DESIGNING VIRTUAL ARCHITECTURE

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Abstract. Virtual architecture as the design of functional virtual places is not well understood. Most virtual places are created by programmers rather than designed a places in the sense that buildings are designed. As a result, we are in the era of vernacular virtual architecture. While current virtual architecture fulfills certain needs of online users, a well-designed virtual place is becoming essential to cope with the growing complexity and demand in virtual worlds. This paper presents a basis for the design of virtual places that draws on our knowledge of architectural design.

1. Introduction

Virtual architecture is an electronic representation of architectural design. The phenomenon of virtual architecture can have two purposes: a simulation of physical architecture or a functional virtual place. The simulation of physical architecture is the most common purpose of virtual architecture and is increasingly being used to visualise, understand, and present architectural designs. We have seen a gradual but persistent move from visualisation as drawings on paper to visualisation as digital media on computer screens. The second purpose of virtual architecture involves the design and creation of virtual places in terms of its functional organization and electronic representation. Architects design buildings to provide places for people to live, work, play, and learn. Such places are embodied as buildings with internal spaces called rooms, halls, theatres, etc. An emerging concept for designed virtual places is to provide an electronic location for people to socialise, work, and learn. The metaphor of buildings and rooms can be revisited and used in virtual places, suggesting the potential for virtual places to be designed by architects and then constructed by programmers.

Since the users of virtual architecture do not have physical needs or extents, the geometric description of the space does not hold the same significance as it does in a physical building. This does not mean that it doesn't have any

significance. A consistent description of the frame of reference and topology of the space can help in the orientation and navigation within the place, whether we refer to a room, group of rooms or other part of the place. It also contributes to setting the ambience and indicates what the place and different parts of that place feel like. The design process however, must necessarily focus on provision of functionality. Without a provision for functionality, the space is not useful, whereas neglecting the geometric description of the room does not affect its functions although it may result in a less user-friendly environment due to the lack of sense of place and presence.

In this paper we focus on virtual architecture as the design of virtual place for online activities. We present several examples of virtual architecture, illustrating the variety of functions and forms. The design of virtual places draws on knowledge of architectural design, while recognising the differences between designing a building that is intended to be a physical building and a "building" that serves its function in a virtual world. The architecture of a virtual office (in contrast to a virtual office that is a set of web pages) involves more than describing the appearance of a place as an interface to office functions. Design principles for virtual architecture include the explicit representation and characterisation of the relation between the function and the visualisation of the form of the virtual place. This characterisation provides a basis for designing new virtual architecture. Implementation issues, such as the development of a persistent object-oriented representation of place and people, provide a basis for understanding the structure of virtual architecture.

2. Architectural Design in Virtual Worlds

From the early Dungeons and Dragons, a text-based virtual world, to Active Worlds (http://www.activeworlds.com), a 3-D immersive collaborative modelling world, we witness a gradual transition from textually described online environments through to virtual places that are described in 3D geometry, sounds and textures. Various design approaches have been developed to provide virtual world designers with a set of design principles and parameters in order for them to effectively design an online environment. Among them, text and graphical approaches (Cicognani and Maher, 1998) have been identified although possibilities also exist for other approaches. Our experience in designing virtual worlds reveals a process whereby precedents studies are carried out by reviewing the current state of virtual architecture followed by a formulation of a design brief (Maher, Simoff, Gu, and Lau, 1999). This indicates the importance of both, the product and process of architectural design in designing virtual worlds. Although architectural design is noted for the forms and places created, the semantics of these places lies also in their function. The

functional aspects of physical architecture can influence the design of virtual worlds.

"Click, click through cyberspace; this is the new architectural promenade" (Mitchell, 1995). This seemingly utopian remark made by William Mitchell suggests the inherent architectural nature of cyberspace. The involvement of the architect is also subtly implied. However we have yet to witness architects treating the design of virtual worlds seriously. Currently we observe that programmers or computer scientists are designing most of the virtual places.Iin most cases these places are functional in a sense that they do fulfil the demands of certain people at least in the short-term. Although the individually provided solutions might seem optimal for specific cases, especially when users "own" the portion of online space hosting their products (e.g. the disk space on a Web server), on a global scale the environment suffers from long term difficulties in its organisation and accessibility (Cicognani, A., 1999). Some of the more popular virtual places are often perceived as linear spaces rather than spatial. For example a common chat place is often treated as a single existing dialogue window, rather than a room with spatial quality. The approach is pretty much a desktop metaphorical one and it does fulfil its chatting purpose. We may later think of these early virtual worlds as vernacular virtual architecture.

