford opening and storing of objects, otherwise it should not have the appearance of a cupboard. Having this appearance, it provides visual information that this object affords opening and storing, so its function should be consistent with this.

Qualities of built structures in a PE, such as the materials, thicknesses and weights of structural or other built elements, have no significance in VEs. For example, a wall, that is the object that divides two places, may be a surface of zero thickness or it might have more dimensions or be transformed during the course of time. Textures, sampled from real materials or artificially constructed and mapped on the surfaces of the VE, can significantly enhance the perception of these surfaces and consequently the overall spatial experience of the VE, according to Gibson's (1986) approach.

4. LEARNING FROM FILM RELATED STUDIES

4.1 Cineplastics

Since the late nineteenth century, film has provided a platform for spatial experimentation. Abel Gance (1912) expressed the hope that cinema would be a "sixth art" which would provide "synthesis of the movement of time and place".
It was the art historian Elie Faure, however, who first coined a term for the cinematic aesthetic that brought the two dimensions together: cineplastics. "The cinema", he wrote in 1922, "is first of all plastic. It represents, in some way, an architecture in movement that should be in constant accord, in dynamically pursued equilibrium, with the setting and landscapes within which it rises and falls. ... The cinema incorporates time to space. Better, time, through this, really becomes a dimension of space" (Faure, 1922). By means of the cinema, Faure claimed, time becomes a veritable instrument of space, "unrolling under our eyes its successive volumes ceaselessly returned to us in dimensions that allow us to grasp their extent in surface and depth". The "hitherto unknown plastic pleasures" thereby discovered would, finally, create a new kind of architectural space, akin to that imaginary space "within the walls of the brain". "The notion of duration entering as a constitutive element into the notion of space, we will easily imagine an art of cineplastics blossoming that would be no more than an ideal architecture, and where the 'cinemimic' will ... disappear, because only a great artist could build edifices that constitute themselves again ceaselessly by imperceptible passages of tones and modelling that will themselves be architecture at every instant, without our being able to grasp the thousandth part of a second in which the transition takes place".

4.2 Cinematic time and movement

One of the most striking preoccupations of modernist and postmodernist aesthetics is the question of time. Bergson (1912) puts forward several theses on movement and time, which are of relevance to virtual worlds. The first (and best known) is that movement is distinct from the space covered. Space covered is past whereas movement is present - the act of covering. The space covered is divisible whilst movement is indivisible. This leads to the proposition that the spaces covered all belong to a single, homogeneous space, whilst the movements are heterogeneous, irreducible amongst themselves. Thus movement cannot be reconstituted with positions in space or instants in time. If we examine a sequence of film stills we see a succession of "frozen instants" but the movement always takes place in the intervals between. Movement thus always occurs in a concrete duration and each movement has its own qualitative duration.

Deleuze (1986) comments that modern science has related movement not to privileged instants but to any-instant-whatever. Bergson (1986, p. 355) remarks "Modern science must be defined pre-eminently by its aspiration to take time as an independent variable." Cinema simply follows this lineage. Deleuze (1986, p. 5) thus defines cinema as the system which reproduces movement as a function of any-instant-whatever; that is, as a function of equidistant instants, selected so as to create an impression of continuity. The relevance to Virtual Worlds becomes apparent if we consider the "intermediary" form of animated film (cartoons). If the cartoon belongs to the cinema, this is because the drawing no longer constitutes a pose or completed figure, but the description of a figure which is always in the process of being formed or dissolving through the movement of lines and points taken at any-instants-whatever of their course. The cartoon film is related not to an Euclidean, but to a Cartesian geometry. It does not give us a figure described in a unique moment, but the continuity of the movement which describes the figure.

Writing around the same time as Faure, Erwin Panofsky (1991) asserted "these unique and specific possibilities" of film could be "defined as dynamatisation of space and, accordingly, spatialisation of time. ... Not only bodies move in space, but space itself does, ap-
proaching, receding, turning, dissolving and recrystallising as it appears through the controlled locomotion and focusing of the camera and through the cutting and editing of the various shots. This led to the inevitable conclusion that the proper medium of the cinema was not the idealisation of reality, as in other arts, but physical reality as such.

The elements of cinema relate to VEs insofar as they operate within a closed system. Following Deleuze (1986, p.18) again, we will call the determination of a closed system, a relatively closed system which includes everything which is present in the image - sets, characters and props - framing. Framing is the art of choosing the parts of all kinds which become part of a set. The closed system determined by the frame can be considered in relation to the data that it communicates to the spectators: it is "informatic" and saturated or rarefied. Considered in itself and as limitation, it is geometric or dynamic-physical. It is an optical system when it is considered in relation to the point of view, to the angle of framing. Finally it determines an out-of-field, sometimes in the form of a larger set which extends it, sometimes in the form of a whole into which it is integrated.

Cutting is the determination of the shot, and the shot the determination of the movement which is established in the closed system, between elements or parts of the set. Thus movement has two facets: it is the relationship between parts and it is the state of the whole. The purest form of this kineticism may be seen in the Expressionist films of the 1920's, such as Robert Wiene's (1920) "Das Kabinett des Dr. Caligari" and "Raskolnikov" (1923), or Wegener's (1920) "Der Golem" whose great set designs would not look out of place today. Geometry was emancipated from the co-ordinates which condition the extensive quantity and from the metrical relationships which regulated movement in homogenous space.

5. CONCLUSION

The conclusion arising from this analysis is that virtual environments should not attempt to model the "real" world in ever increasing detail (like Borges' map makers who drew maps at greater and greater levels of detail until they finally produced a map which fitted exactly over the real space). Architectural design theory can inform the design of such VEs, which do not simulate real-world experiences. But VEs provide the user with a substantially different experience than PEs and this differences should be taken into account, when viewing the problem of VE design from an architectural viewpoint.

More specifically, in a VE:

- space is non-contiguous, multidimensional and self-reflexive,
- time is not continuous, can be multidirectional and its pace can be altered,
- there exist no physical constraints,
- there is no scale consistency,
- users do not receive enough kinaesthetic information from the representation of their bodies in the VE,

Film theory and philosophical readings are valuable for enhancing our understanding of the intrinsic characteristics of VEs. Moreover, our everyday experience with new media proves that we can cope with spatiotemporal discontinuities.

REFERENCES