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## The design of 3D cyberspace as user interface: Advantages and limitations

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The Design of 3D Cyberspace as User  
Interface: Advantages and Limitations

by

Maria Borisovna Quick

A Thesis Submitted in Partial Fulfilment of the Requirement for  
the Award of

**Bachelor of Communications Honours**

At the Faculty of Communications, Health and Science  
Edith Cowan University  
Perth, Western Australia, Australia

Supervisor: Dr Arshad Omari

Submission date: 26/11/01

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The Use of Thesis statement is not included in this version of the thesis.



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## ABSTRACT

Virtual reality propagandists, technologists and the Internet community have long debated the issue of the usability of online three-dimensional (3D) environments. A lot of work was published about the benefits of 3D spaces for human-computer interaction and information visualisation due to their realism (Anders, Kalawsky, Crossley, Davies, McGrath, Rejman-Greene, 1998, Hamit, 1993, Heim, 1992, Aukstakalnis, Blatner, Roth, 1992). This topic also receives continuous industry support including standardisation of *Virtual Reality Modeling Language* (VRML, VRML Consortium, 1997) and the more recent Macromedia & Intel alliance “to bring web 3D to the mainstream” (2001, Intel Corporation). The actual implementation of this technology is, however, still “challenging” (McCarthy & Descartes, 1998) and minimal because “3D is too new and waiting for good design to be discovered” (Nielsen, 1998). The practical aim of this project is to fulfil the niche by creating a functional 3D interface for the access of two-dimensional (2D) information, such as text, using VRML. The theoretical aim is to contribute to further research into 3D usability by describing and analysing the design process in terms of possibilities, challenges and limitations.

The web site referred to in this paper can be found at <http://www.scam.ecu.edu.au/vrml>.

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## DECLARATION

I declare that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any institution of higher education, and that, to the best of my knowledge, it does not contain any material previously published or written by another author or organization, except where due references is made in the text.

Signature



Date

04/03/02

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## **1. INTRODUCTION**

### **1.1 The Project Background**

The aim of this section is to introduce the reader to a concept of computer generated, web enabled cyberspace. This chapter will also focus on the limitations of 2D cyberspaces. 3D cyberspace or “electronically constructed virtual places” (Anders, 1998) and the enabling technologies will then be reviewed with the focus on VRML. Potential advantages of 3D will then be examined, including a discussion of the current level of 3D world implementation. Finally, the characteristics of a desirable virtual environment will be established.

#### **1.1.1 The Role of Third Dimension**

On a daily basis human beings interact with three-dimensional reality. Anders (1998, p.15) illustrates our connection with the physical world by stating that space is “an extension of our being” and objects are “extensions of our mind”. The mind is also multidimensional because it consists of three mentalities: enactive, iconic and symbolic (Anders, p. 18). These mindsets are responsible for navigation, recognition and reasoning respectively but “none of them is supremely useful to the exclusion of the others” (Kay, cited in Anders, p.18). Therefore, in the process of discovery, it is only natural to strive for environments, which would match the “3D spatial processing capabilities of the human being” (Kalawsky, 1993, p. 64).

The invention of the personal computer, advancements in telecommunications technologies and finally, the establishment of the World Wide



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Web (WWW) has enabled the formation of a concept of non-physical reality, a space commonly referred to as *cyberspace*. The term has many definitions and can be applied equally to two-dimensional and three-dimensional environments. To support this notion, Bricken (1990, p.9) labels cyberspace as an “electronically mediated experience.” Similar to physical entities, these spaces can be entered, exited, explored, and most importantly experienced simultaneously by multiple users. The networked nature of the WWW facilitates collaboration and sharing crucial for senses of immersion and realism (Heim, 1998, Hughes, 1995).

The WWW is inherently text based because of the underpinning technology *HyperText Markup Language (HTML)*. HTML has evolved to support 2D graphics - the elements associated with the *Graphical User Interface (GUI)*, Xerox Corporation, 1970). To date, HTML driven cyberspaces prevail on the Internet. Opinions vary as to the reasons for such popularity. From one point of view, text is the most efficient form of expression due to bandwidth considerations. Hypertext, however, limits the exploration of two-dimensional sites to “pointing and clicking” (MacDonald & Vince, 1994, p. 25). Its interconnected and limitless nature is likely to “confuse the user because it is difficult to establish a mental model of [the web] structure” (Munzner, 1995, online). From a linguistic perspective, writing is really a constrained type of imagery (Hughes, 1995) because “graphics ... convey meaning more directly and succinctly than ... words” (Tversky, cited in Mullet, 1995).

Despite worldwide implementation, Fisher & Samuel (1998, online) and Bodker (cited in Andres, 1998, p. 66) consent that GUIs require an extensive learning curve and are implemented largely because nothing else is available. Even through text based interfaces can be enriched by graphical and multimedia elements, Anders (1998), Kalawsky (1993), Trevett (2000) and Vacca (1998) insist that the full

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potential of cyberspace is not realised by “visual gratification of graphics and animations” until “it taps into our natural capacity for using space as a medium [for] visualisation, abstraction, movement, and ultimately being” (Anders, p. 54).

### 1.1.2 Advantages of Three-Dimensional Cyberspaces

The attractiveness of 3D displays may reflect many factors, from a simple technology-driven delight in surpassing the all-too-familiar WIMP interface, to an implicit belief in the inherent efficacy of more *natural* perceptual processes and more *realistic* visual displays (Schiano, 1995, online).

There are many definitions of cyberspace. According to Hughes (1995), in its true form the term must refer to an environment presented in “rendered three-dimensional form”. Pesce (1994, online) thinks that “the World Wide Web should be extended, bringing its conceptual model from two dimensions...into three”. Crossley, Davies, McGrath, Greene and Erickson (1998, online) also agree that using three dimensions of space can enhance display, navigation and access to information. Waterworth (1996, cited in Crossley et al.) supports this notion stating that “3D user interfaces capitalise on natural human abilities to deal with objects in space, behaving in space and attaching meaning to spatial dimensions”. McCahill (1994, online) and Shum (1990, p. 10) attribute these advantages to our familiarity with, and understanding of, space.

Information visualisation, particularly for navigation and search operations, is another avenue for effective 3D implementation because the form provides “another perspective” (Muzner & Tesler, 1995, online) and “highly intuitive visual tools for direct manipulation of static and animated content objects and sequences” (Information Visualisation Workshop, 2000, online). Additional areas of successful

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3D implementation include e-commerce by allowing consumers “exploration of content from all angles” (Adobe, 2001) in such industries as telecommunications, automotive and building. Medicine, engineering and chemistry are also on the benefiting list (Nielsen, 1998, online) due to the 3D nature of organs, widgets and molecules. Without doubt, “consumers clearly enjoy the 3D button” or “virtual room” (Hughes & Mullet, 1995) and the engaging nature of the technology in the areas of entertainment and education

### **1.1.2.1 Enabling Technologies**

The multitude of 3D technologies is constantly being updated to enable interaction with entities arguably defined as “online virtual environments” (Glenn, cited in Heim, 1991, p. 65). Flatland Rover (Flatland Online Inc, cited in Netscape plug-ins, online), for instance, allows a user to *walk through* a three-dimensional shopping mall. Metacreation’s MetaStream Plug-in facilitates “fast delivery and progressive display of streaming 3D objects over the Internet” (CNET, 1999, online). QuickTime VR technology (Apple, cited in Netscape plug-ins, online) “immerses” (Geswind, cited in Helsel, 1991, p.51) the audience in a 360 degree panoramic scene. IRapid 4.0 by Emultek (Netscape plug-ins, online) builds prototypes and simulations of training applications. Cult3D Viewer (Cycore, 2001, online) enables exploration of objects by zooming, clicking, spinning and moving for the benefit of e-commerce and for multi-sensory experiences. The very latest 3D technologies, such as Macromedia Flash enables “real-time 3D animation” (Macromedia Flash Support centre, online, 2000) where 3D scenes are rendered on demand.

More recently, Macromedia in alliance with such companies as Intel, NewTek and SoftImage are working on “bringing 3D to the mainstream”

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(Macromedia Press Release, 2001, online) by enabling the import of three-dimensional content into Director 8.5 Shockwave Studio using the web based 3D file format W3D. Models can then be dynamically animated through scripting control of all the properties including position, rotation, scale, lightgroups, cameras, textures and individual bones. Alternatively, 3D primitives and text objects can be created with Director's internal scripting language Lingo.

In parallel, Adobe released a cyberspace authoring tool Atmosphere which enables "immersion in true-to-life settings, exploration of content from all angles, and real-time interaction with other visitors" (Atmosphere White Paper, 2001). Since plug-in download is a major hurdle for most web users (McCloskey, 2000, online), the Java based 3D rendering engine Shout3D "works with any browser, on any platform, at any connection speed" (Eyematic, 2001, online).

In addition to these technologies, continuous work on open standards for online 3D specifications is being done by the Web3D Consortium. Their major projects in progress include the next-generation Extensible 3D (X3D) Graphics, the X3D Scene Authoring Interface (SAI) and Java 3D Application Program Interface (API) for integration of 3D graphics with Java.

#### **1.1.2.1.1 Virtual Reality Modeling Language**

Perhaps the biggest achievement of the Web3D Consortium has so far been the establishment of Virtual Reality Modeling Language (VRML 1.0). It has since evolved to become VRML 97 the ISO/IEC *standard* (VRML Consortium, 1997) for describing interactive 3D graphics and worlds on the web. VRML was intended to be a universal interchange format for integrated 3D graphics and multimedia (VRML specification, 1997). Vacca (1998, p. 8) defines it as "the glue that allows a range of

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technologies, including multimedia-equipped personal computers, high-speed communications, and others, to bring networked virtual reality to the end user”.

Sadly, it has not come true as yet.

Many books have been written about the evolution of VRML. Lea (1996, p.8) traces its origins “to a fusion of science fiction, virtual reality, 3D graphics, and the phenomenon of the World Wide Web”. The language was inspired by Labyrinth, a prototype three-dimensional interface to the web developed by Mark Pesce, Peter Kennard and Tony Parisi in 1994. Presentation of the software at the First International Conference on the World Wide Web in the same year sparked an agreement to create a common language for description of 3D scenes. The goal of the VRML working group has been to achieve a platform independent, extensible, and low-bandwidth 3D format (Web3D Consortium, 1999). The Open Inventor ASCII File Format from Silicon Graphics Incorporated (SGI) was selected as the basis of VRML.