The expanding internet world and the ever-increasing intensity of online activities is having a significant impact on our social and cultural environment, hence affecting the built environment and potentially altering lifestyle. Since architecture is concerned with the condition of the built environment, the current state and development of virtual architecture is certainly not to be ignored by anyone who is concerned with the quality of the physical built environment. As the effect of online activities is gradually penetrating into our daily life, architects will be presented with a design situation that poses more complicated and interwoven problems.

In three-dimensional virtual places we are increasingly confronted with a higher degree of spatial organisation, including descriptions and the relationship between content and space. As we try to go beyond casual social activity and do more complex and demanding tasks we find we need a few interconnected rooms with different functional objects for differentiation of tasks. This is when the concept of spatial design and organisation comes into play. Since the architect is traditionally educated to manipulate spaces and places to provide functionality, they may well be suited to design online places.

3. Designing Virtual Rooms

The design of virtual rooms can be as simple as a chat room window in which the conversation that takes place comprises the "room", or as complex as a 3D full scale immersive virtual reality experience requiring headsets and data

gloves to see and use the room. Here we expand on our developments in virtual architecture (see Maher et al, 1999 and Maher and Simoff, 1999) to consider the design of a virtual room that starts with an analogy of a physical room. We explore the activities and use of space as it supported by architectural design, and then apply these concepts in two case studies: the design of a virtual office and the design of a virtual conference facility.

Central to our approach to the design of virtual rooms is the analogy between physical and virtual rooms. Although this analogy may be seen to limit the possibilities of virtual rooms, at this point the analogy suggests functions and spatial relations that are not present in chat rooms that do not use the metaphor of architectural design. We expect that the design of virtual rooms will go beyond the analogy of physical rooms and become a type of design on their own. For now, we focus on how the physical room inspires the design of virtual rooms.

3.1. VIRTUAL OFFICE

Before starting to design a virtual office, it's important to consider the meaning of being virtual and what can be done with an office in regard to being virtual. In an object-oriented sense, we can consider a virtual world as a collection of objects, each object corresponding to things, space, and people. Being virtual means being able to move around as an independent object in the virtual world, and interact with the objects in the virtual world. The kinds of things a person would do in a virtual office can be similar to the things done in a physical office. However, the behaviour and the structure of the virtual office are much different from their counterparts in the physical world. The behaviour of a virtual office is active, where a physical office is passive. The structure of a virtual office is a digital representation where a physical office is made from solid materials

The space layout of the virtual office does not necessarily follow the traditional pattern, it could be varied for aesthetic reasons and to acknowledge that navigation need not be limited to “walking” around. The efficiency of the circulation is the most important element for the physical office. In a virtual office, correspondingly, layout provides a clarity for the different activities and secondarily, provides the basis for navigation. Navigation in a virtual office is a way of moving from one functional area to another, rather than a move from one physical location to another.

We illustrate the design of a virtual office with an example of a student office, shown in Figure 1, in our Virtual Campus (Maher, Skow, and Cicognani, 1999). According to the types of activities that take place in a virtual office, the layout of the virtual student office has been divided into five activity areas.

1. Entrance area: introduction, security devices and message services.
2. Working area: a place to work, to provide software applications, navigation windows, reference and other general office tools.

3. Communication area: a place to meet with guests, work on collaborative projects, and to provide tools or space for the guests.
4. Storage area: an information base, to store a wide range of relevant tools and data for the possible activities, users can move the data and tools to any areas which are convenient for them.
5. Relaxation area: to provide online entertainment.

