Representing Virtual Places - A Design Model for Metaphorical Design

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Abstract

The design of virtual places is metaphorical because it relies on references to the physical world. The use of a consistent metaphor provides a sense of place that combines functionality, familiarity, richness and an awareness of the presence of others. In this paper we consider such designs from a representational perspective. We discuss the characteristics and distinctions of a model of metaphorical design representation and propose a framework for the development of the representation of metaphorical design. We illustrate this framework with examples of designs of virtual places.

Keywords: virtual worlds, architectural design, design representation, design model, metaphorical design

1 Virtual Worlds and Design

Virtual worlds are online environments for people to access information and have experiences with the added feature of an awareness of others. This awareness of others distinguishes a web page presentation of information from a virtual world. Most virtual worlds create a sense of place through metaphorical reference to physical places. In this paper we are concerned with the representation and design of virtual worlds that both create a sense of place and also include an awareness of others in the place.

The literature on virtual worlds addresses one or more of three aspects of their design and implementation (Maher, 1999a):

- Implementation level. The technology associated with the implementation of the virtual world, such as the use of a distributed or central database, the use of client-server technology, etc.
- Representation level. A consideration of the representation of the virtual world as a metaphorical reference to some aspect of the physical world.
- Interface level. The type of interface provided to people in the virtual world, such as interactive 3D models, command driven text, iconic images.

Many studies focus on the implementation level, presenting advantages and disadvantages of the use of databases that host the virtual world and its implementation in the design of the virtual worlds. For example, Rowley (1997) studies the implementation issues in lambdaMOO, an object-oriented text-based virtual world. Das (1997) presents a revised version of an object-oriented database that resolves some of the inefficiencies in the lambdaMOO approach.

Other studies focus on interface level and how they are used, for example, Curtis (1993) looks at nonrecreational use of virtual worlds, Toomey et al (1998) consider the phenomena of meeting in virtual space, and Chen (1999) discuss the role of virtual worlds in information visualisation. Some studies examine the social behavior of the participants in the environments, for example:

- Social navigation (Diegerger, A. 1997)
- Turn-taking in virtual meeting (Bowers, J. et al. 1997)
- Social position (Jeffrey, P. et al. 1998)
- Social activity in game (Muramastsu, J. et al. 1993)
- Patterns of social interaction (Schiano, D. J. et al. 1998)

A representation level study of virtual worlds design considers the concepts behind the design. There is little research on the representation of virtual worlds. However, there are studies that emphasise the role of design in virtual worlds. Cicognani (1998) studied a linguistic characterisation of the design of virtual worlds. These examples of research in virtual worlds design reveal many ideas of how virtual places can be designed and the way they can be represented.

2 A Representation Study of Virtual Places

Many online virtual worlds have used a metaphor of physical place design. More generally, virtual worlds adopt a spatial metaphor and can be classified into two categories: non object-oriented systems like simple online chat systems and object-oriented systems like MOO based systems. Our representation study is based on the object-oriented VW system. An object-oriented system has many advantages over a non object-oriented system. In technological terms, the object-oriented system has a more robust and dynamic software core, which is easier to modify and expand. The merits of the object-oriented system in terms of design and representation are:

- When representing a virtual place (VP), we can represent the design as classes of objects in accordance with the object-oriented characteristics of the system. Thus the representation of the VP, which is based on the definition of objects and their relationship, can also be conceptually depicted as an object-based representation framework.
- Design in the sense of a sequential refinement process can be better handled with this object-based representation. The representation of a design model as class objects not only passes the common identifying design properties of the class to

the descendants, but also provides a framework from which the refinement process starts. As such, the design itself can be more efficient and manipulable.

- Conceptual objects described by design can correspond to the objects in the object-oriented database. This makes possible the use, as an analogy, of the research in design of physical places that use the prototype formalism (Gero, 1990). For example, we can consider the function, behavior, and structure of objects in each case.

In most object-oriented VW systems, for example MOO systems, everything that exists in them is represented as objects. The fundamental class structure of these systems is shown in Figure 1. The root class has the basic properties of all objects. The next level of classes, Generic room, Generic thing, Generic player, and Generic exit, define the major types of objects in the world. The generic room is the basic representation of place. The generic thing is a representation of the objects that can be placed in a room. The generic player is an object representation of the people in the world. The generic exit is the basis for navigating and taking things and people from one room to another. In a VW based on a spatial metaphor, the "geographical locations" and ‘buildings" distributed as places are actually composed by the arrangement of the objects created from the Generic room object.