The Inventor File Format supports complete descriptions of 3D scenes with geometry, lighting, materials, 3D user interface widgets, and viewers. It had all of the features that developers needed to create highly interactive 3D applications, as well as an existing tools base with a wide installed presence (VRML Consortium, 1998, online).

With great enthusiasm the draft of the VRML 1.0 specification was presented during the Second International Conference on the World Wide Web in October 1994. The format allowed scene building and navigation, but it was missing such key features as “animation, interaction and behaviors” (Carey & Bell, 1997).

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## VRML 2.0

In January 1996 an official request for proposals for VRML 2.0 was issued. From 6 contestants including Apple, Microsoft and Sun Microsystems, The Moving Worlds tender led by SGI in collaboration with Sony Corporation and Mitra received a strong majority of the votes and became the working document for the VRML 2.0 specification. On August 4, 1996, the official VRML 2.0 specification was released at SIGGRAPH 96 in New Orleans. The Web3D Consortium announced that VRML was approved as an International Standard in 1998.

As an ISO/IEC standard, VRML has gained international endorsement and provides a guarantee of specification stability, which will promote content compatibility to drive the growth of 3D on the Internet” (Web3D Consortium, 1999, online).

According to relevant literature, VRML’s popularity soared in the year 1998 (Ames, 1997, McCarthy & Descartes, 1998). Vacca (1998, p.5) thinks that it was driven by the language’s commercial potential. Cyberspace exploded with 3D chat sessions, virtual stadiums, real-estate demonstrations and so on. The industry was working on a myriad of virtual worlds, VRML browsers and WYSIWYG editors to enable any netizen to own the piece of cyberspace. In parallel, proposals for a binary VRML standard, External Authoring Interface (EAI) and multi-user capabilities have also taken shape.

Despite all the hype, even when VRML was in its infancy, the topic of its usability in the mainstream was highly controversial. Pescovitz (1997, online), for instance, from Wired magazine compared the development process to “a party with few guests – [evangelists of the software]” due to “an overall distaste for web-based

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3D". The verdict of the sceptics was "it remains to be seen just whether there is real demand for VRML-based products" (Pescovitz).

In 2001 VRML has officially evolved into *Extensible 3D (X3D)* format –“a new-generation successor [to the original technology], to bring rich and compelling 3D graphics to the web for a wide variety of applications and devices” (Trevett, Nelson, Divilly, Park, 2001, online). The standard was developed by the Web3D Consortium, formerly the VRML Consortium with “strong” support from such companies as Blaxxun, Nexternet, OpenWorlds and ParallelGraphics. First commercial product shipments are expected to take place “at the end of 2001” including the prioritised release of the *VRML97* profile to provide complete compatibility between the two formats. This particular plan encouraged the CEO of Nexternet Neal Park (cited in Trevett et al. 2001, online) to put his company behind the venture:

X3D not only provides the latest rendering and Web3D functionality in a compact form, but through the VRML 97 profile this new standard also preserves our customers' investment in the significant amount of VRML content that is in active use today. This powerful mix of forward-looking technology that does not abandon our VRML heritage has convinced Nexternet to invest significant resources into aggressively supporting X3D.

What's more, an amalgamation of VRML 97 and X3D formats may produce VRML 200X specification sometime in the future, according to the president of the Web3D Consortium Neil Trevett (2000, online).

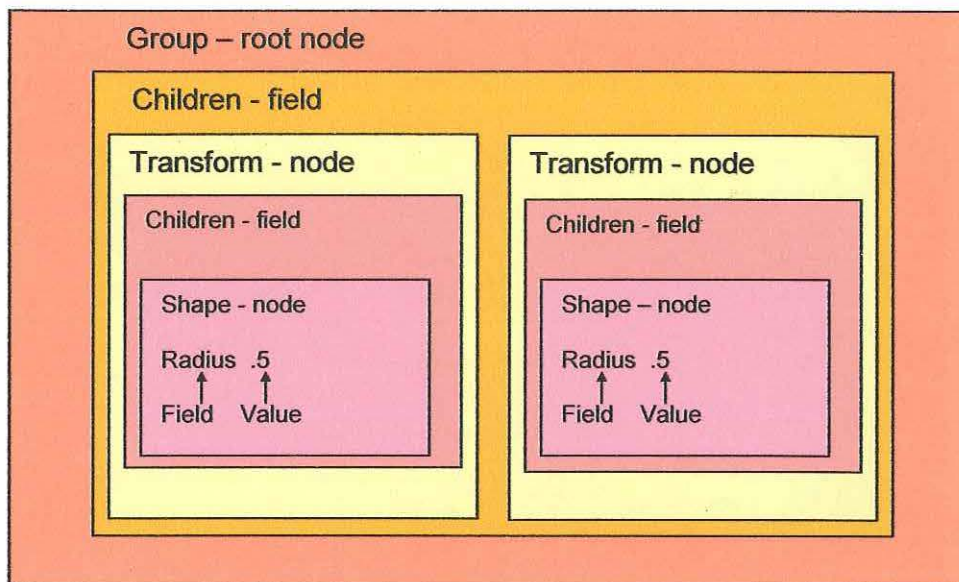
---

## VRML Scenes

Carey and Bell (1997) point out that “VRML is neither virtual reality nor a modeling language” because it does not imply full immersion and contains capabilities “far beyond” that the modeling language can offer in combination with limited geometry. VRML can be defined more correctly as a file interchange format and the “3D equivalent to HTML” (Ames et al. p. 5, 1997) because it provides a textual description of the resulting virtual world. VRML code is written in plain ASCII format and saved in a file with an extension .wrl (world). Typically, the code consists of a large number of polygons referred to by Vacca (1998) as to “the basic building blocks of a three-dimensional scene on a computer”. It describes the “blueprint” (Ames et al. 1997, p. 11) for geometrical shapes within the world defining their type, size, colour and position.

Shapes and their properties are called *nodes* in VRML terminology. Nodes contain *fields* and *field values*, which describe their attributes. All these elements or building blocks exist within a distinct hierarchical structure called a *scene graph*. A scene graph begins from a *root* node and is continued by subordinate, embedded, nodes, referred to as *children*. Children act as parents of other nodes and so on building a strongly hierarchical model of the world. Figure 1 demonstrates the structure of parent & child relationship within a scene graph. Metaphorically, Lea et al. (1996) associate the root node with a tree trunk and its children with the tree’s branches. Children inherit position and orientation properties from the parent and are then transformed relative to the parent node.

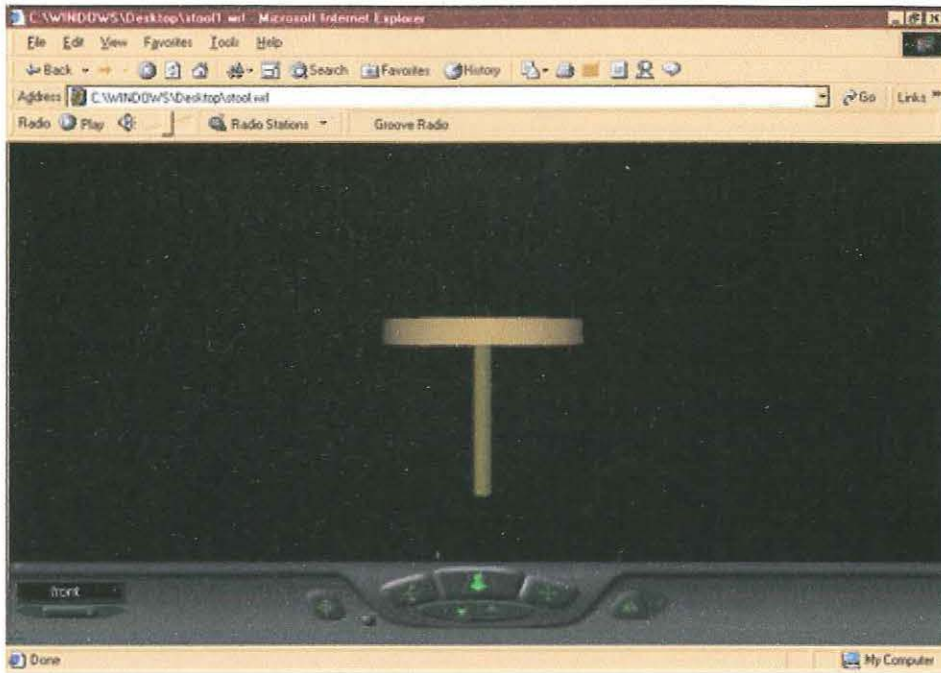




**Figure 1: Hierarchical structure of VRML scene**

## **VRML Viewing**

When a web browser encounters a VRML file embedded in an HTML page, it is rendered according to the structure represented by the scene graph with the help of VRML plug-ins. One can also use dedicated VRML viewing software to view scenes. Fundamentally, viewers differ from browser plug-ins in the way they display data via a separate browser window. One viewer called Cosmo Player created by Silicon Graphics is used to display a basic VRML scene, as shown in Figure 2. The scene is made up of two cylinders grouped together to form the seat and supporting leg of a simple stool.



**Figure 2: Rendered cylinders forming a simple stool**

Every VRML world is a self-contained environment, fully loaded into the user's computer upon access. Size wise, it can range from a few hundred bytes as in the above example to several megabytes. This aspect has direct impact on the download and the access times of the scene. Once fully loaded, the scene's performance is largely dependant on the speed of the CPU and any available hardware acceleration, mostly controlled using OpenGL. High performance processors and those with 3D graphics support allow for fast and smooth navigation through a scene.

## **VRML Interaction**

VRML browsers enable users to interact with VRML driven virtual worlds via the use of special control panels. They typically support movement forward and backward in addition to collision detection within the scene. The applications also constantly record the user position within the world so the motion can be replayed.

More advanced VRML viewers allow visitors to slide and float above the virtual *landscape* as well as incorporating gravity. Similar to a guided tour, users can be automatically moved to places of interest with a pre-programmed viewpoints list. The geometry of the scene as a whole can be rotated, tilted and zoomed to allow examination of elements and details. Some of these actions are typically controlled by preferences defining navigation type, movement speed and collision detection. Rendering options can be specified as well as background colour, screen resolution, scene optimisation, CPU load and frame rate can also be managed.