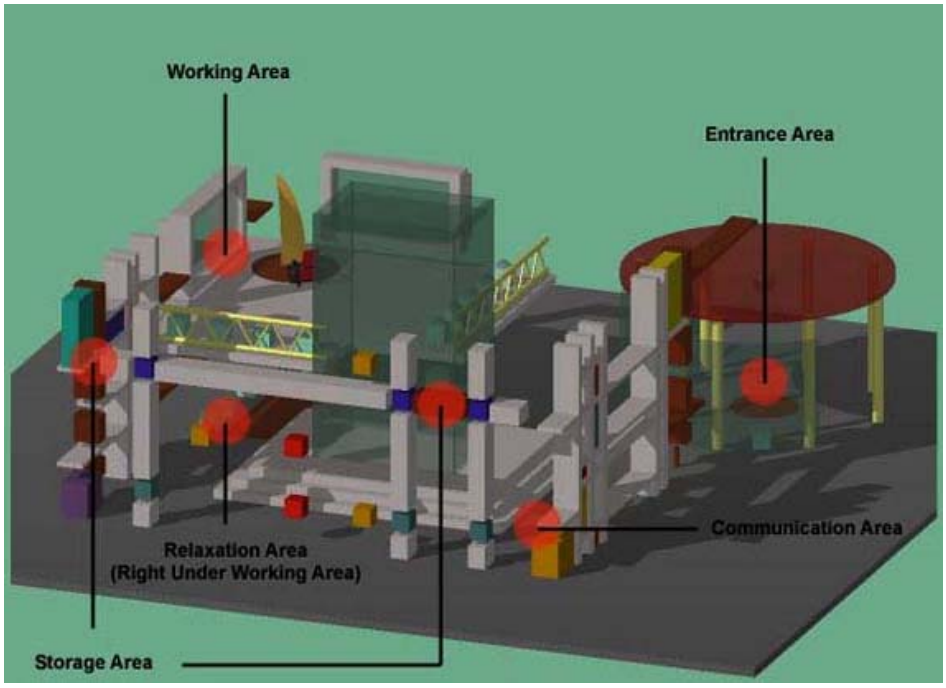

Figure 1. Virtual Office Design

The design concept is inspired by the Neoplastic paintings of Piet Mondrian. The walls are not "solid" in appearance and are functional in providing a frame for placing objects as well as defining the boundaries of the office. Objects on the wall are presented as rectangular prisms. In this design, the position of the colour cubes and the balance between warm-hued and cold-hued colours are decided after careful consideration. Interactivity is a key issue in the design of a virtual office. The cubes are given an initial location but the user can relocate them.

Although the magnitude of the dimensions of virtual space is not a cost issue, the room is designed with a geometric size for each activity creating the sense of virtual movement when changing activities. Larger size in 3D visualisation helps to distinguish the function tools from each other and avoid confusion.

The office as a structure is an object, which is constructed with different parts. The function tools within the office are separate objects. The office and these separated objects have their own design presentations and properties, and they are represented by different VRML models. We maintain this object-oriented representation so that each object has distinct properties, including not only a 3D model representation, but also functional properties, location that can be changed, and programmed behaviours. Therefore it is essential to clearly define what the office is and what the objects within the office are. In this specific case, the office itself is made up of:

- Exterior walls,
- Ground floor
- Interior frames
- Stairs
- Entrance area columns and roof
- Working area floor

The objects within the office are:

- Glass lift
- Entrance area: sliding screen, recording, tape (digital audio, invisible), security, camera, left crystal cylinder and right crystal cylinder
- Working area: chair, tools menu, information screen, communication screen, assistant tools and main tools
- Communication and storage area: all the colour cubes
- Relaxation area: flying carpet, tools menu, and entertainment screen

The real cost in a virtual office design is the size of the objects in memory. When designing the office, revisions were made in response to the needs of a student in the office and the "cost" of downloading and moving around the office. The first 3D model of the office was defined in a CAD system and exported as a VRML model for use in our object-oriented virtual campus database. The file size was very large which made it impossible to be loaded and navigated efficiently through the Internet. We revised the design and recreated the VRML models. There are two kinds of shapes in this office design: rectangles and circles. The rectangular patterns are good for computing because one object has only six faces. However, the circle pattern is computationally expensive. Many more faces are needed to form the shape of a cylinder, especially a hemisphere. Therefore the forms of some elements were changed. For example, we deleted the handrail in the Working Area and use texture mapping instead of creating more geometry, and we changed the crystal balls (hemispheres) to crystal cylinders (cylinders).

3.2. VIRTUAL CONFERENCE ROOM

We designed a virtual conference room for use during the DCNet99 conference (http://www.arch.usyd.edu.au/kcdc/conferences). The conference room is part of our Virtual Campus (http://www.arch.usyd.edu.au:7778), and is used as a 3D representation of a place with slide projectors, shared whiteboards, and a chat-like talking capability.