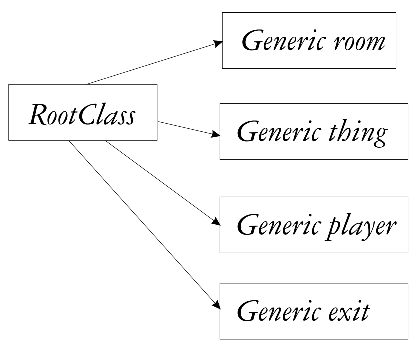

Figure 1: Basic class structure of the MOO based representation

2.1 Tappedin

Tappedin is an educational environment for teacher development (Schlager, Fusco and Schank, 1998). Tappedin is based on the lambdaMOO database (Rowley, 1997). The place resembles a conference center to evoke a professional atmosphere and encourage the kinds of discourse one would find at a conference institute.

As shown in Figure 2, Tappedin reinforces its spatial metaphor by 2D graphical layouts. The metaphor of a newly built office building is used, with the upper part of the building empty waiting for new users to occupy. There is an elevator to move people "vertically" to different levels in the building, and on each level and a person moves by clicking on a word or icon. Figure 3 summarizes the metaphorical structure of the whole environment: named objects and buildings, floors, and rooms.

Figure 2: Visual representation of place in Tappedin

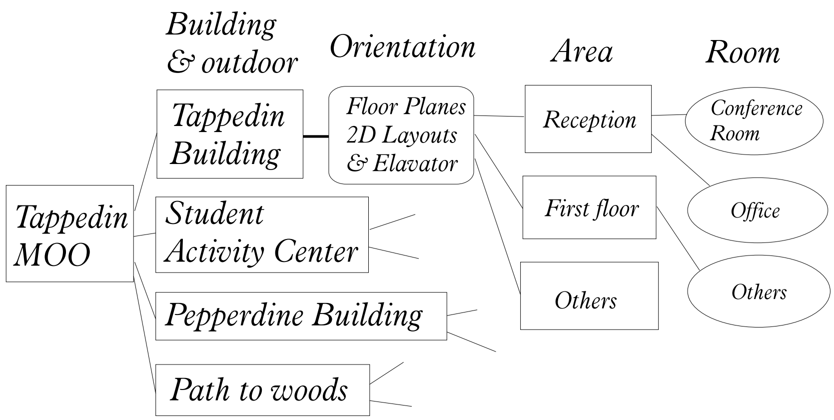

Figure 3: Place representation as an object hierarchy in Tappedin

The objects in Tappedin that compose the virtual place are referred to by their name. In a room of Tappedin, there are names on the floor plan images that are active links. A typical office is shown in the Figure 4. Most of these names stand for the exits (e.g. "ED's Oasis Library") and links (e.g. "out", "Elevator") to other areas. There are also names that stand for often used objects (e.g. "Whiteboard") and names that link to a web site (e.g. "ED's Website" in the "ED's oasis library"). In Tappedin there are also some things that don't have any substantial use but create ambience. For example, "Red Table" and "Blue Table" in the "ED oasis library" and the table, chairs and plant.

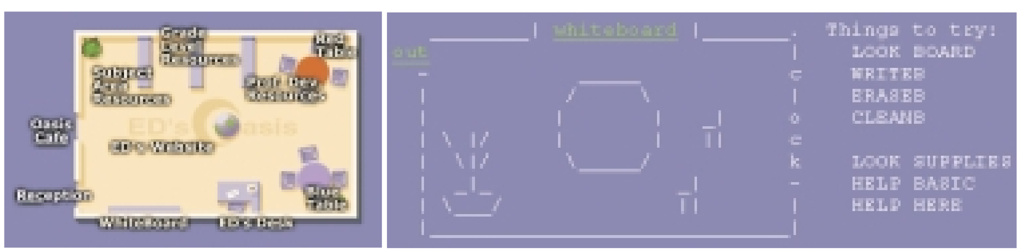

Figure 4: ED's oasis library and an office room in Tappedin

Figure 5 shows the object-oriented structure of the rooms in Tappedin. All rooms are derived from the Generic room. From the Generic Room to the specific rooms in Tappedin, there are several intermediate classes. Each inherits its predecessor class's "functions", and meanwhile has its own added "functions" which are special to this class and all of its descendants. This layered object-oriented structure of place representation is useful beause it simplifies the process of maintaining, designing and redesigning the VP.