## VRML Syntax

The source code required to build the simple stool depicted in Figure 2 is shown below:

```
#VRML V2.0 utf8
Viewpoint {
  position      1 0 8
  orientation   0 0 0 3
  fieldOfView   .4
  description   "Front"
}

# stool
Group {
  children [
    Transform {
      translation 0 0 0
      # seat shape
      children DEF Seat Shape{
        appearance Appearance {
          material Material {
            diffuseColor .68 .61 .31
          }
        }
        geometry Cylinder{
          radius .5
          height .12
        }
      }
    }
    Transform {
      translation .01 -.3 .2
      # leg shape
      children DEF Leg Shape{
        appearance Appearance{
          material Material {
            diffuseColor .44 .44 0
          }
        }
        geometry Cylinder{
          radius .5
          height .7
        }
      }
    }
  ]
}
```

code segment 1

code segment 2

---

What follows is a detailed analysis of the above scene graph to demonstrate how the building blocks are defined and connected to each other. An essential component of every VRML file is the header `# VRML V2.0 utf8`. The header tells the browser that it encountered a VRML file, which is compliant with version 2.0 of the VRML specification and contains an international UTF-8 character set.

The *Viewpoint* node allows the definition of viewpoints provided to the user by some VRML browsers. The viewpoints enable visitors to see the 3D scene from specific camera angles by controlling position, orientation, rotation and field of view. To view the stool as shown in Figure 2, the scene graph begins with:

```
Viewpoint {  
  position      1 0 8  
  orientation    0 0 0 3  
  fieldOfView   .4  
  description   "Front"  
}
```

The *Front* string in the description field ensures that this viewpoint is listed in the Viewpoints menu by the browser.

The scene is continued by a comment `# stool`. Comments allow developers to make notes about different parts of the file for ease of identification. Apart from that, they have no other purpose because VRML browser always ignores any text following the pound sign.

Next element *Group* is one of the most common root nodes. It starts and ends with required structural/syntax element `{ }` within which other nodes - children are grouped hierarchically.

The *Transform { }* node is the first child of the *Group* node. It controls the position of other nodes or children within the world's three-dimensional coordinate system. 3D space as illustrated in Figure 3 has three axes X, Y and Z. Any position in space is specified by 3 values defining a location along each axis. Thus,

*translation 0 0 0* commands the browser to place an object at point 0 on the X axis, point 0 on the Y axis and point 0 on the Z axis. This set of coordinates is also known as the *origin* due to intersection of all the axes.

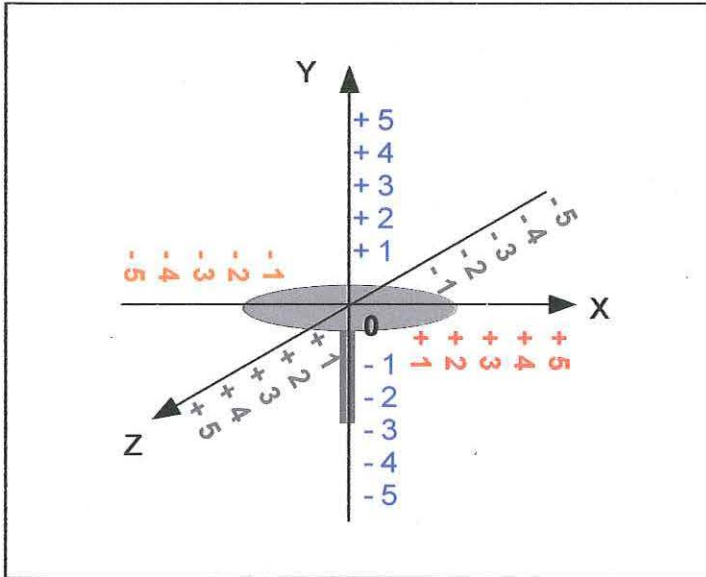


Figure 3: The stool positioned inside the world's coordinate system

### Code Segment 1

The *translation* element which comes after the Transform node, is the *field* where 0 0 0 is the *field value*. The set of curly braces {} indicates that the field translation belongs to the Transform node. Translation moves a node relative to the parent node, other transformations which may be applied include rotation and scale.

The line *children DEF Seat Shape{* defines a shape called Seat and makes it the child of the Transform node. DEF enables one to allocate a name to any node in the world. The named node then acts as a template, which can be reused again. In such cases, each duplicate is defined as an *instance* of the original node with the ability to inherit all its field values.



---

The Seat node contains fields and field values listed below:

```
appearance Appearance {  
  material Material {  
    diffuseColor .68 .61 .31  
  }  
}
```

These specify that Seat is a yellow-green (material) Cylinder (geometry) with radius and thickness of 0.5 and 0.12 cm respectively. In general, the Shape node simultaneously refers to a number of geometrical primitives in VRML. In this instance it is a cylinder but it can also be a box, a cone or a sphere. The *Appearance* field defines the Seat's color (material) based on Red, Green and Blue (RGB) color components.

## Code Segment 2

The next segment as a whole, beginning from the second Transform node means that another bottle green cylindrical shape named Leg has a radius and thickness of 0.05 and 0.7 respectively. It is positioned at the negative point 0.01 along the X axes, negative point 0.3 along the Y axes and 0.2 along the Z axes.

## Dynamic VRML

VRML can build dynamic cyberspaces through *wiring* instructions. Such instructions describe how to wire two nodes into a *circuit* with a wiring *route*. The route allows nodes to send messages to each other. Each message contains a value and is called an *event*. The events classified by a type, may contain logical values (*SFBool* event type), color values (*SFColor* event type), or time values (*SFTime* event type). They are sent by the node's output *jack eventOut* and accepted by the node's input *jack eventIn*. An eventOut sends events out when it is connected to a

route. An eventIn receives events when it is connected to a route and when an event is sent to it. In response, the node may trigger a sound, play an animation or turn on the light. The action depends on the node's individual features.

A node's fields can also have input and output jacks of different type: an input jack to set the field value and an output jack to send the field value upon change. The Viewpoint node, for example, has the following syntax:

```
Viewpoint {
  position      1 0 8      # field      SFVec3F
  orientation    0 0 0 3    # field      SFRotation
  description    "Front"    # field      SFString
  set_bind      # eventIn   SFBool
  isBound       # eventOut  SFBool
  bindTime      # eventOut  SFTIME
}
```

This example contains one input jack *set\_bind* of SFBool type and two output jacks *isBound* and *bindTime* of SFBool and SFTIME types. If an event containing TRUE or FALSE logical value (SFBool type) is received by the *set\_bind* eventIn, a viewpoint controlled by this Viewpoint node can be removed from or placed into a viewpoint stack maintained by a VRML browser. Depending on the existence of this viewpoint inside the viewpoint stack, the node can send either TRUE or FALSE logical value via its *isBound* eventOut. The node is also able to output the current absolute time via the *bindTime* eventOUT.

This example also has 3 fields: position, orientation and description. If an event containing three coordinates 4.5 6 7 (*SFVec3F* type) is received by the node's position field, then the position of this viewpoint will change from 1 0 8 to 4.5 6 7 relative to the local coordinate system. Likewise, the orientation field can orient the viewpoint to a different direction according to the set of 4 coordinates inside the *SFRotation* event type received by its orientation field. Instead of "Front", the node can assume any other name if it is send to the node's description field by the *SFString* event type.

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### 1.1.3 Current Implementations of 3D

One of VRML cofounders Bruce Damer (1999, online) in his petition *The Postmortem on VRML* proclaims:

For years I have been vocal (and largely unrecognised) in my views that VRML was being handled wrongly, aiming at technical specs rather than what users wanted. In addition, and sharing your frustration, the fact that multi-user was never treated as a priority was a big problem for VRML and potentially its fatal [emphasis added] mistake.

On top of that, “VRML content is challenging to make” and cannot be streamed over the web (Damer, 1999). The technology was developed on the basis of conflicting interests and objectively speaking was always “an answer rather than the answer” (McCarthy & Descartes, p.8).

Recently, Neil Trevett (online, 2000) president of the Web3D Consortium stated that a “much deeper problem facing the whole of 3D: it is not pervasive on the desktop”. Continued use of 2D GUIs and “lack of mainstream 3D applications are to blame.” The solution in his opinion is a “3D Version of Windows”.

Incidentally, a 3D interface to Windows was released in 1999 by ClockWise Technologies Ltd (Win3D, online) but not by Microsoft. Possibly, major operating systems (OS) vendors can’t yet offer the product due the need to overcome “a variety of challenges ... such as 3D user interface and navigation, user training, and ubiquitous 3D graphics performance” (Carey & Bell, 1997). Although, it must be pointed out that a VRML browser plug-in came with Netscape Navigator for a number of years and was anticipated to be included with Windows 95 (Pesce, 1998).

While the performance issue was more relevant in 1997 and there is ever growing support for “next generation [low bandwidth, optimised] software” (Adobe, 20001, online) by the major hardware and software vendors, other challenges still



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remain. Most recently, *Market Study of 3D on the Web* by John Peddie Associates (2001, online) found that “consumer resistance, bandwidth limitations, 3D file sizes, installation of plug-ins and digital asset management” continue to prevent online 3D deployment. At the same time, the report forecasts “one million web sites with 3D content by 2007” due to the joint efforts of companies “that exhibit the foresight to work together [and survive this tough embryonic phase]” (Staples, cited in Valley, 2001, online). First and foremost, high hopes are placed on Macromedia’s Shockwave 3D plug-in to entice the consumer (Staples & McCloskey, 2000, online).

#### **1.1.4 Desirable 3D Environments**

In order to solve the apparent lack of 3D implementations, a variety of visions have emerged. It was anticipated that their deployment would cause a wide spread acceptance of the technology and resulting products. Anders (1998, p. 99), for instance, considers the ultimate 3D space to be “an entirely cognitive entry” rather than the present reliance on “sensory perception”. Although Hughes (1995, online) agrees that realism is a highly desirable and a native attribute of virtual environments, he takes a slightly different perspective:

The idea is to provide a system that gives users a sense of place so that they may interact and feel comfortable with it. There is no need to make exquisitely detailed and rendered objects, as long as the world is consistent with its rules, it becomes possible for people to believe in it and learn from it.

