Abstract

This paper presents part of the work produced for the project "The Architectural Design of a Virtual Environment for a Three-Dimensional Human-Computer Interface" which is sponsored by the Commission of the European Communities under the Human Capital and Mobility Programme and is being supervised by Dr Alan H. Bridges. It argues that one suitable source to refer to when designing virtual environments (VEs) is architectural theory. Its main aim is to inform the design of VEs by providing a background for the consideration of possible design metaphors and it is assumed that this aim can be achieved by establishing an existential conception of space in a VE.

In order to achieve this aim, the paper builds on Norberg-Schulz's theory of existential space and attempts to expand it by referring to other relative studies, which follow a phenomenological approach towards analysing the concept of space. These studies all share a common desire for dealing with the nature of the subjective, phenomenal experience of space. The construct of "existential space" is being used as a starting point for identifying the constituting elements and for conceptualising the structural levels, that the physical environment (PE) consists of.

Consequently, differences between PEs and VEs, which result from the limitations of the current state of the art of VE systems, will be considered. These differences will help to identify ways of adapting the proposed taxonomy of existential space elements and structure to the intrinsic nature and characteristics of VEs. This adaptation is a starting point towards building an existential conception of space in VEs.

1.1 Introduction

Science fiction films and novels have frequently inspired the designers of computer generated animations or virtual environment (VE) applications to borrow several terms, concepts or even specific imaginative forms and objects of any scale, in order to cope with the problem of giving shape and function to something so novel and unexplored as a virtual world.

Whilst literature and film are appropriate precedents, there are more suitable sources to refer to when designing virtual worlds. (Bridges, 1995) This paper argues that one such source is architectural theory. In support of this argument it builds on Norberg-Schulz's theory of existential space and attempts to expand it by referring to other relative studies, which follow a phenomenological approach towards analysing the concept of space. These studies all share a
common desire for dealing with the nature of the dynamic, subjective, phenomenal experience of space. The construct of "existential space" is being used as a starting point for identifying the constituting elements and for conceptualising the structural levels, that the physical environment (PE) consists of.

Consequently, differences between PEs and VEs, which result from the limitations of the current state of the art of VE systems, will be considered. These differences will help to identify ways of adapting the proposed taxonomy of existential space elements and structure to the intrinsic nature and characteristics of VEs. This adaptation is a starting point towards building an existential conception of space in VEs. The main aim of the paper is to inform the design of VEs by providing a background for the consideration of possible design metaphors and it is assumed that this aim can be achieved by establishing an existential conception of space in a VE.

Another aspect of the ongoing VE related research in ABACUS is the conception of time in VEs. (Bridges, 1995) It is not possible, however, to present both the spatial and temporal aspects of the problem in one paper, therefore this study will focus only on the spatial attributes of the environment and on how these relate to our understanding of places. Personal and social aspects of behaviour will not be taken into account.

The phenomenological approach, followed by the paper, can be criticised as having an exclusively subjective and qualitative character and as such being in opposition with the systematic and quantifying methods of traditional psychological research. It is considered, however, that the concepts and ideas which will be generated at this level can later be approached and evaluated with the help of more systematic and quantifying methods of research.

1.2 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 or documentation purposes and
- virtual reality can employ architectural design, as one of the disciplines, needed for the design of virtual environments.

This paper focuses on the latter aspect of this relationship.

The experience of a virtual environment has, predominantly, a spatial character. A virtual environment is experienced, by the user, as a kind of three-dimensional space, only a "virtual space", in the sense that the user only virtually exists in it. To the extent that designing a virtual environment necessarily involves designing spatial entities, which will accommodate human activities like navigation, interaction and communication, the design of a virtual environment is an architectural problem as well.

However, it is understood that not all VEs require the contribution of architectural design knowledge for their development. In the case of a simulation of a real-world task all spatial entities and objects of the environment are modelled precisely so as to imitate their real-world counterparts, and so there is no need to design any novel entities of a spatial nature.

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 do not necessarily have real-world counterparts and which will accommodate the interaction of the operator with the VE. In this case, the design of the VE may benefit by making use of architectural design knowledge. The extent to which architectural knowledge is relevant to the
design of VEs will be better defined when the differences between VEs and PEs are clarified, according to the current state of the art of enabling technologies.

2.1 The Concept of Space

The spatial experience, according to Norberg-Schulz, is "a dimension of human existence and not merely a dimension of thought and perception, essential for orientation and action in the environment." (1971, p.9) Our world consists of phenomena and the most permanent relations between phenomena constitute an object. We survive in our environment by orienting ourselves to objects, which are being manifested to us through the psychological and cognitive processes involved in perception. Our existence in the PE cannot be conceived separately from the very experience of space, since it relates to our perception-of and behaviour-in "space" and is therefore dependent on our awareness of this "space", around us and beyond.