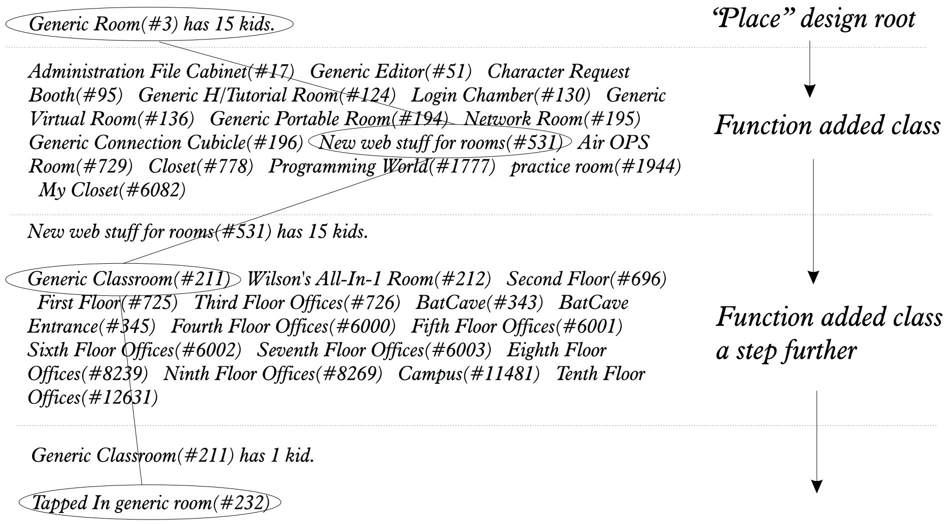

Figure 5: Inheritance hierarchy of rooms in Tappedin

2.2 The Virtual Campus

Another example of a nonrecreational virtual world is the Virtual Campus (VC) in the Faculty of Architecture at the University of Sydney (http://www.arch.usyd.edu.au:7778; Maher, 1999). The VC uses the MOO object structure to create an inheritance hierarchy similar to Tappedin. Navigation in the VC is also hierarchical according to the function of the room, as shown in Figure 6. The VC is divided into several functional areas. It orients users to "go" layer by layer to a specific place or "out" all the way back to the "Main Hall".

In a VC room, there are several aspects determining the function of the room. There are icons or words that give access to the things in the room, for example the projector and recorder, and functions of the room, for example asking who is in the room and talking to someone in the room. An example of class structure of objects is the list of parents of the meeting room shown in Figure 6:

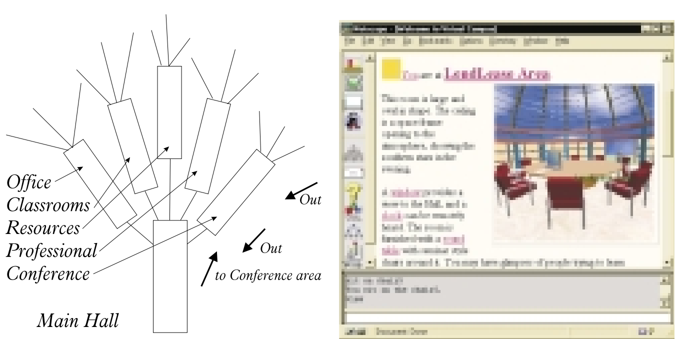

Figure 6: Place representation in Virtual Campus

Generic Room(#3), Generic Improved Room(#184), Generic Improved Room with Cleaning and Scripts(#206), Meeting Room Prototype(#211)

The rooms then are created using a design verb "@sketch". @sketch combines the process of creating a room object from the class object and creating things and putting them into the room. The design prototypes and design verbs like "@sketch" were studied as part the linguistic design study of VWs (Cicogonani, 1998). This study presents a view of the design of VWs as a design representation interpretation and refinement process.

2.3 Active Worlds

Active Worlds (http://www.activeworlds.com/) is a collaborative 3D modeling world in which each object can have active links to behaviours and web pages. The basic representation outline is as shown in Figure 7. The Active Worlds environment is a universe with many worlds, for example, alpha world in Figure 8.