Nielsen (1998, online), on another hand, feels that the ultimate goal of the web as a whole is “to go beyond the reality to things that are impossible in the physical world”.

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It is evident that most of these issues depend on the developer's understanding of the needs of the target audience and of the interface design as a whole rather than on technical capabilities. According to Crossley et al. (1998) 3D interfaces can be effective as long as they are clutter-free, contain objects within an easy reach and foster the user's prior knowledge. In addition, they must allow for a certain amount of experimentation due to the partial invisibility of 3D geometry. Furthermore, Shneiderman (cited in Dror, 2000, online) suggests pre-programming alternative means of navigation such as menus and predefined camera views in order to *ease* the user experience.

Apart from the cognitive and design issues, many technical challenges must be overcome as well. By combining past experiences, previous arguments, current limitations of 3D technologies and resulting worlds, Luber (2001, online) fairly accurately summarises existing technological shortcomings:

1. Eliminate the need for a plug-in.

Their installation is often time consuming and confusing, especially for a novice user unless it is happening behind the scene (McCloskey, 2000, online). Macromedia, for example, already adopted discrete installation of the Flash 5.0 plug-in but security settings on the host computer may prevent the setup process. Thus, it would be more advantageous to implement plug-in free technology. To the best of the researcher's knowledge, only the Java based Shout3D has this ability at present.

2. Display photo-realistic, geometrically precise 3D images.

Although examples of highly convincing 3D models can already be seen on Cult3D technology's web site (Cycore, online) and on the others, it must be

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pointed out that rendering quality depends at large not only on the tools employed but also on the graphic capabilities and speed of the end user's workstation.

3. Work effectively over standard Internet connections (such as a 56K modem) without the need for broadband.

The good news are that Macromedia, Intel and Adobe claim that the bandwidth problem can be solved through the use of highly optimised Shockwave player and Atmosphere browser plug-ins (2001, online).

4. Be easy to use, intuitive and responsive.

The ease of use factor must be considered from the designer's and the end user's viewpoints because the first influences the experiences of the latter. Ideally, all technologies should be customisable and have an optional visual interface for non programmers. Since the invention of VRML, many WYSIWYG cyberspace building tools have been produced but their mass development halted in parallel with the initial excitement about the web based 3D (Pescovitz, 1997, online).

Except perhaps for the freedom from plug-ins and the bandwidth limitations not achieved as yet by most available 3D technologies, VRML is capable of satisfying a number of the above criteria. Textures, for example, can add realism and conceal the coarseness of VRML objects. If used sparingly, they can also reduce the download and access times controlled by the arrangement of elements within the scene graph (McCarthy & Descartes, 1998, p. 41). A methodical approach to modeling can achieve precision while, initial planning, research and an evaluation of the users' needs are able to contribute a great deal towards the ease of use factors.

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## 1.2 Significance of the Study

Wherever it be in education or entertainment, the future promise for 3D environments on the web relies on bringing users a level of experience otherwise impossible (Vacca, 1998, p. 65)

It is inevitable that 3D cyberspace will eventually populate the web in abundance as indicated earlier by JPA's report (2001, online) and by the growing list of companies producing and supporting the enabling technologies. Due to intensified search for alternatives to WIMP driven interfaces, even sceptics at least theoretically understand the many benefits 3D can bring to users with one of fundamental arguments being "we live in 3D reality" (Zikovsky, 1999, online).

3D deployment is still in "embryonic phase" (Staples, cited in Valley, 2001, online) and one of the reasons preventing its popularity is the limited amount of the actual experimentation. By using such "ancient" (McCloskey, 2000, online) technology as VRML, the project will demonstrate one of the many possibilities to build interactive, bandwidth friendly 3D worlds in anticipation that it will encourage the development community to create a great deal richer "cognitive interfaces" (Anders, 1998) with *today's tools*.

## 1.3 Purpose of the Study

As a result of building a 3D interface, the study attempted to evaluate why the medium is not prominent on every desktop by identifying the practical challenges and limitations which face the 3D cyberspace developer. In addition, the project discovered if it is possible to create spatial metaphors for the representation of textual data as opposed to the usual 2D depiction. Finally, it contributed to similar research by recording possibilities offered by 3D environments.

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## 2. LITERATURE REVIEW

### 2.1 Introduction

The literature review will elaborate on the numerous visions, partly realized with VRML, of the cyberspace implementations for more intuitive human-computer interaction. Despite the obvious shortage of 3D interface design paradigms, many unanswered questions and challenges, such applications as the Knowledge Garden, Miner3D Site, CubicEye and Win3D provide sensible solutions to the issues raised throughout this paper.

### 2.2 General Literature

Levy (1998) together with Tiffin and Rajasingham (1995) illustrate how the concept of virtual was present in our imagination, memory, knowledge and religion long before the invention of computers and digital networks. Strate, Lance, Gibson, Jacobson and Ronald (1996) support this argument by stating that such words as *navigation*, *dimension* and *connection* preserve their meaning in virtual environments. However, McCarthy and Descartes (1998) point out that virtual reality and virtual realism are not the same thing. During creation of 3D objects and worlds, designers are aiming for *believability* rather than for realism. Furthermore, Schum (1990) concludes that space in the real world, and as an interface metaphor, has fixed location in contrast to Internet dependant virtual environments.

To reflect these differences, Pesce, Kennard and Parisi (1994) coined the term *cyberspace* – a spatial equivalent of the WWW and pioneered the use of VRML for online data visualisation. “The need for cyberspace is justified by our excellent

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ability to visualise, to spatio-locate and to spatio-organise as opposed to the limited comprehension of depth through standard navigation” (Pesce et al. 1994).

Anders (1998) thoroughly demonstrates the potential of the cyberspace to relate to the ways we think, and live with physical space. Specifically, his work is focused on the dependence of human thinking processes on spatial models. Hughes (1995) perceives cyberspace as the medium which encompasses all prior means of communication, entertainment and visual culture such as TV, radio, multimedia and so on. Vacca (1997) predicted that with the standardization of VRML, 3D objects would become a “commodity”. Furthermore, the technology would enrich the web with new types of interfaces: “self running exhibits and simulations, unfolding structures, dynamic sculptures, self-extracting and self-constructing objects” (Hughes, 1995). Poupyrev (1999) deems this vision possible only if “cohesive 3D interface paradigms” are established beforehand.

Nielsen (1998) sees the advantages of 3D spaces for visualisation of physical objects, education and entertainment. Milligan (1998) also considers the *virtual classroom* helpful for education by enabling students to interact with visualised data. Martin (1997) prizes such *natural* attributes of cyberspace as collaboration, interactivity and accessibility. He believes that these qualities in combination with *realistic* properties of 3D graphics can create endless business opportunities in retail and entertainment.

## 2.3 Literature on Previous Findings

Popuyrev (1999) conducted an insightful review of the status of 3D interface design. He found that in contrast to 2D interfaces with well-established guidelines, processes and mainstream development tools, 3D UI design is more of an *art form*, which relies heavily on the author's experimentation, skill and interpretation. Gershon (1999) shares the sentiment by stating that "while the desktop metaphor and its various GUI widgets have become standardized, there is as yet, no satisfactory 3D equivalent". Nevertheless, Popuyrev speculates that the 3D design process is luckily to branch into the 4 codependant directions shown in Figure 4.

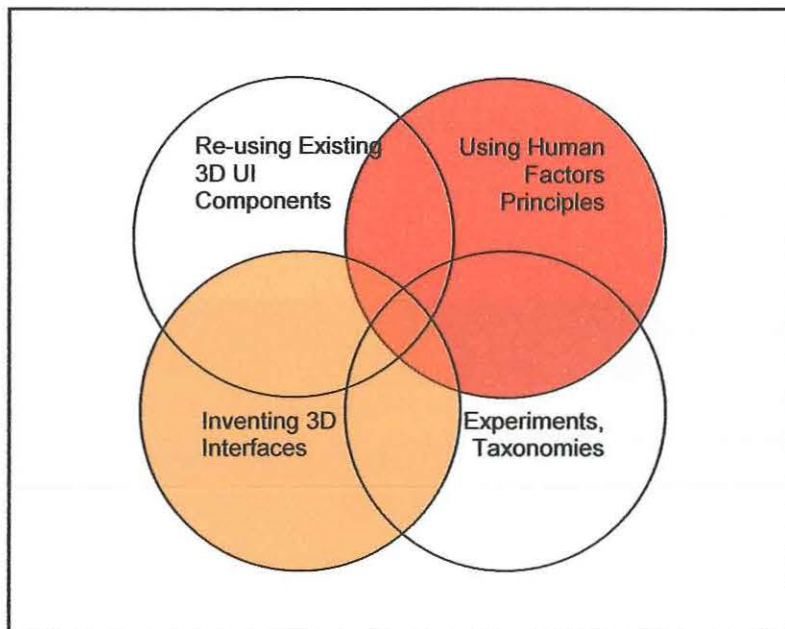


Figure 4: Four components of 3D user interface design (Popuyrev, 1999)

*Re-using Existing 3D UI Components* is undertaken when the elements of a 3D interface are effectively *borrowed* from the existing metaphors used in previous interfaces. The design can incorporate familiar 2D elements such as buttons and menus together with the wealth of relevant research. This tactic is advantageous for an end user due to recall of prior knowledge. At the same time, it may introduce the



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limitations of metaphors from the physical world increased by technological shortcomings inherent in their representation.

An interface can also branch into *Experiments/Taxonomies* and *Inventing 3D Interfaces* by using one's imagination. This approach can be very effective if the resulting metaphors are easy to understand and are culturally referenced. Regardless of the selected path, the most important consideration has to be given to *Human Factors Principles* through consistency, constraint and multi-dimensional feedback.

These findings are supported by Crossley et al. (1998) who adapted a realistic approach to construct a VRML based 3D space, the Knowledge Garden, for access and management of online data. The authors explain that due to the “highly cross-cultural” concept of a garden, the interface is able to easily represent the organic nature of online information.