"Most of man's actions comprise a spatial character, in a sense that objects of orientation are distributed according to spatial relations." (Benedikt, 1991, p.125) But these things/objects, which are distributed in space, actually allow for space and the spatial experience as such. Man orients to objects... (and) his cognitive or affective orientation to different objects aims at establishing a dynamic equilibrium between him and his environment."(Schulz, 1971, p.9) "The universe is built up into an aggregate of permanent objects connected by causal relations that are independent of the subject and are placed in objective space and time. Such a universe...is imposed upon the self, to the extend that it comprises the organism as a part of the whole." (Piaget, 1955, p.351-352)

Space is void and this emptiness is its essence, which makes a building or a landscape useful. (Thiel, 1961, p.35) We become aware of things via the stimuli provided by them and accordingly our sense of space is being established by these things, because they all possess the quality of form. However, "space is inherently formless. Its visual form, quality of light, dimensions and scale depend totally on its boundaries as defined by elements of form." (Ching, 1979, p.108)

"Moulding clay into a vessel, we find the utility,
in its hollowness;
Cutting doors and windows for a house, we find the utility,
in its empty space;
Therefore the being of things is profitable, the non-being
of things is servicable." (Lao-tzu, 1929, as quoted in Chang, 1956)

In architecture, form and space maintain a symbiotic relationship, in any scale. When architects design a building, they read the configurations of walls as the positive elements in a plan drawing, but conceive of the white space in between the walls, which represents "space", as having shape and form and not merely as a background to the configuration of the walls. In fact, they usually design the forms of these voids so that they accommodate human needs, dictated by the program, and accordingly design the form of the elements which establish these voids.

As Heidegger (1971, p.154) suggests "space is in essence that for which room has been made, that which is let into its bounds." He relates the concept of "space" to that of the "boundary"; the boundary (greek: peras) meaning that from which something begins its presencing. "The location allows the human to enter into a site by arranging the site into space...The making of such things (locations that allow for spaces) is building. Building...is a founding and joining of spaces...Because it produces things as locations, building is closer to the nature of spaces and to the origin of the nature of "space" than any geometry and mathematics." (ibid., p.158)
It is important to illustrate the way that a phenomenological conception of space differs from the abstract, geometrical notion of space. In Heidegger's (ibid., p.156) words: "Even when we relate ourselves to those things that are not in our immediate reach, we are staying with the things themselves. We do not represent distant things merely in our mind, so that mental representations of these things run through our mind and head as substitutes of the things...When we think of a thing, this is not merely an inner experience but it gets us through to the distance to that location; we are not at some representational content in our consciousness but we are at that location of the thing."

Heidegger suggests that to say that we "are" is to say that we "dwell" and in doing so we persist and pervade through spaces and because of that we are able to go through spaces...But in going through spaces we do not give up our standing in them. Rather we always go through spaces in such a way that we already experience them by staying constantly with near and remote locations and things. When I go toward the door of the lecture hall, I am already there, and I could not go to it at all if I were not such that I am there. I am never here only as this encapsulated body; rather I am there, that is, I already pervade the room, and only thus can I go through it." (ibid., p.157)

2.2 Schemata and Existential Space

Neisser acknowledges Bartlett's concept of the schema as the central cognitive structure in perception. He gives an explanatory definition of schema as "that portion of the entire perceptual cycle, which is internal to the perceiver, modifiable by experience, and somehow specific to what is being perceived. The schema accepts information, as it becomes available at sensory surfaces, and is changed by that information; it directs movement and exploratory activities that make more information available, by which it is further modified." (Neisser, 1976, p.54) Schemata could be considered as information-accepting systems but can also function as plans and as the executors of these plans; they are patterns of action as well as patterns for action. (ibid, pp.55-56)

Eysenck and Keane (1990, p.283-285) define schemata as complex, structured clusters of concepts, which usually contain generic knowledge about stereotypical situations. There is considerable psychological evidence to support many aspects of this theory, but Eysenck and Keane also present several fundamental problems relating to the unconstrained nature and the specificity of the content of schemata. "Schemata are based upon similarity between phenomena and they are significant because they mediate the intended meaning...They give form to the world, because they organize the phenomena as manifestations of objects." (Schulz, 1963, p.43)

The stable space schemata, along with the perceptual and cognitive levels of spatial experience, together, make up man's "image" of the environment. Schulz defines existential space as a relatively stable system of perceptual schemata, meaning a system of three-dimensional relations between meaningful objects (Schulz, 1971, p.11), in the same sense that Lynch (1960) defines the concept of an "environmental image", as a generalized mental picture of the exterior physical world, at an urban scale.

The experience of space consists of the tension between one's immediate situation and existential space. When our immediate location coincides with the centre of our existential space, we experience "being at home". If not we are either "on our way", "somewhere else", or we are "lost". (Schulz, 1971, p.34)

Schulz (ibid., p.18) interprets the Gestalt organisational principles, which are in accordance with Piaget's elementary topological schemata, and suggests that the constituent elements of existential space correspond to and are being established by these elementary organizational principles:
• centres or places, are brought about by proximity,
• directions or paths, are brought about by continuity and
• areas or domains, are brought about by enclosure.
Places, paths and domains, therefore, are the basic topological schemata for orientation in the environment, that is, the constituent elements of existential space.

2.3 Ambient and Hodological space - Cognitive maps - Image of the environment.

Two conceptions of space, which may enhance our understanding of the spatial experience, are introduced here:

• Ambient space is the objective, measurable space defined by surfaces and objects that we design and build and which corresponds to the lower-level perceptual processes which inform orientation in the environment.
• "Hodological space (from the greek "odos") is identified with the activity of movement through space. Not only towards a visible goal but also towards a non-visible destination, which requires a mental map." (Mitropoulos, 1975, p.201) Schulz (1971) translated Lewin's (1938, p.54) term of hodological space as "space of possible movement". It is a subjective, behavioural kind of space, which is being determined by an additional parameter: the immediate state of mind of the subject or the specific situation for movement. "We are born with hodological space, but not with ambient space. We build ambient space allowing for hodological space." (Mitropoulos, ibid.,p.200).