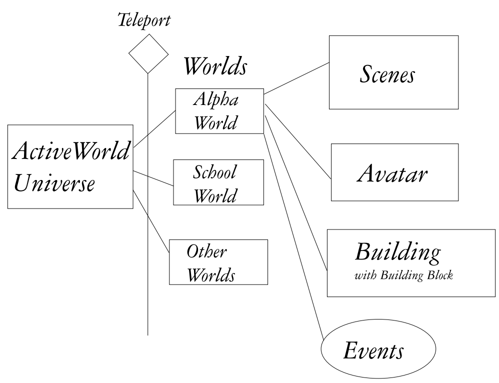

Figure 7: Active Worlds Universe and Worlds

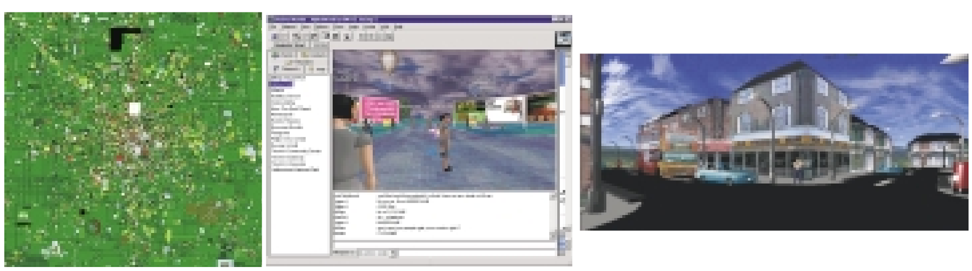

Figure 8: An example of a world in Active Worlds

A world is a virtual geographical territory of a specified size measured by kilometers. This "land" is surrounded by a panoramic skyline picture, which gives the world a scene. The system provides users with modeling tools and object building blocks. Users can clone these building blocks to construct their own buildings. Figure 8 (left) is a "satellite view" of the Alpha world. It shows the construction distributed in the world is just as in the physical world. Apart from building models and land scenes, there are also avatars and events. Events are programs attached to a model in the world that provides interactions. For example, the most used events are those that changing the position or orientation of an avatar or a model. In Active Worlds, despite the richness of a 3D enhanced place, the function of the place is restricted to talking and building.

From the representation point of view, we see that there is no place object existing in Active Worlds. A building is just the stacking of building blocks. Building blocks are objects with properties that can be modified. However, the buildings themselves are not objects. A building does not have a separate identification in the world. It doesn't have any properties and functional attachment, hence it does not have a dedicated representation.

3 A Representation Model for Metaphorical Design in Virtual Worlds

In this paper we focus on introducing and describing a model for representing the design of virtual places, drawing on developments in representing the design of physical objects and conceptual metaphor as a cognitive structure (Lakoff and Johnson, 1999). First we explore the use of the Function-Behavior-Structure framework (Gero,1990) in designing physical objects and show how this framework applies to the design of virtual places that have a metaphorical reference to physical buildings. Then we present the basis for conceptual metaphor as a representational framework for metaphorical design. We conclude with the benefit of using this framework when designing virtual places.

3.1 The FBS framework

The FBS framework characterises design objects and is the basis for a representation of designs. Here we consider the FBS framework for physical and virtual place design:

- F (function) is related to the purpose of the design. It is not directly related to any substantial design structural component. A finished design as a product can serve many purposes. However, only the one that the designer intended is defined as the direct function of the design. The function of place design in physical worlds (PW) and virtual worlds (VW) are the same in the sense that in both cases the place is intended for similar purposes.

- B (behavior) reflects the performance of the design artifact or the design components. It is closely related to design structure. Behavior includes expected behavior (Be) and actual behavior (Ba). When Ba equals Be, we infer that the design satisfies the intended design function. In the designs in the physical world, it is generally known how B is derived from F and how B is linked to S. These relationships are defined by the long formed design convention and protocol. This is not the case in design in VW. A meeting room in the VW is not a room in a building even if we call it a "room". In metaphorical design, we name the design behaviors after those in physical place design. However, they aren't derived from either the function or the metaphorical structure of the object. Behaviours in a VW are defined by the code that implements the VW.

- S (structure) is the basic condition of existence, and it is the carrier of the design behaviors. In a VW, verbs and properties in the object permit the existence of virtual entities. What makes the design artifact a room and a room for meeting is totally different for the PW and VW. One of the differences of the (FBS framework) model for VW representation is in the identification of the design structure. In the physical world design representation, for example in the case of a wall design, the design structure is the wall itself, and the design structural elements are the components that make up the wall. The structure of the wall is the mechanism that produces the behaviours and together they are responsible for the fulfillment of the design function. However, in VP design, the metaphorical structure is not the mechanism that produces the behaviour.