**Figure 5: The Knowledge Garden (Crossley et al. 1998)**

The central circle within the interface illustrated in Figure 5 is a social space with shared electronic whiteboards. The outer areas are dedicated to the different information sources. The information itself is represented by clusters with green stalks and colour coded *flowers* at their ends to reflect changes in the information



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status. Thus, the original shade of the document is blue, recent updates are marked by red and black shows that a link is invalid.

After using the application for “some time”, the developers found that the lifelike metaphor of the garden, visual representation of different data, alternative views, predefined viewpoints and colour coding were particularly useful and appealing. On top of that, the tendency to get lost in hyperspace (Muzner, 1995, McCahill & Erickson, 1994) was minimised due to the confined location.

In contrast to the spherical setting of the Knowledge Garden, contemporary web search system Miner3D Site (Dimension 5, 2001, online) utilizes *perspective walls* (Mackinlay, Robertson, Card, 1991) to display search results. This technique visualises large information spaces by “smoothly integrating detailed and contextual views” (Mackinlay et al. 1991). In a similar fashion, Miner3D Site uses geometry to represent search results through colour coded objects suspended in space. Figure 6 illustrates information sources found by the system for a search string *3D interface*.

Using a mouse the results view can be zoomed in and out. A user is able to control the amount of data simultaneously on display and can customize desirable aspects by colour, height and shape. The result is a “high-throughput multimedia landscape” (Dimension 5, 2001, online) that has been used on auction sites, online music stores, news servers and so on.

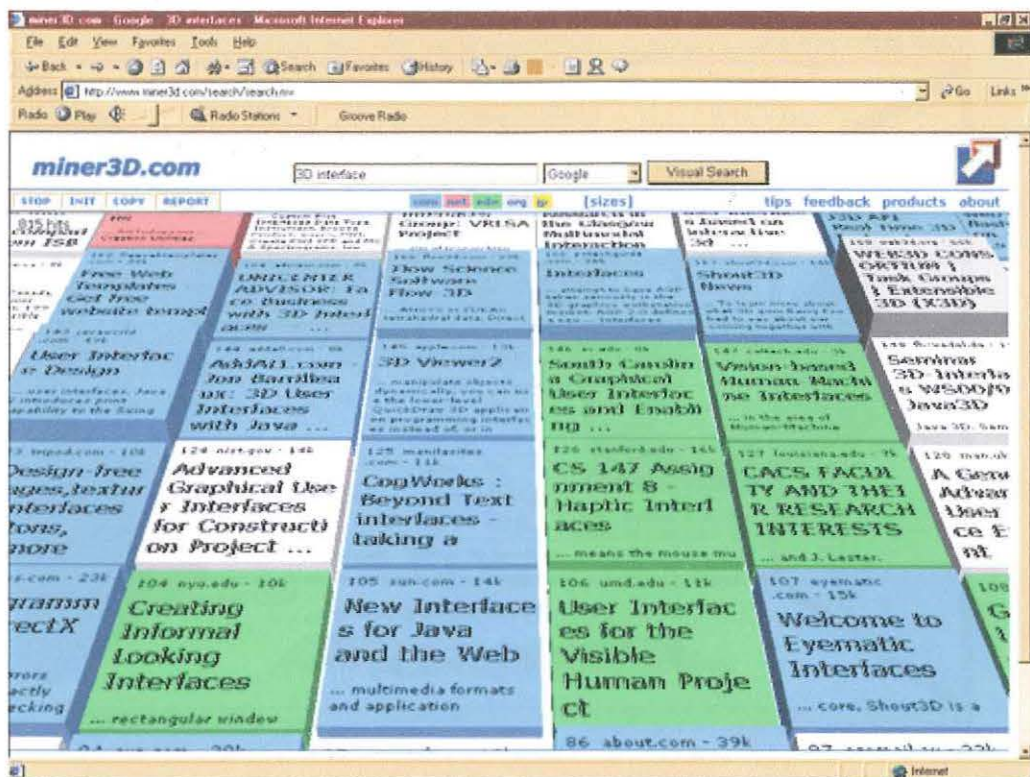


Figure 6: Miner3D Site web search system

Another 3D visualisation system, CubicEye (2ce, 2001, online) shown in Figure 7 implements a cube metaphor to project the WWW content on 5 internal visible sides of a cube. Each side can be turned into a cube in continuous fashion, which results in a tunnel like view. Despite perceived complexity, “extensive user testing” of the product, particularly with novices, had minimal orientation and usability problems (McCracken, 2001, online).

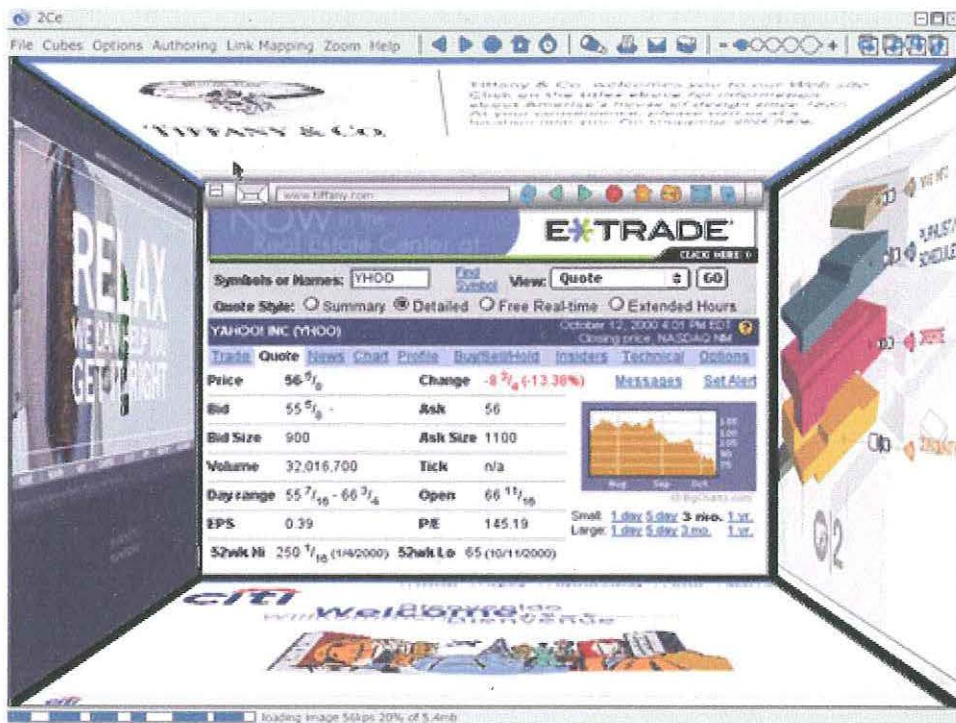
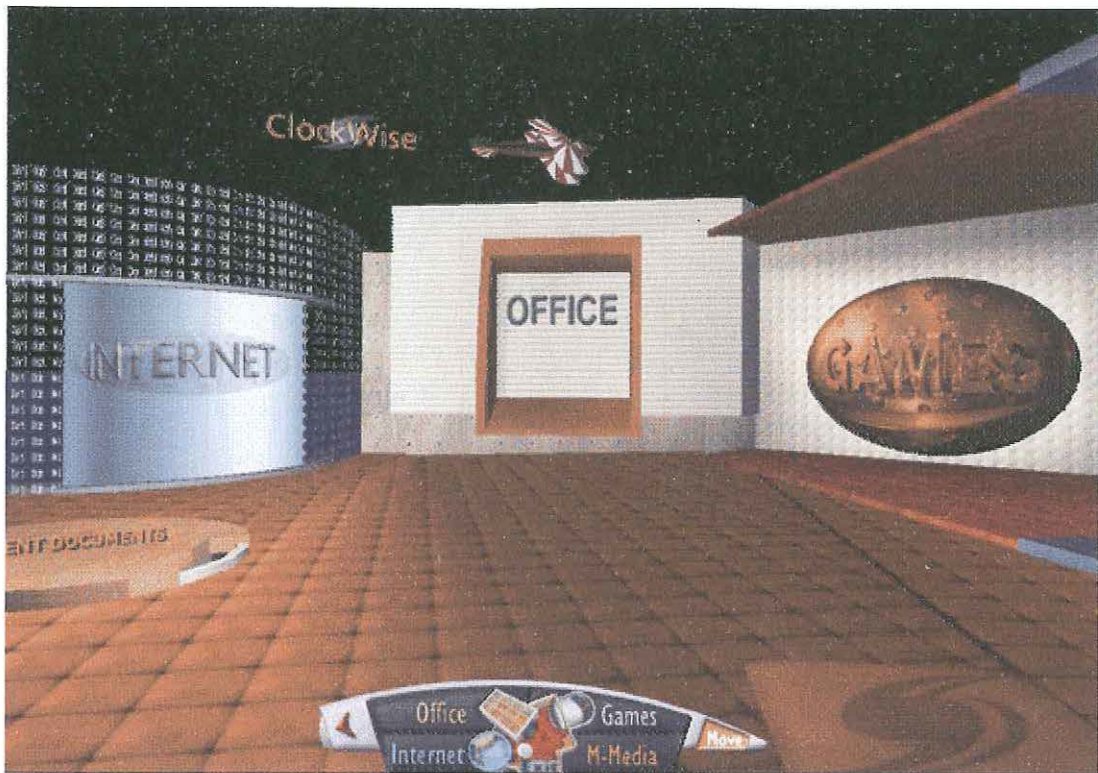


Figure 7: CubicEye web browser

The idea of utilizing cubes or *rooms* for certain tasks in user interfaces was originally developed by Xerox Palo Alto Research Centre (PARC) as part of their integrated *information workspace* (Young, 1996, online). Much later, this concept laid the foundation for Win 3D (ClockWise Technologies Ltd. 1999, online), a three-dimensional interface to the Windows operating system. The interface depicted in Figure 8 allows navigation between 4 rooms: an Office, Entertainment area, Internet and Games. As the names imply, each room houses relevant artefacts: documents, applications, multimedia control panels, web browsers and so on. Such arrangement brings more structure to the user's working environment (Shum, 1990).

According to the company's CEO Ronen, the software had 50,000 users worldwide as of 8 of August, 2000. Shneiderman (cited in Dror, 2000, online) attributes such success to avoidance of many problems related to three-dimensional interfaces. In particular, objects don't overlap each other; text is readable regardless of the distance and alternative means of navigation are perpetually available.