Mitropoulos (1974, p.202) proposes a model for understanding the movement of a pedestrian through urban space: "You move through ambient space along which you perceive, and which is part of the measurable Euclidean space. Your activity of walking is not in "space-of-possible-movement" but your own hodological (intention based) space. Your mind and your body senses are in fusion. You anticipate the "tube" (the notional corridor which connects where you are now with where you were coming from and where you are going to) and check by feedback provided by incoming perceptual information."

Downs and Stea (1973, p.9) state that "human spatial behaviour is dependent on the individual's cognitive map of the spatial environment." They call the process of acquisition, amalgamation and storage of information, available in the environment, cognitive mapping and the product of this process at any point in time cognitive map. "Given a cognitive map, the individual can formulate the basis for a strategy of environmental behaviour...Cognitive mapping is a basic component in human adaptation...it is a coping mechanism through which the individual answers two basic questions quickly and efficiently: (1) Where certain valued things are; (2) How to get to where they are from where he is." (ibid., p.10).

The term "cognitive map" was coined by Tolman (1973) and is defined by Neisser as a synonym of "orienting schema", that is an active, cognitive, information-seeking structure, which accepts information and directs action and exploration. Neisser (1976, p.123-124) suggests that cognitive maps and perceptual schemata are related in two different ways that can both be illustrated in Lynch's analysis: a cognitive map is a perceptual schema but also contains embedded perceptual schemata. The relative concepts of "cognitive map", Lynch's (1960) "environmental image" and Schulz's "existential space", all refer to cognitive structures of spatial information consisting of perceptual schemata, which are being used to interpret incoming perceptual information and to guide action.
3. The Elements of Existential Space

Adopting the above mentioned (in 2.2) Schulz's taxonomy of the constituent elements of existential space as a starting point, this paper now attempts to expand this definition, by making use of other relevant studies. Before presenting these elements of existential space it is important to clarify that they may either be:

- material elements which have form and thus establish space by bounding it (objects and surfaces) or
- spatial elements which are void and allow for passage or actions to take place in them (place, path, domain, threshold).

3.1 Space Establishing Elements

As explained in 2.1, space is being established by things, because all things have a form. Thiel (1961) suggests that "the (visual) experience of space results from the visual perception of light-defined relationships between positions and qualities of these things." He goes on to classify things, as space establishing elements and these could either be:

- objects, which may be thought of as three-dimensional convex forms existing as visual entities in a larger space than that which they may help establish or
- surfaces, as two-dimensional plane forms, limited in visual effect to the space they help establish, although in reality they may be a part of a larger object when experienced in a different context or
- screens, as perforated surfaces, or closely-spaced objects, classified as an intermediate condition. (1961, p.35)

Apart from facilitating purpose by generating functional space, these things, by their relationships and their organisation, may also communicate meanings. These could either be literal, denotative meanings of form and space, which can be translated by the subject as notions of place, domain, path, hierarchy and order or connotative meanings, which Ching (1979, p.386) understands as "associative values and symbolic content that is subject to personal and cultural interpretation and can change with time."

Edges and landmarks are identified by Lynch (1960) as two of the constituents elements of the urban environment. In this paper, both of them are understood to be space establishing elements.

3.1.1 Edge

Lynch (1960) defines edges as the linear elements not considered as paths (these are explained in 3.3); they are usually, but not always, the boundaries between two kinds of spaces, linear breaks in continuity. They act like lateral references. The strength of and edge depends on:

* its visual prominence,
* its formal continuity,
* how easily it can be penetrated by cross movement.

"While continuity and visibility are crucial, strong edges are not necessarily impenetrable." (ibid., p.65) Edges can be barriers, more or less penetrable, which close one region from the other; or they may be uniting seams, lines along which two regions are related and joined together. Edges may be paths as well, and like paths they can have directional qualities.
3.1.2 Landmark

Lynch (ibid., p.48) defines landmarks as objects within the urban context which are used as a reference for orientation and which can also communicate meaning. Landmarks cannot be entered and vary widely in scale. Their main characteristic is singularity and Lynch suggests that they become memorable and easily identifiable:

- if they have a clear form,
- if they contrast with the background and
- if there is some prominence of spatial location.

Figure-background contrast seems to be a principal factor." (ibid., pp.78-79)

Lynch has concluded from his case studies that a sequential series of landmarks, in which one detail calls up anticipation of the next and key details trigger specific moves of the observer, appeared to be a standard way in which subjects moved through the city. The sequence facilitates recognition and memorization. However, recognition may break down when the sequence is reversed or scrambled. (ibid., p.83)

3.2 Place - Centre

Man's space is subjectively centred. (Schulz, 1971,p.18) The notions of the "centre" and of "home" are equally identified with the centre of one's world, the first point of reference employed at the beginning of life. The centre represents to man what is known in contrast to the unknown and uncertain world around.