"Direct" design (in contrast to metaphorical design) is designing the design artifact as what it is; metaphorical design is to design something as if it is something else. The design artifacts of metaphorical design have two parts:

1) The design artifact in the form of what it is in the design environment. In metaphorical design, if the representation addresses the design artifact as only what it is, the design FBS can be too unfamiliar and too abstract to grasp. For example, to treat the design object as what it is in the computer, our understanding of the object and its performance may not be much higher than the "bit" level. If we use the metaphoric structure to help us understand the design, we can design behaviours and functions consistent with the metaphor.
2) A shell outside the design artifact that makes it seem to be something else. The shell is something added and unique to metaphorical design, which is not part of the FBS framework model.

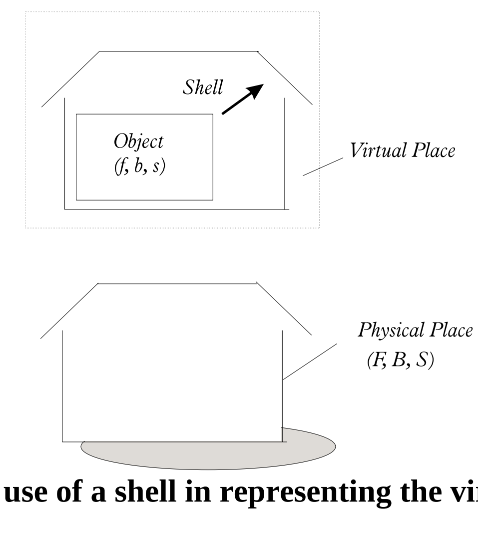

Figure 9: The use of a shell in representing the virtual place design

Figure 9 illustrates the analogy of object design representation based on the FBS framework model of the physical world design and the virtual world design. We use (F, B, S) to refer to a physical design object and (f, b, s) to refer to its metaphorical equivalent in a virtual world. In the metaphorical design of the virtual object, we take F as the design function of the virtual object. However, F only bestows f with meanings that are relevant to the physical world. F cannot replace f. B is introduced partly into the virtual design to name b, yet B and b are actually different because b is programmed and B is a physical phenomenon. s is only a metaphorical reference to S.

3.2 A model for metaphoric design

Lakoff and Johnson (Lakoff and Johnson, 1980, 1999) present four structures of the cognitive unconscious that provide the basis for understanding how metaphor influences our ability to make sense of subjective experience:

1) Basic level concepts
2) Semantic frames
3) Spatial-relation concepts
4) Conceptual metaphor

According to Lakoff and Johnson, the cognitive unconscious is all unconscious mental operations concerned with conceptual systems, meaning, inference, and language. Appealing to the cognitive unconscious in the design of virtual worlds allows us to conceive of and develop a virtual world that can be used by people with a more "natural" response. Since we are born and learn to act in a physical world, much of our unconscious thinking is based on our learned responses to the physical world. Lakoff and Johnson have argued that much of our thinking is also based on conjunctions of physical experiences with subjective experiences. In designing and understanding virtual worlds, creating a place that is consistent with our understanding of the physical world will allow us to consistently apply the primary metaphors we used.

Basic level concepts are a result of our innate ability to categorize the world. We categorise all the time to distinguish the things in the world in order to survive, but also in order to comprehend the world around us. Establishing the basic level of categories as the model for designing a virtual world allows people to use their intuition in interacting with the components of the world.

A semantic frame defines relationships among whole fields of related concepts and words that express them. Using a consistent metaphor allowing a person to draw on their semantic frames can be the basis for designing in a virtual world. For example, when designing a virtual classroom, appealing to the semantic frame, a person would be able to develop a relationship between the classroom, a lecture, a blackboard, a desk, etc. The use of these words as the design extends the metaphor to draw on the physical classroom to provide more functionality in the virtual world.

Spatial-relation concepts allow the designer to define consistent actions on the virtual object as the person would expect to do with the physical object. A person would put things "on" the desk, go "out" of a room, and write "on" the blackboard. The world is a metaphor, the programmed virtual world does not exist spatially. The use of these words provides a consistent experience in the virtual world when compared to the physical world.