The conference room has an oval shape, as illustrated in the plan view in Figure 2. The curved wall on each side presents the same information to the people seated on different sides of the discussion table. Figure 3 shows a 3D perspective of the room.

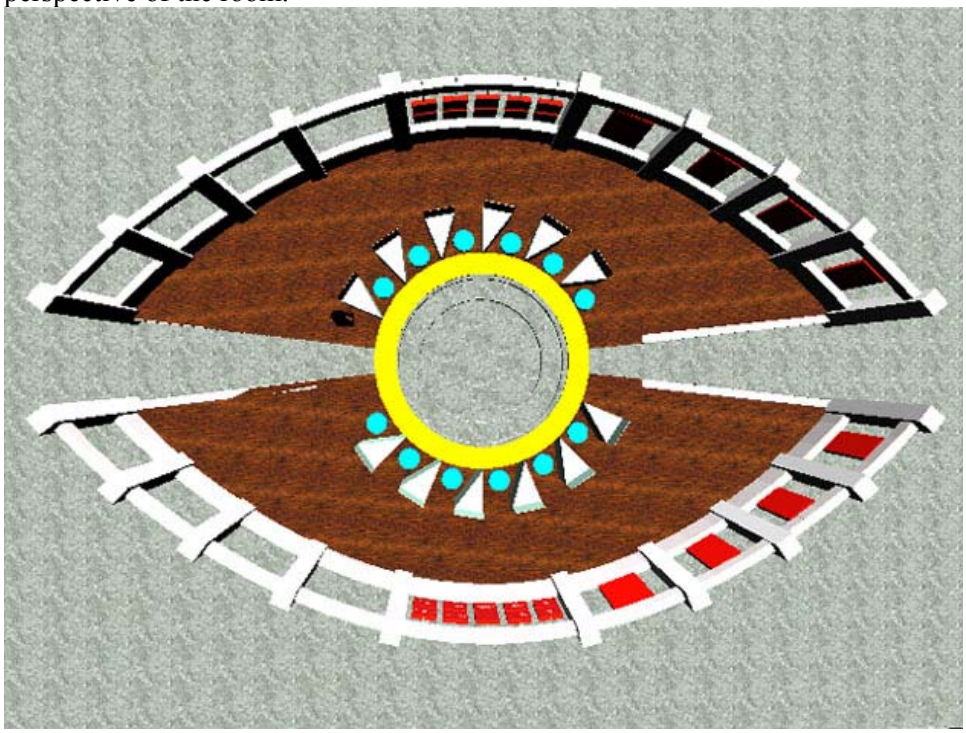

Figure 2. Plan view of the virtual conference room

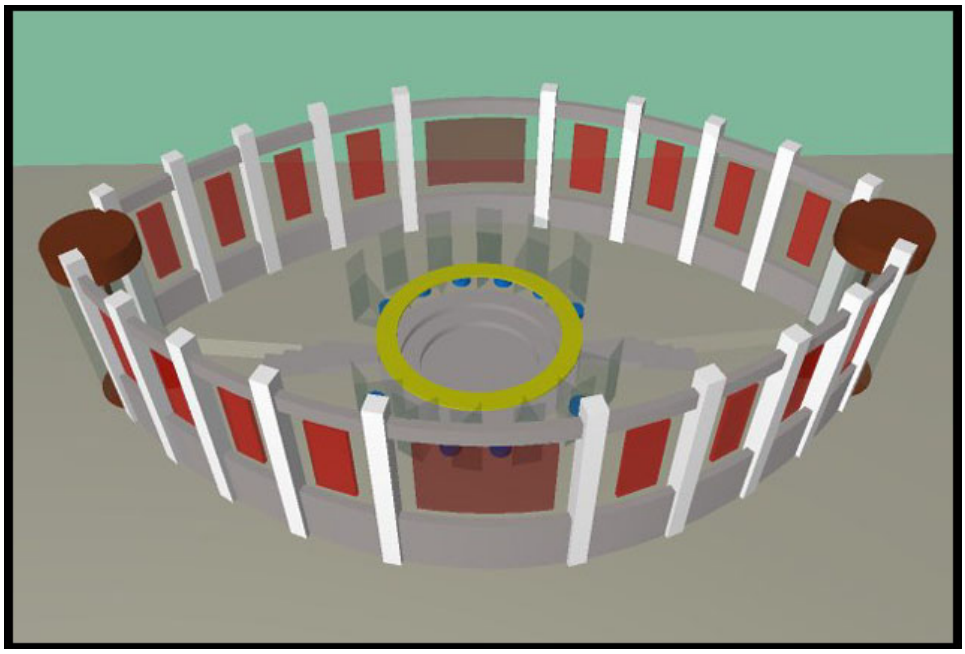

Figure 3. Design of the virtual conference room

The conference room is divided into three areas according to the different activities: entrance, information access, and discussion areas.