**Figure 8: Win3D interface to the Windows OS**

## 2.4 Studies Similar to the Current Project

Campbell (n d.) reviews methods of coexistence between VRML and HTML views in a single browser window. The simplest approach is to break the view area into two frames where a 3D rendered filing cabinet, for example, would facilitate access to textural data as shown in Figure 9. Different drawers containing folders with documents can be opened via a mouse click. However, the author believes that the best approach is to embed HTML documents directly into 3D space. Thus, a mini version of the same document would appear inside the folder. As a result, the user has advantages of multiple views and improved association in addition to normal HTML controls. Funkhouser (1996) also values VRML's ability to provide viewpoints and to animate objects so as to signify the "illusion of immersive walk-through".

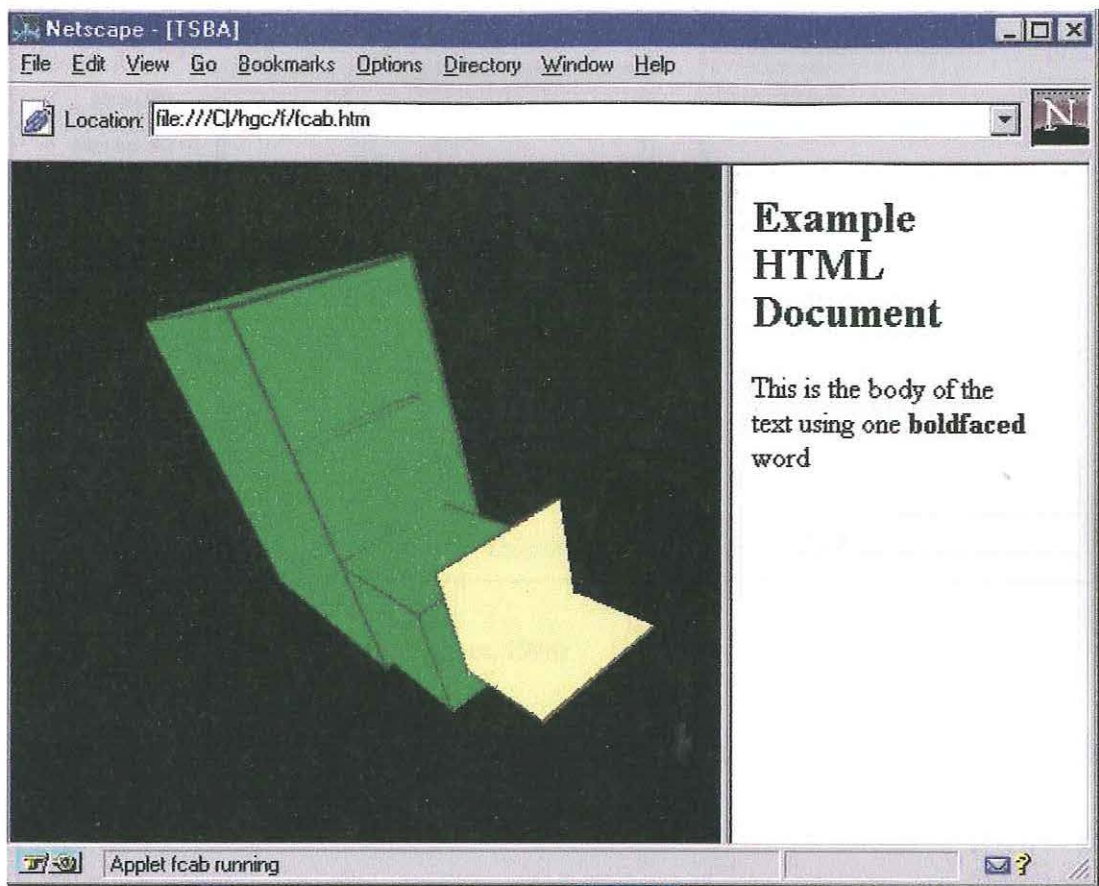


Figure 9: Coexistence of VRML and HTML (Campbell, n d.)

In a similar study, Raggett (1994) proposed to incorporate a desktop VR environment based on VRML where users would be able to *walk* through rooms and gardens, doors would symbolize links and sound would be spatialised to increase *realism*. In addition to doors, wire frame models, image titles and other resources would act as URLs. So as to “cut down on computational load”, avatars in the shape of “disembodied hands” only would manipulate objects. Hunter (cited in Poupyrev, 1999) also supports a mix of physical and real in 3D interface design due to “enhanced immersion”.

A more detailed model of VRML/HTML system shown in Figure 10, was offered by Hughes (1995). The system consisted of a VRML display area, HTML display area and navigation widget offering multiple views and hypertext controls.

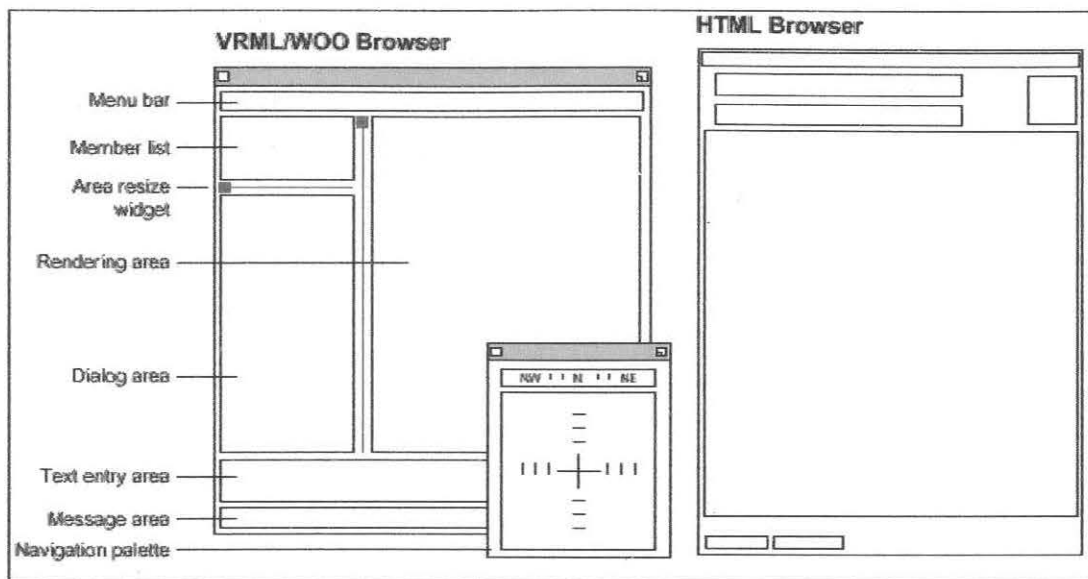


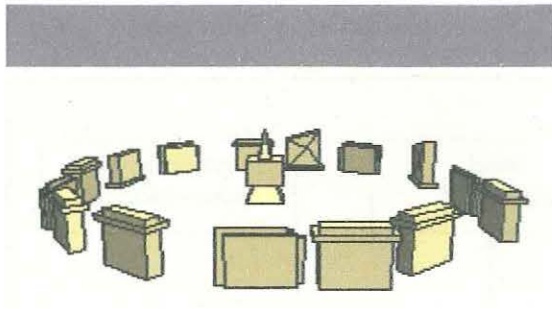
Figure 10: VRML/HTML system (Hughes, 1995)

In addition, it contained an avatar menu and a dialog box for communication. To describe the implementation of the software, the author wrote:

I go forward; my 3D environment moves with me. I can drag things around, keep them in a personal wallet, tag along or hang out with friends watching plays. And as people move on the virtual stage, I can follow the script in a HTML viewing container somewhere in my space, or see it using some generic web browser. If the play were run by a program, I could fast forward it, make changes to the script, talk to the players and have them do different things. If someone else wishes to rewrite the script with me, fine; we can gather at my personal site somewhere and make the changes to a personal copy.

In an exploratory design project, McCahill and Erickson (1994) constructed a simulation of a 3D spatial interface for management of the information system Gopher. A user interacts with “three levels of representation: the *overview*, the *neighbourhood* and an individual item” as a result of a search or hierarchical access. The neighbourhood, for example, was represented by a circular composition of shapes in Figure 11, the overview by spiral arrangement because the user had a lesser chance of getting lost and could easily count the quantity of the results.





**Figure 11: The Neighbourhood in 3D system for Gopher (McCahill & Erickson , 1994)**

As in the instance of Raggett's vision (1994), sound was considered to be an important entity for "sense of place" so different neighbourhoods had different sounds. A variety of 3D icons characterised diverse components of the information space including documents, search engines, interactive sessions and gateways to other directories. As a result of building the prototype, the authors came across such challenges as inclusion of simple, yet recognisable 3D icons, selection of a spatial layout and the preservation of individual appearance without sacrificing consistency.