By centres Schulz means places of action, where particular activities are carried out...Actions are only meaningful in relation to particular places, and are coloured by the character of the place..This character must be understood as a product of its interaction with its surroundings, which include other elements of existential space...We say that something "takes place"...The places are goals or foci where we experience the meaningful events of our existence, but they are also points of departure from which we orient ourselves and take possession of the environment. This "taking possession" is related to places which we expect to find or discover by surprise." (ibid., p.19)

A place is always limited and Schulz (ibid., p.20) suggests that for its definition, the place needs a pronounced limit or border. Due to the fact that all places are in a way bounded by certain limits, they can be experienced as an "inside" in contrast to the surrounding "outside". For Relph (1976, p.114, as quoted in Bonnes and Secchiaroli, 1995, p.164) "existential insideness" (the degree to which people feel a part of a place) as opposed to "existential outsideness" (which involves feelings of strangeness and separation from the place) is the foundation of the place concept.

The problem of inside/outside is created when places interact with their surroundings. The intention behind "being in place" is that of "being inside" away from what is "outside". Humans locate their personal experiences and memories to places so that they can identify with them; we can say that places are the spatial expressions of their own "selves". Only when the relations between "inside" and "outside" are defined, man can "dwell", that is "remain", "stay in a place", but also "be brought and remain in peace", "be safeguarded", according to Heidegger (1971, p.146,149) Humans need to feel secure and to indentify with a certain space in order to engage into activity there. The concept of place is better described as the physical counterpart of the state where these human needs are being satisfied.

The form of a place, of course, affects the way that we experience it. "A place that is being experienced as an "inside" should generate a spatial sense of proximity, centralisation and closure.''. (Schulz, ibid., p.20) According to Ching (1979, p. 175) the qualities of the place
(proportion, scale, form, definition, colour, texture) depend on the properties of the enclosure (dimensions, shape, configuration, surfaces, edges, openings) which defines this place.

Limiting the size of a place corresponds with a centralised form, which primarily means concentration. A place therefore is basically "round". The round form consists of two elements, a centre and a surrounding ring. According to Schwarz (1958, p.24-25) a maximally closed form is a ring and the closure can be increased through geometrisation, as Schulz (ibid., p.25) suggests, that is by making the ring circular: "Geometrisation, in general, does away with all the causal directions of the topological form, and has always been used by man to make the intended relationship more precise."

Thiel (1961, p.41) classifies spaces according to their intrinsic nature, on the basis of the quality of form-relationships:

- At the one pole, are spaces characterised by a feeling of centralisation, completeness, closure, cohesion, symmetry and balance; places are such spaces.
- At the other pole are spaces exhibiting tendency towards mobility, freedom, expansion and change, and paths are good examples of this kind of spaces.

There are, of course, spaces where both tendencies are combined and the character of such spaces is determined by the way that this combination is being structured and experienced.

### 3.3 Path - Direction

The concept of direction and its physical correlate, the path, are brought about in existential space by the organisational principle of continuity and as such are linear by nature. A path consists of a starting point and a direction to be followed towards a goal/destination, through a sequence of places and events. Due to these events the path is experienced as having a character of its own. "What happens along the way is added to the tension created by the goal to be reached, and the point of departure left behind. In certain cases the path has the function of being an organizing axis for the elements by which it is accompanied, while the goal is relatively less important." (Schulz, 1971, pp.22-23)

A path's configuration is influenced and does influence the organisational structure of the places it links. Ching (1979, pp.270-271) identifies six kinds of path configurations: linear, radial, spiral, grid, network and composite. He also suggests that a path relates to places in three different ways:

- path passes by places,
- path passes through places,
- path terminates in a place.

Thiel (1961, p.40) attempts to classify unambiguous spaces according to their perceptible form, due to their overall proportions. He introduces the concept of "run" as "a space which has any one overall dimension (length, breadth or height) two or more times greater than any other dimension"; a kind of space which has an implicit directional character and induces movement of the eye or the body. As such, the "run" is in agreement with the physical requirements for a path.

As mentioned earlier, the concept of place implies an awareness of an inside and an outside. A place is always situated within a larger context and any interaction with its surroundings implies directions. "Any place contains directions...Aristotelis, already recognized the qualitative distinctions between above and below, in front and behind, right and left, which are rooted in man's constitution and in his relationship to the gravitational field." (ibid., pp.20-21)
The direction of "above-below" implies the notion of verticality, and Schulz attempts to identify its meaning for the human: "The vertical has been always considered the sacred dimension of space... (because) it represents a "path" towards a reality which may be "higher" or "lower" than daily life. The "axis mundi" is thus more than the centre of the world, it represents a connection between the three cosmic realms, and it is the only central axis that a breakthrough from one realm to another can occur. (Eliade, 1958, p.111) However, verticality also symbolises man's ability to "conquer nature" by raising vertical structures. Bachelard considers verticality as one of the basic properties of the house, along with concentration and he discusses the cellar and the attic, of a house as particularly meaningful places. (1957, ch.1)