Conceptual metaphor allows us to conceptualize the virtual world in terms of time and motion in the physical world of architecture. Based on the analysis of virtual design in VW using the FBS framework model and Lakoff and Johnson's theory of metaphor concerning the four cognitive structures affecting the human's understanding of experience, we present a representation model for VP design in the VW. It consists of the following three elements:

1) conceptual basis,
2) semantic frame, and
3) realisation shell.

Conceptual Basis (CB) is developed from the "Basic level Concept" of Lakoff and Johnson's theory about metaphor. It is the part of VP design corresponding to people's ability to categorize. In metaphorical design, CB defines the basic concepts and conditions of the existence of a design object. For example, in designing a VP, the CB assigns "Lend Lease room" to the room representation category; "Wilkinson Building" to the building category; "Slide projector" to the tool category. In metaphorical design, the CB not only clarifies the basic concepts for design, but also provides knowledge about the common characteristics and properties of this concept and the knowledge about common actions and the possible methods of interaction of the users with this concept.

In the VW, CB is the object in the system's object-oriented software environment. The object is the basic condition of existence. In the VW, the object is the basis for the use of the world. In a programming sense the object is made of groups of properties and verbs. Our task is not to study the verbs and properties or how they make the existence possible. These are the technological issues related to the software core of the VW system. Our task is to characterize and classify the design concepts using a building or room metaphor. For example, a room is a "container". A user can "go" in and out of it. It belongs to a building. It contains the characters of "exclusiveness" and "security", etc. In the design of VP, CB is in the set of class objects in a VW. A class object carries mechanisms that are responsible for the object's existence and use.

Semantic Frame (SF) corresponds to the "semantic frames" in Lakoff and Johnson's theory. A person understands the virtual environment he/she is experiencing through what can be done in the environment. And this is manifested as mechanisms that represent the technological possibilities of the virtual environment. In virtual place design, these mechanisms can either be in the design object that stands for the place, or they can be in the objects in the place, for example "recorder", "projector". In a VW, there are many mechanisms responsible for the "actions" in the design object. These mechanisms serve roughly the following general purposes:

- Communication (saying, whispering, paging, mailing other users)
- Activities (such as recording a conversation, showing slides on the projector)
- Information Access (links)
- Navigation (moving from one place to another)

Realization Shell (RS) is a shell that realizes the meaning the designer wants to put into the metaphorical design. It is those things that make the existence and action meaningful in the VW, for example, naming and defining the action of a kind of synchronized communication as "speak". For the place design in VW, RS creates spatiality for the design object. According to the methods RS uses, RS consists of the following:

Names and a naming system for objects, properties and verbs

2D and 3D visual representation

Many forms of RS have been used in VWs, such as text, images and 3D. A 3D realisation shell conveys more explicitly the spatial representation of the virtual place. We have developed 3 kinds of 3D realisation shells in our Virtual Campus:

1) Ambience: With this kind of RS, the functions of the place are implied by the visualisation of the place. The 3D models present the character of a certain kind of purposeful place. These characterized 3D models, like functional icons, remind users of the functions of its physical place counterpart or link the user's visual impression to their physical experience of a physical place. This "imply" type of RS can be created as part of the place object. In the place object, they are built into the object's properties that are related to the 3D description. For example, a 3D visualisation of a table may only be creating ambience and does not provide any of the functions of a table.
2) Function: These are 3D models that have independent, functional objects behind them. Unlike the ambience type of RS, the functions related to this kind of RS are programmed as part of the objects behind these 3D models. For example, a door object can be opened, closed, locked, etc.
3) Action: The 3D models themselves, due to the description language they use, can carry a special kind of behavior. In VRML2.0, for example, it is called Event. However this kind of RS is not programmed as part of an object. They are embedded in the 3D description files of the 3D model. This kind of RS normally is used as an enrichment of the other two kinds of RS. For example, a part of a VRML object can be a hyperlink to a web page.

These three kinds of 3D RS are similar because they each provide the visualisation of virtual place. They differ in how the visualisation is related to the underlying object representation of the place and therefore the intended purpose of the visualised objects.

4 Summary

Computer models provide the freedom and flexibility to explore the "impossible" of physical design (Sakamura, and Suzuki, 1997). The design of virtual worlds can be begin with an analogy of place design – the design of virtual places. Therefore the design of virtual places is metaphorical. The design of VP as metaphorical design has characteristics that are different to that of a physical design. We proposed a (CB, SF, RS) model for the VP design. This model views the VP in a unique way so that when representing design, we recognise and make explicit the metaphorical nature of the design.