## **2.5 Literature on Methodology**

The rapid prototyping model described by Bearman (1997, online) and depicted in Figure 12 was adopted in the realization of this project because it encourages fast initial design. Subsequently, the design was tested and corrected continuously until an adequate level of satisfaction was achieved based on the Popuyrev's (1999) system for 3D user interface design. It was translated into series of steps listed below:

- Research proposed and implemented 3D environments
- Examine the results of their evaluation
- Consider human factors
- Combine the three with a realistic physical metaphor

- Assess other possibilities

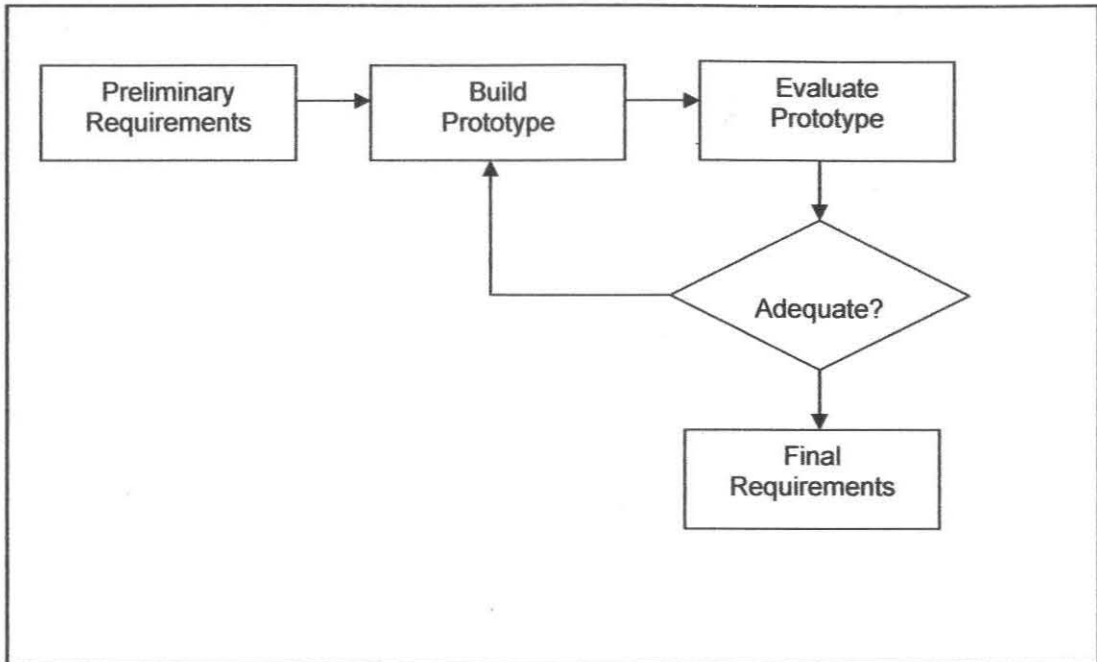


Figure 12: Rapid Prototyping model (Bearman, 1997)

## 2.6 Summary

In short, we are in great need of creativity in the search for new metaphors and visual/aural/haptic idioms [for 3D environments] (Gershon, 1999, online).

The literature review demonstrates the potential of three-dimensional spaces to transform human computer interaction to a more intuitive level, particularly with the invention of VRML. It also discusses current findings in approaches to 3D interface design and describes their successful adoption in the VRML based project the Knowledge Garden and in a variety of contemporary spaces and interfaces. Furthermore, it has shown that 3D spaces hold as many promises as there are challenges by examining relevant to this project studies focused on VRML's coexistence with HTML. The key finding of this review is that many experimentations and implementations are needed to achieve the *appropriate* 3D interfaces.



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### **3. MATERIALS AND METHODS**

The goal of this chapter is to conclude the study with an in depth analysis of VRML's implementation for construction of the proposed 3D interface. The approach taken adopts a realistic metaphor based upon physical objects represented in 3D. Some 2D elements were also included where they are deemed more appropriate.

Initially, VRML's similarity to HTML will be viewed as useful and beneficial for the project's outcomes. In many ways, the technology provides a sound, and mostly successful means for visualisation of the chosen 2D environment but at the same time imposing limitations in its potential.

This chapter will also focus on routine variables used in the construction process namely the browser, the coding application and the development platform.

#### **3.1 Choice of Development Technology**

With the current abundance and rapid growth of 3D technologies, it is imperative to explain why VRML was selected to develop this project.

Pearce (1998, p. 25) and Hughes (1995, p. 65) attribute HTML's prolonged survival to the ease of its implementation and assembly in any text editor. It is bandwidth friendly and easy to learn. VRML is often compared to a "3D equivalent of HTML" (Vacca, 1998, Lea et al. 1996) because it was developed as a successor to the original technology. Like HTML, VRML is a text based, intuitive, "highly accessible, platform independent and widely supported online format" (Anders, 1998, p. 2). Furthermore, the language was created specifically for online cyberspace

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implementations. Since VRML's invention in 1994, it has been well documented and experimented with.

### 3.2 Choice of Development Environment

Despite many similarities, the fundamental difference between HTML and VRML is that the first deals with text formatting while the latter outputs geometry. Therefore, it makes sense to use a visual environment for the assembly of the 3D space. However after thorough investigation of available software, it was evident that most VRML enabled application packages limit the design process to predefined options and create enormously large, often semantically incorrect files due to unnecessary duplication of the scene graph.

As an example, 3D modeling software Strata 3D offers conversion to the VRML 2.0 file format. However, the procedure excludes animation and sound. With regard to file size, 4 simple shapes consume only 336 bytes when hand coded in Notepad in comparison to 282 kb after conversion from Strata's native format. The problem occurs because the application converts every original primitive, except the cube, into a group of *faces* properly referred to as *IndexFaceSet* node. Every face inside each node is defined by using a coordinate index. The number of coordinates forming the total coordinate index is determined by the quantity of faces required to build a shape: the smoother the shape, the more faces there are inside it.

In view of the above issues, it was evident that the most bandwidth efficient method is to hand code VRML. Parallel Graphic's VrmIPad (2001, online) was selected to fulfil this purpose. The software provides an integrated text editor designed to manage, create and edit VRML files. VrmIPad auto completes syntax, dynamically visualises a scene tree, provides bookmarks to identify specific line(s) in

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the source code, detects errors and includes a world-publishing wizard to get the project ready for online delivery. While VrmIpad is suitable for writing VRML, it does not preview rendered 3D geometry. In order to do so, a VRML plug-in for a standard web browser is required.

### **3.3 Choice of VRML Viewer**

Many plug-ins with different capabilities and for a variety of platforms are available for viewing VRML content. When choosing a VRML browser, Crispen (2000, online) recommends taking into account functionality, extra features, hardware acceleration, scripting and performance. Typically, constantly updated browsers such as Cortona VRML Client (2001, online) from Parallel Graphics support more features and are far more stable than their predecessors like SGI CosmoPlayer (n.d. online). In addition to the VRML97 specification, Cortona supports Splines and NURBS nodes, which offer more optimised, more advanced geometry with fewer demands on viewer's hardware. Moreover, the application enables keyboard input, 3D text, advanced texture mapping and support for the vector based Macromedia Flash technology (Parallel Graphics, 2001).

Despite all the extra features, the researcher found that Cosmo Player, development of which stopped with Windows 95/NT and in beta version for Macintosh, offers the smoothest navigation and rendering. It was therefore used to preview the world during the development process.

### 3.4 2D Information Space Selected for 3D Interface

The WWW site for the School of Communications and Multimedia (SC+M) at Edith Cowan University was selected as the foundation information repository for the future 3D interface. The School's home page captured in Figure 13 can be found at <http://www.scam.cowan.edu.au/>. It branches into 6 major areas including general information about the facility, courses offered, an honour roll, current research and a gallery of student work. The site also contains lecture notes, notice boards, workshop files, staff directory, discussion forums and so on. The site's content is largely text based except for occasional images mostly in the *Gallery* section.



Figure 13: Home page of the School of Communications and Multimedia

The *Course Information* link enables passage to the largest chunk of data within the site because it lists all courses conducted at Undergraduate, Postgraduate and International levels, and eventually leads to the main pages of every web enabled unit within each course. The home page also connects directly to 8 major streams within the Undergraduate Bachelor of Communications degree namely *Multimedia*, *Photomedia*, *Public Relations*, *Film and Video*, *Media Studies*, *Mass*

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*Communications, Advertising and Journalism*. As a whole, the online infrastructure can be compared to an interconnected information structure with many branches.

As formal usability evaluation of the domain was not the intention of this project, the researcher relied on previous findings and similar projects to determine its need for the extra dimension. Firstly, the School's architectural presence in the real world was deemed as effective and suitable criteria for 3D visualisation. According to Shum (1990, p.8) and Anders (1998), "conceptual structure" of hypertext embedded inside "a physical structure [buildings and rooms]" offers a number of useful properties inherent in the physical world. In particular, such an arrangement is of greater benefit to the sense of context, to navigation and to an overall structural understanding of the information system (Malone, cited in Shum, 1990).

Secondly, a diagram of linking relationships between all information units within the site reveals that a large cyberspace is encountered, consisting of approximately 60 pages. Therefore, a user presence in one spatial location might be helpful for reducing "the tendency to get lost [in sizeable information structures]" (Muzner, 1995, McCahill & Erickson 1994). By using natural attributes of three dimensions such as the depth and the extra perspective, the interface could "enhance display, navigation and access of information" (Crossley et al. 1998). Specifically, VRML is able to provide a variety of viewpoints in addition to visual aids, colour coding, texture mapping, sound and dynamic visualisation – the abilities prized in prior investigations.

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### 3.5 A Combination of 2D and 3D Views

VRML provides the technology that integrates three dimensions, two dimensions, text, and multimedia into a coherent model. When these media types are combined with scripting languages and Internet capabilities, an entirely new genre of interactive applications is possible (Carey & Bell, 1997).

From the existing information visualisation methods, this project located at <http://www.scam.ecu.edu.au/VRML> implemented Campbell's (n.d.) approach. This consolidates the VRML powered 3D space and the original HTML driven SC+M site in a single browser window. The method separates a single HTML page into 2 discrete *frames*, one 3D and one 2D used for the display of information.

In addition to simplicity of implementation, it is anticipated that such coexistence will empower users to explore information in "an intuitive and natural" fashion (Funkhouser, 1996). Carey and Bell (1997, online) also favour the combination because "3D metaphor presents a natural user experience that supports classic two-dimensional (2D) desktop models as well as extends into broader contexts of space and place".

#### 3.5.1 Impact on the Target Audience

Despite the experimental nature of the project, the researcher believes that it is important to briefly examine the potential impact of its outcomes on the existing target audience of the web site.

In theory, "friendly 3D user interfaces will allow [consumers] to work more effectively, spend less time on routine procedures and be creative" (Poupurev, 1995, online). So far, developers of contemporary 3D applications such as Win3D,

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Miner3D Site and CubicEye target mostly a young, well informed, efficient percentage of the user market who “like technological innovations” (Dror, 2000). Perhaps, their expertise and affection for experimentation will compensate for the perceived “complexity” (Nielsen, 1998) of the medium. Yet, the proposed “multi-modal” interface (LaViola, 1999, p. 2) will allow all users to choose a preferred interaction style. The preference is influenced by “prior experiences” (Swan & Allen, cited in Vasilakis et al. 2000), duration of the interaction (Czerwinski, van Dantzich, Robertson, Hoffman, 1999) and an individual working style (Ronen, cited in Dror, 2000).