"If verticality has something surreal about it, horizontal directions represent man's concrete world of action. In a certain sense, all horizontal directions are equal and form a plane of infinite extension. The simplest model of man's existential space is, therefore, a horizontal plane pierced by a vertical axis; on the plane man creates paths, which give his existential space a more particular structure. Man's "taking possession of the environment" always means a departure from the place where he dwells, and a journey along a path which leads him in a direction determined by his purpose and his image of the environment. "Forward" means direction of man's activity while "behind" denotes the distance he has covered...The "path" therefore represents a basic property of human existence and it is one of the great original symbols...Man's ways, however, also lead back home and the path therefore always contains a tension between the known and the unknown. (Schulz, ibid., p.21)

The significance of the path as a structuring element of existential space has been stressed by Lynch's and Mitropoulos' analyses of the urban environment. Mitropoulos (1975, p.202) defines urban space as a network, meaningful only with respect to activities, and considering movement-through-space as a basic activity of man and as a means of organising the urban environment. He subscribes to the concept of "hodological space" (as presented in 2.3) also used by Lewin (1938) and Schulz (1971). "Rather than straight lines, "hodological space" contains "preferred paths", which depend on: "short distance", "security", maximum experience" or other min/max possible demands, which are determined in relation to the topographical conditions. When these demands are uniform, and no particular human activity influences the situation, hodological space approaches Euclidean space. (Schulz, 1971, p.22)

3.4 Area - Domain - District

A place is usually related to several directions by a system of paths, which expresses man's possibilities of movement, the range of his world. "Paths divide man's environment into, more or less well known areas, which are qualitatively defined and which we call "domains". (Schulz, 1971, p.23) Domains can be considered as places, since they are also defined by closure and proximity. However they are different from places in that

- man does not identify with domains as with places,
- they do not function as goals for a path and
- they are of a relatively larger scale than places.

Muller (1961, as quoted in Schulz, ibid., p.23) discusses the ancient symbolism of dividing the world into domains and explains the idea as an expression of man's general need for imagining his world "as an ordered cosmos within an unordered chaos. By structuring the world into domains defined by natural directions, the ancient man gained an existential foothold...Taking possession of the environment implies structuring the environment into domains by means of paths and places...The domain can therefore be defined as a relatively unstructured "ground", on which places and paths appear as more "pronounced" figures". Domains with greater density of paths are experienced as "shapes" and since man can identify with them they become places.
Lynch (1960) names such spaces as districts and stresses the fact that they are conceived as having two-dimensional extend, which the observer can mentally go inside of. The conception of the size of the district may partly depend on how well its structure can be grasped. The main requirement for the legibility of a district is the constitution of a thematic unit that contrasts with the rest of the city; the internal homogeneity is less significant. Districts may be introvert or extrovert, according to their degree of connection to surrounding elements. Similarly, they may stand alone in their zone or may be linked to others, making a continuous mosaic of districts.

3.5 Threshold

A very important element of existential space, which has not been clearly identified by any of the above mentioned spatial analyses, is the space where interaction between any of the other elements takes place. The "threshold" is the transitional space located where one element ends and another begins. The need to view such spaces as a separate category is being justified by their significance for human existence and their dynamic character.

Schulz (1971, p.25) presents examples of such spaces and explains why they are significant: Any closed form, such as a place, has to be entered and so a direction is introduced. This direction unites the inside with the outside, so it influences a place by stretching its inside towards the outside; this way a transitional area is created and this area is related to an opening, which, according to its formal qualities, expresses the degree of continuity in existential space. "No wonder why the door has always been one of the important symbolic elements of architecture. A door can close off and open up, unite and separate. Psychologically, it is always open and closed at the same time, although one of the aspects is dominating, as any door may be opened. The opening makes a place alive; it generally expresses what the place "wants to be" in relation to the environment."

The space of interaction between a place and a path is the locus of a tension between centralisation and longitudinality; whereas centralisation symbolises the need for belonging to a place, the longitudinal nature of the path expresses a certain openness to the world, a dynamism which may be physical as well as spiritual.

The meeting point of two paths is a point which has very strong existential implications; there are several possible, expressive solutions, on the basis of the continuity principle. The choice as to which direction to follow is a basic problem of human life, especially when the goal to be reached is more or less clearly imagined.

Thiel (1961, pp.44-45) identifies three types of connections between spaces:
- "a merge occurs when two or more spaces join in a manner such that there is no definite point of juncture and one space merges or flows into the other
- a port exists when a constriction occurs when passing from one space to the other and
- an end exists when a juncture of one space with another is neither a merge nor a port."

The ambiguity inherent in a merge can be reduced with the positioning of space establishing elements.

3.6 The levels of existential space and their interaction

The elements of existential space appear on several levels, determined by the given environment and by man's constitution. The level-hierarchy of existential space is a product of man's taking possession of the environment. (Schulz, ibid., p.33) Schulz identifies five
different levels, which, along with the schemata developed in them and the interaction between them, constitute the structure of existential space:

a) The geographical level has a cognitive character. It is "thought" rather than "lived", but may influence the more directly experienced levels. Paths and places of geographical space have an abstract character; they do not represent what is directly known, but are potential elements of existential space. The content of this level primarily consists of domains. (Schulz, 1971, p.28)

b) The level of landscape has always the function of forming the continuous background of our environmental image as well as of our visual field. If the continuation is corrupted we stop talking about landscape. A landscape offers possibilities for orientation and identification when it displays strong formal properties. We can then imagine ourselves taking possession of it by physical and psychic movement. (ibid., pp.28-29)