Entrance Area. There are two entrances in this room, which are located in the two ends, one is an entrance from the main hall of the virtual campus and the other is an entrance from a practice studio. The practice studio is a quiet room for preparing slides and trying the slide projector.

Information Access. The walls are the boundary of the room and also provide information access. They are frame-like structures for holding function tools and multimedia presentations. The center panel provides links to the online multimedia presentation of the conference papers and proceedings. The other panels in the wall provide access to the slide projector, discussion recorder, conference survey, conference notices and recorded discussions of past sessions.

Discussion Area. This is the central space of the room. There are a few stairs up to this area to create a sense of movement when changing activities. A Conference Assistant, which is a conversational robot, has been placed here to provide a basic introduction and guideline for people to use the Conference Room. We use a floating ring to define an area for the presenter. Around the ring is the place for other people who attend the conference, it has been divided

into twelve units. Each unit has a sliding door, a lectern for placing individual data and a small stage to stand on.

In designing and modelling the virtual conference room, we considered the objects that make up the room and the objects that are things in the room. The room is made up of:

- Ground Floor
- Walls
- Stairs to the discussion area

The objects inside the Conference Room are:

- Functional Panels on the walls
- Conference Assistant
- Entrances
- Individual units for each presenter in the discussion area

4. Conclusions and Directions

A virtual place that is object-oriented combines function, behaviour and geometric properties for each "object" in the virtual place. This means that the design of a virtual place involves the definition of objects that comprise the place. This makes the design process a modelling exercise similar to modelling a physical place. When designing the office and conference room described above, although we thought about the creation of a place, we ultimately thought about the design as a collection of objects.

In summary, the designs presented in this paper are based on the following assumptions:

- The virtual room can be designed with an analogy to the physical room, introducing new possibilities for function and geometry of cyberspace.
- Virtual architecture is comprised of objects that have properties in an object-oriented programming sense.
- The definition of the objects in virtual architecture follow from the intended function of the place.
- The geometry of the virtual room provides the visual cues for its use and creates ambience for the people in the room.

The geometry of a virtual place is subtly different to the geometry of its equivalent physical place. The walls of a room are important in defining the boundaries of the room, however, they need not be solid in a virtual room. In a physical room, solid walls provide security, visual privacy, and a barrier for sound transmission. In a virtual room, the concept of boundary is relevant for the wall since its visual presence indicates when you are in the room or outside the room. However, the other functions of a wall can be a programmed behaviour of the wall and not dependent on its geometric definition. For example, the security of a room can be programmed to only allow those people

with a key or an invitation to enter and regardless of the geometry of the wall, a person without permission cannot go through the wall.

The function of the virtual place is derived from the corresponding physical place. In our examples above, the office provided many of the functions of a physical office and the conference room supported the kinds of activities we expect in a physical conference room. We expect that this is only the starting point and we may find that we need rooms for functions that are not possible in the physical world but are valid functions in a virtual place.

The behaviour of the objects in a virtual place is a new consideration. Behaviour in the physical world is dependent on the geometric and material properties of the objects in the world. Behaviour in a virtual world is a programmed feature that introduces new possibilities in design. We can create behaviours that can support online activities in new ways. For example, the geometric size of a room can be programmed to change in response to the number of people in the room.

Finally, the directions for the design of virtual architecture include:

- The establishment of principles for the design of virtual architecture.
- The development of a representation framework for virtual architecture
- Experimentation with the use of virtual architecture.
- The development of a set of proactive objects that fulfill the needs in virtual architecture that are not possible in physical architecture.
- Consideration of the implementation of efficient virtual architecture.
- Development of 3D modeller and navigation tools that support the principles of virtual architecture.

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