The benefit of using the (CB, SF, RS) model for designing a metaphorical place lies in the development of a consistent and comprehensive representation of the place from which the implementation can be derived. Rather than start and finish with a visual representation of the virtual world, this model starts with the definition of a set of categories of objects that will be part of the place and these categories establish the metaphor. For example, defining the categories of building as office building, house, or museum establishes the type of metaphorical design. Once the conceptual basis is established, the semantic frame elaborates on the design by filling out the intended use and the behavior of the place with a consistent set of properties and actions. The realisation shell provides the visualisation of the place and is constructed on a structured representation of the virtual place, providing consistency and ease of use. The realisation shell, through the use of form as colour and shape, can be developed into a particular design style. The visual representation of the virtual place need not look as if it were physical but can suggest the reference to the physical.

As more virtual places are designed, we are developing experience with their visualisation and potential use. The development of a model for metaphorical design can provide the theoretical basis for new designs and new metaphors.

References:

Bowers, J., Pycock, J. and O'Brien, J. (1997). Talk and embodiment in collaborative virtual environments, *Proceedings of Computer-Human Interaction Conference*, ACM Press, New York, pp. 58-65

Chaomei, C., Thomas, L., Cole, J. and Chennawasin, C. (1999). Representing the semantics of virtual spaces, *IEEE MultiMedia.* **6**, (2):54-63

Cicognani, A. (1998) *A Linguistic Characterization of Design in Text-based VWs*, Ph.D. thesis, p 95

Curtis, P. and Nichols, D. A. (1993). MUDs *Grow Up: Social Virtual Reality in the Real World*, Technical Report, Xerox PARC, Palo Alto, Calif., 1993; ftp://ftp.lambda.moo.mud.org/pub/MOO/papers/MUDsGrowUp.ps

Das, T. K., Garminder, S., Mitchell, A., Kumar, P. S. and McGee, K.. (1997). *Developing Social Virtual Worlds using NetEffect*, Institute of System Science, National University of Singapore, http://www.iss.nus.sg/RND/cs

Dieberger, A. (1997). Supporting social navigation on the world-wide web, *International Journal of Human-Computer Studies*, **46**, (6): 805-825

Fuellen, G. (1996). *Biocomputing For Everyone*, http://www.techfak.uni-bielefeld.de/bcd/ForAll/welcome.html

Gero, J. S. (1990), Design Prototype: A knowledge representation schema for design, *AI Magazine*, **11** (4): 26-36

Jeffrey, P. and Mark, G. (1998). Constructing social spaces in virtual environments: A study of navigation and interaction, *Proceedings Workshop on Personalized and Social Navigation in Information Space,* pp. 24-38

Lakoff, G. and Johnson, M. (1980) *Metaphors We Live By,* Chicago: University of Chicago Press

Lakoff, G. and Johnson, M. (1999) *Philosophy in the Flesh : The Embodied Mind and its Challenge to Western Thought*, Chicago: University of Chicago Press

Maher, M. L. (1999). *Design the Virtual Campus as a Virtual World*, Proceedings of CSCL 99, Stanford University, pp 376-382. http://kn.cilt.org/cscl99/A47/A47.HTM

Mynatt E. D., Adler, A., Ito, M. and O'Day, V. L. (1997). Design for network communities, *Proceedings of CHI,* ACM Press, New York, pp.210-217.

Muramastsu, J. (1993). Computing, social activity, and entertainment: a field study of a game MUD, *CSCW Journal*, **7**(1/2):.87-122

Rowley, M. N. (1997). *Distributing MOO-Based Shared Worlds, Intermetrics,* Inc. IEEE 1997

Sakamura, K. and Suzuki, H. (1997) *The Virtual Architecture*, Tokyo: Tokyo Daigaku Sogo Kenchiku Hakubutsuka, p1

Schiana, D. J. (1998). The first noble truth of CyberSpace: People are people (Even when they MOO) *Proceedings of CHI,* ACM Press, New York, pp.352-359.

Schlager, M., Fusco, J. and Schank, P. (1998). Cornerstones for an online community of education professional, *IEEE Technology and Society*, **17**(4):15-21.

Toomey, L., Adoms, L. and Churchill, E. (1998). Meetings in a virtual space: Creating a digital document, *Proceedings 31st Anniversary Havaii International Conference of System Sciences,* IEEE CS Press, Los Alamitos, Califonia, pp.236-244.