c) The urban level comprises structures which are mostly determined by man's own activities, by social interaction and by his interaction with a man-made environment. During their development, individuals learn to identify with these structures. The primary quality of the urban image is the single identifiable place. The most elementary typical urban images are those of "enclosure" and of the "cluster", which are the direct expressions of functions taking place and of social togetherness respectively, and can often appear in combination. Schulz agrees with Lynch in that: "Man needs an urban environment which facilitates the image-making, needs districts which have a particular character, paths which lead somewhere, and nodes which are distinct and unforgettable places." (ibid., p.29-30)

d) The house is a private space that we find in the urban level; it really brings us "inside" and represents the need for being situated. This is where humans find their identity and this is where the fundamental function of "dwelling", as defined by Heidegger (1971), is fully expressed. (Schulz, ibid., p.31)

Bachelard (1982, pp.30-31) argues that: "the house is a privileged entity (in that) the images of our life gather around it like if being attracted by some sort of image-attraction-force." The more a man is "at home" the more precisely he can define his environment. We could try to define the concept of "house" if we could approach the value of our images from the interior space where our existence takes shelter in, through the memories we have of all the houses that we have dwelled in and all the houses that we dreamed of dwelling in.

Schulz quotes Alberti's analogy of calling the house "a small city" (1971, p.31) and agrees to the extent that they are both determined by the basic elements of existential space, but there are substantial differences in the way they are determined. The city mainly lives by means of its paths, whereas the house is a function of place.

e) The "thing" is the lowest level of existential space. Things are objects of a specific form, known by man in the most direct way possible because the human body is being directly related to them. This renders them as significant elements of our phenomenal world. The elements of this level may serve as foci in the house. Things "articulate" the environment and make its character precise and this is the basic function of detail in our surroundings; to explain the environmental character and thereby become meaningful. (ibid, p.31-33)

Man exists in relation to physical, psychic, social and cultural objects and these form all levels of our environment. As we move from the level of landscape towards the level of the house, Schulz notices a growing precision of form and structure and an increasing tendency towards geometrization. We imagine the things that we do not know on the model of things known and therefore we tend to represent aspects of levels that we cannot conceive of with aspects of levels that we directly experience.
Levels can contain each other and on each level we may find any of the above-mentioned elements of existential space possessing their own individual formal qualities and characteristics and interacting with each other in different ways. Existential space can also be described as a simultaneous totality, where the levels interact to form a complex, "dynamic field", which is neither continuous nor uniform. The concept of the "dynamic field" is similar to that of the cognitive map. Parts of the field are experienced through perception, but the general image exists independently of the individual situation. This field firstly contains a system of centres, connected by paths, with one of them usually dominating. The degree of our acquaintance with an area of any level is determined by the elements and sub-elements known. In general, existential space consists of several overlapping and interpenetrating such systems, which interact with each other. (ibid., p.33)

4 The differences between virtual and physical environments

4.1 The limitations of VE systems

Due to the limitations of current technology:

- Input and output devices cannot display the complexity of sensory information, which is available in the PE, for humans to pickup with their sensory systems; they output mainly auditory and visual feedback or limited kinaesthetic and tactile feedback and cannot provide thermal or olfactory information,
- VE systems support unrealistic modes of interaction with the operator; quite often, supernatural tools and actions are being employed, and these may be made easier to understand through the use of metaphors, but they still do not correspond to the perceptual schemata of interaction with the real world that humans have developed.
- The human body cannot be convincingly displayed in the VE, neither its actions can be fully tracked by the system's tracking devices in order to update the images generated by the image generator accordingly, with an acceptable, minimum lag. Only the hand of the operator is being usually represented in the VE. Body suits for getting input from the whole body have been developed, but they demand extremely powerful systems for computing all spatial transformations of the body parts and generating a realistic representation of them, not to mention the computation of physical parameters of the events, like collision detection or gravity.

The human perceptual system which perceives a VE evolved and learned to perceive in the real world. (Carr and England, 1995, p.3) Therefore the operator will perceive the VE system through the same perceptual processes involved in the perception of the PE, so the understanding of how these processes work and which aspects of the environment provide the critical stimulation is needed for informing the design of such synthetic experiences. Although being perceived in a similar way by the human, VEs and PEs are still very different, as the above mentioned limitations reveal.

4.2 The differences between PEs and VEs

In a VE:

- users do not receive enough visual, auditory or tactile kinaesthetic information from the representation of their bodies in the VE,
- there exist no physical constraints to dictate its dynamic, spatio-temporal nature,
- there is no scale consistency,
- space is non-contiguous, multidimensional and self-reflexive, (Bridges, 1995)
- time is not continuous, it is reversible and its pace can be altered (slowed-down or speeded up).
The ways that the user or the VE designer experience some of the differences between VEs and PEs will be identified in the next three sections. Their identification may lead to useful insights into the problem of designing VEs and to defining the limitations of using architectural knowledge in such a design.

4.2.1 The human body and its "avatar"

A fundamental factor which affects the spatial experience in a VE is that operators cannot see their bodies. As McLellan (1994, pp.33-35) describes, in an immersive VE system, "avatars" are the only representations of the operators' bodies, displayed to them, since HMDs do not allow for any visual input from the PE. This is not the case in a projection-based or an augmented-reality system.

"One sees the environment not with the eyes but with the eyes-in-the-head-on-the-body-resting-on-the-ground...An observer perceives the position of "here" relative to the environment and also his body as being "here". His limbs protrude into the field of view and even his nose is a sort of protuberance into the field...Since the occupied point of observation is normally a moving position, not a stationary one, he sees body moving relative to the ground. He sees that part of the environment toward which he is moving; he sees the movement of his feet, relative to his body and also over the ground. When he looks around during locomotion, he sees the turning of his head. These are all cases of visual kinaesthesia." (Gibson, 1986, pp.205-208) If the avatar is merely a representation of a glove, the operator cannot experience such visual kinaesthetic feedback, as described above by Gibson. Smets (as quoted in Carr and England, 1995, p.196) argues, on the basis of experimental research, 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.

Steed et al. (1994) suggest that the sense of presence increases when there is a direct visual consequence of each of the user's movements and when there is an obvious mapping between the user's movements and the movements of the virtual body. On the basis of experimental evidence, they suggest that the 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.

Bollnow (1963, p.166) points out that man's active relationship to the world is characterized by his vertical position; he takes a "stand"; to sleep means to return to the very "point of departure". But these differences cannot be experienced in a VE, since the body is not being adequately represented and there is not enough kinaesthetic feedback to provide a sense of "seating" or "laying down".

The kinaesthetic information that operators receive from their own body acting in the PE does not usually correspond with the phenomenal action and events which are being displayed to them. Such discrepancies may break down the illusion of the VE and may also have distressing physical effects on the operator (Regan, 1994). Tactile and force feedback, tightly coupled with the auditory and visual output may provide proprioceptive information which may mask such a problem.

Humans develop space schemata at a very young age, through senso-motoric activity or through communication of experiences and cultural traditions; they continuously update a large part of these schemata through new experiences, during their existence in PEs. Since these existing space schemata cannot always effectively organise perception of space in a VE, the operator has to develop new schemata corresponding to the nature of existence in a VE.
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.35), who agrees with Piaget in that "a mobile world would tie a man to an "egocentric" stage, while a stable and structured world frees his intelligence". Spatial anchors and elements of stability should be carefully incorporated in the experience of a VE.

A basic aspect of man's being in the world is movement along a path, in the environment; how we get from one place to another. The changing character of movement is related to pace and rhythm. We move because we want to "take possession of the environment", according to Schulz (1971, p.35), and we can achieve that by running, strolling, marching or dancing. In VEs we cannot move in these natural ways; instead we are limited to the forms of interaction, defined by the input/output devices, which determine the metaphor for movement in the specific VE; ie. walking on a treadmill, flying where the virtual finger points, walking or rolling on floors or other surfaces, etc.

4.2.2 Physical constraints and scale consistency in VEs

Another fundamental characteristic of VEs is the lack of any physical constraints, similar to the ones, which define our existence in a PE. One cannot speak of natural phenomena like gravity or friction in a VE unless we design and implement them. We cannot speak of three-dimensional Euclidean space, although all object models are generated in such a space, since any point of a VE may be defined by several dimensions or can unfold to reveal other VEs. Benedikt (1991, pp.119-224) describes how the principles of real space may be violated in VEs. The natural characteristics and implied constraints of a VE are determined by the specifications, which define it.

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

5 Conclusion

5.1 Realism in VEs

Both simulation and virtual reality try to create a synthetic experience, but while simulation tries to imitate reality, virtual reality does not necessarily do so. (Carr and England, 1995, p.3) VEs may communicate to the operator synthetic experiences which cannot be possible in the real world but which still come across as convincing and effective for a specific task. This is due to the fact that VEs are being experienced via the same perceptual processes employed for the perception of 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, the synthetic experience is perceived as being realistic. (ibid., p.6)

Baudrillard (1983) argues 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". VEs can be seen as such "hyperrealities" carrying experiential qualities, existing independently in their own right, and not necessarily as simulations of any realities.

5.2 Existential space-establishing elements in a VE

In accordance with the terminology of programming languages used for the design and development of VEs, we may refer to all the elements which establish existential space in a VE as "objects". With respect to their form, they could be classified as:
• surfaces or planar objects, which may have zero thickness or one of their three dimensions may be very much smaller than the other two,
• objects, when their form is clearly three-dimensional.

Their size and scale, relative to the operator, may vary widely. Thiel's (1961, p.35, as mentioned in 3.1) definition of surfaces and objects is helpful in explaining why a directly experienced surface may be a part of a much larger object, and this object may only be perceived as such when in a different level of existential space. However, Thiel's taxonomy does not exactly stand in VEs since a surface is not necessarily limited in visual effect to the space it helps establish.

According to their function, space establishing elements are either:
• bounding objects or edges, in a more generic sense than the term used by Lynch, which define all elements of existential space by suggesting a spatial form out of the void, in varying degrees of explicitness,
• bounded objects which function more like points of reference or as landmarks, cannot be entered into (as Lynch suggests) and generally communicate some meaning to the operator.

However, on the basis of experimental work by Marcos Novak, John Fraser, Karl Chu, Arakawa and Madeline Gins (Toy, 1995, Novak, 1991) it is evident that the distinction between these two classes is not always clear.

All objects in a VE can either be still or animated. The overall dynamics and impact of the object, relative to the VE and interaction with the operator, are determined by:
• its geometry, colour and other formal attributes,
• the degree of interactivity that it affords the operator,
• its autonomous behaviour or intelligence,
• its possible evolutionary nature. (Fraser, 1995)

Since a VE does not have to imitate reality, the designed objects that the VE consists of do not necessarily have to imitate forms that objects of our environment possess (columns, roofs, trees, mountains), unless there is a functional purpose for these forms to exist, as in the case of communicating some meaning. In the real world, forms of structural objects are usually derived from constraints imposed by the nature of materials and construction, so that they visually express their structural character.

In VEs, object qualities like characteristics of materials or thicknesses and weights of structural elements do not exist. For example, a wall-like edge, that is the object which divides two places, may be a surface of zero thickness or it might have more than two dimensions on each of its sides or its shape might be transformed during the course of time. Physical constraints like gravity or friction have more to do with making interaction with or behaviour of objects seem more realistic than constraining the form of an object. Therefore, VE designers should try to abstract the forms they use in designing objects of VEs and explore the expressive qualities that non-constrained form can offer for an application. Formal detail should be added only when it serves some purpose. Objects which carry meaning and express affordances to the operator can then be clearly distinguished against the formally neutral context of a VE, which is not cluttered with unintended formal detail. Textures, sampled from real materials or artificially constructed and mapped on surfaces, can significantly enhance the perception of depth and the overall spatial experience of the VE, according to Gibson. (1986)

5.3 Elements of existential space in a VE

Activities in a VE are carried out in places and these activities are meaningful only in relation to particular places. For a specific operator at a specific point in time, a place may be seen as
a point of departure, a goal or a focus for an activity. An operator "dwell"s in a VE, in the sense that Heidegger speaks about "dwelling" (1971), even if this 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 in places, and the inside of space becomes the inside of their personality (Bachelard, 1982, ch. IX).

By clearly defining the relation between inside and outside, the operator identifies with the place and feels "secure" enough to engage into an activity. This relation is established by appropriate design of the boundaries (edges), which delimit the place. A centralised form induces a feeling of concentration and closure in a place and this feeling is increased by geometrisation of the bounding form.

A path is a kind of space, which exhibits tendencies towards mobility and expansion and within which directions are evident, due to its formal qualities. A path consists of a starting point, a direction to be followed through a sequence of places and events and the final goal. These events determine the character of the path. As Lynch (1960) has suggested, the sequence of moving through the city is facilitated by memorable events, details and points of reference, which the subject anticipates and which trigger specific moves for navigation. A path's configuration and its relation to the places it links is a significant design problem as it determines the character of both path and places.

The symbolic significance of the vertical and the horizontal direction, as described by Schulz (in 3.3), may be taken into account for making orientation and navigation in a VE more meaningful. The concept of hodological space, may be used as a tool for conceptualising the possibilities for movement according to the activities taking place and the particularities of the application that the VE supports.

A threshold is the locus of interaction between spatial elements of the VE. These are spaces where tension between the diverse spatial dynamics of the interacting elements affects the behaviour of the operator who inhabits them. Examples of such spaces are the meeting point between two paths or between a path and a place or all kinds of openings.

An opening should exist in VEs only when the surrounding wall-object where it belongs does not permit the passage through its surface; that is only when collision detection is supported. This gives a meaningful and consistent identity to a door, for instance; if we were able to enter a place by passing through a wall then the door would loose its significance. There should also be a functional differentiation between events that correspond to the two states that a door can be found in (opened or closed). Otherwise the door would simply function as a gate. A window may afford viewing through, or even passage through itself, according to the mode of navigation within the VE. These facts influence not only the opening itself but the relation of the enclosed place, through the direction directed by the door, to the outside and vice versa.

A kind of threshold, specific to VEs, is the portal, which enables non-continuous movement between other elements of existential space. Teleportation may simplify navigation by avoidance of movement via certain paths, but may also prove disorientating as it corresponds to gaps in the cognitive maps that operators will try to create. Therefore, portals should be carefully designed and integrated within the environment and signified accordingly by formal elements.

5.4 Levels of existential space in a VE

The structure of existential space in a VE consists of several levels, which do not necessarily correspond to the ones identified for PEs (in 3.6). These levels may still be hierarchically
arranged and nested into each other, so that a lower level may be included within a higher one. The types and names of levels along with the overall structure of the VE should be determined by the requirements of the application task.

Since the operator may alter the scale of the displayed environment at will, all levels may be experienced in a very direct way. It is understood that frequent transfer between different levels might affect the operators' sense of scale and orientation in their existential space. It is essential, therefore, to design VEs so that each level has a unique identity. This may provide cues to help the operators keep track of which level they directly experience, at anytime.

By way of conclusion, this paper attempts to adapt the above-mentioned taxonomy of existential space elements and structure to the intrinsic nature and characteristics of VEs. This adaptation is a starting point towards building an existential conception of space in VEs, for the purpose of informing their design and for providing a background for the consideration of possible design metaphors. It has to be clarified that this paper merely speculates about the structure, the elements and the nature of VEs and that the observations made are to be seen as hypotheses which need to be evaluated by objective and quantitative methods of research.

REFERENCES