By looking at the users of the SC+M web site on the basis of these findings and speculations, assumptions can be made about the potential appeal of this project. At large, the site is aimed at students enrolled in the School of Communications and Multimedia. It hosts a broad range of courses from Multimedia to Media Studies at Undergraduate and Postgraduate levels. Regardless of enrolment status, it can be assumed with a reasonable amount of confidence that every student within the School is computer literate to some degree. The same notion is made about their familiarity with the Internet since learning materials are largely available online and all students complete a core unit in computer basics. Demographically, the Schools’ student body includes school leavers and mature age students who are all exposed to computers with graphical user interfaces.

All students in the School are assumed to be able to access information through the future interface. Individuals acquiring multimedia degree or those with extensive computing background, particularly in gaming, will have the advantage of minimal learning curve and an understanding of 3D space.



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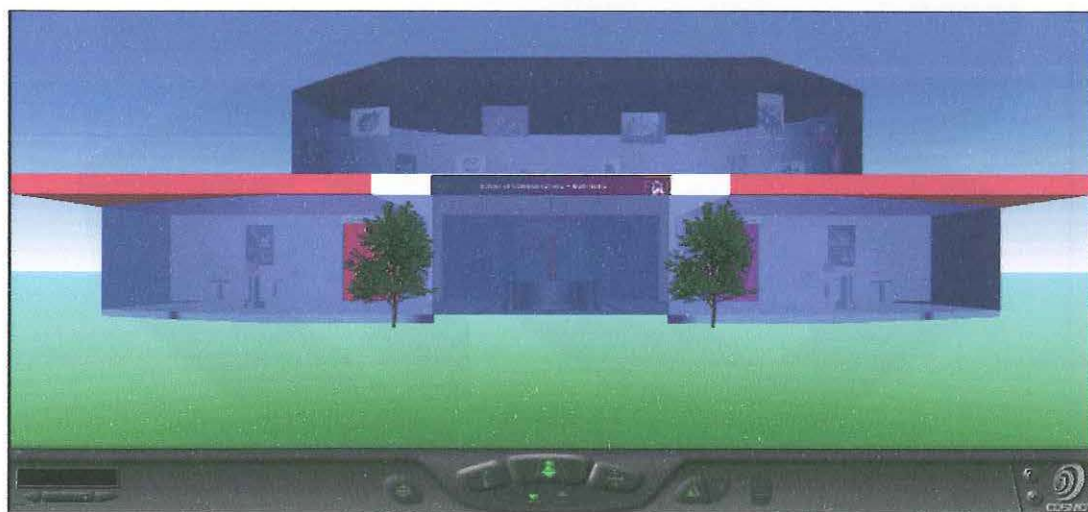
### 3.6 Design of the 3D Component

After the preceding analysis of the School of Communications and Multimedia web site, its 3D alternative assumed a model of a building. The building, its surroundings and the modeling process are discussed in this section.

#### 3.6.1 An Overview

Let us think of cyberspace as virtual environment where visitors can explore the information, manipulate spaces and galleries to explore their individual interests (Shiode & Kanoshima, 1999).

After the initial analysis, it seemed logical to spatialise a number of areas within the SC+M web site, which can *justify* their existence in Euclidean space. To begin with, the content is enclosed within a physical structure shown in Figure 14 to foster *realism*, the pinnacle of 3D usability for Kalawsky, (1998), Hamit, (1993) and Heim, (1992). Top view of its interior is demonstrated in Figure 15.

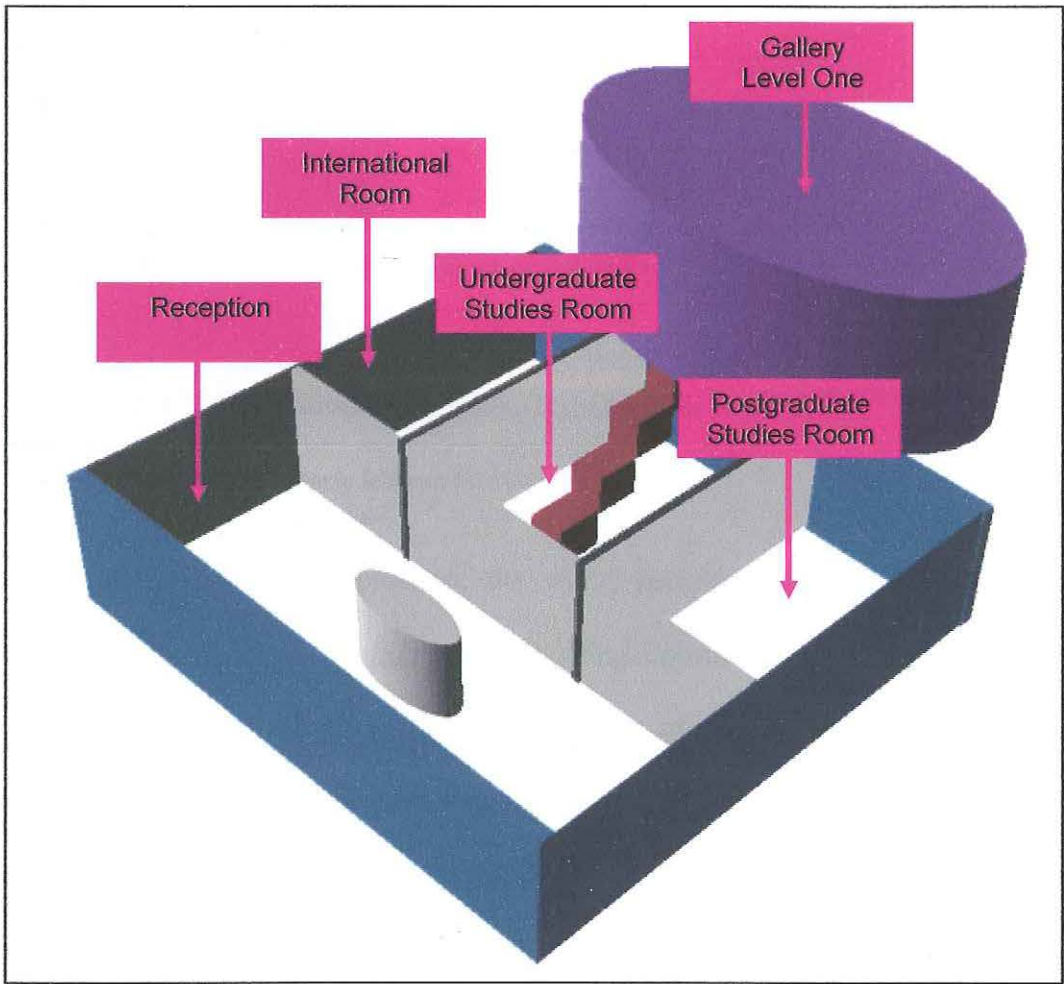


**Figure 14: Virtual School of Communications and Multimedia**

To continue the notion of realism, the original home page of the SC+M site assumed the identity of a Reception – typically the starting point of a user's journey.



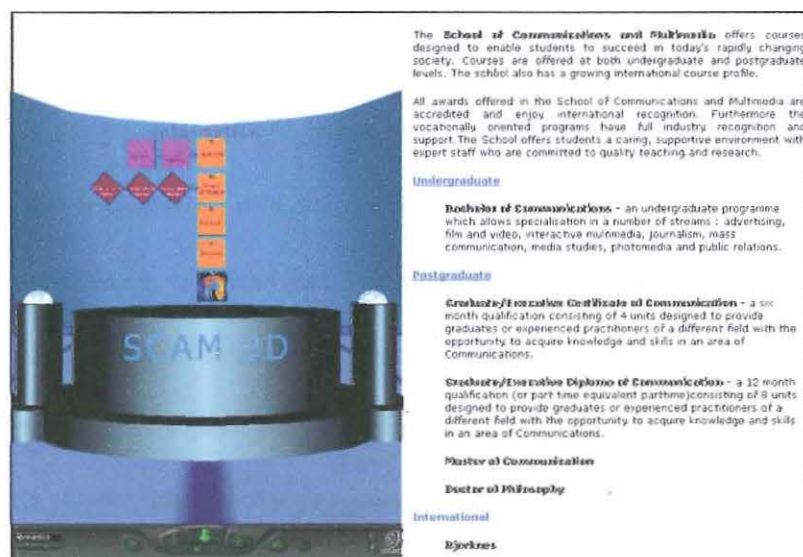
The Reception shares the structure with undergraduate, postgraduate and international rooms because their textual counterparts take up major sections of the original web site and are of primary concern to the students. The three rooms act as 3D data warehouses for access and manipulation of the degree structure information and further studies. Shum (1990, p. 8) together with Mckinlay, Rao and Card (1995) approve of such “an unobtrusive” arrangement because it allows one to “capitalize on human propensity to impose structure”. The Gallery section located on the first floor naturally depicts itself in the reality based cyberspace defined by Casperson (1995), Shiode (1996) and Dodge (1998) as “a new dimension of the living environment” (cited in Shiode & Kanoshima, 1999).



**Figure 15: Top view of the virtual School of Communications and Multimedia**

The design as a whole takes advantage of the three-dimensional attributes of space namely an extra perspective, multiple views and depth. In consideration of the “human factors” (Poupyrev, 1999), the “spatial metaphor” (Shum, 1990, p. 1) is consistent in interface elements, offers multi-dimensional feedback such as sound, colour, movement and also naturally bounds the user to one area at a time.

As stated earlier, the 3D component functions in conjunction with the original web site by visualizing the access of textual data to some extent. Figure 16 depicts the arrangement of 2D & 3D elements in the interface.



**Figure 16: Access of the course information (2D) via 3D view**

With regard to interaction, the world permits *walk* and *examine* modes controlled by a *NavigationInfo* node. *Walking* constrains navigation to the most familiar technique and prevents the occurrence of *limbo* (McCahill & Erickson, 1994, Raggett, 1994) while, the *examine* mode allows the user to tilt, rotate and *explore* the cyberspace (Funkhouser, 1996) from different locations and camera angles.

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### 3.6.2 Modeling the Environment

Greenery and sunlight loosens people up and makes worlds more appealing and easier to work in, despite the fact that they are computer generated. We fall for fake plants in restaurants; why should virtual environments be any different? (Hughes, 1995)

On a more subjective note, Hughes states that “it just seems to feel better”. Accordingly, the user’s viewpoint is initially positioned 28 meters away from the front of the building so that its entire structure is visible surrounded by blue sky and green grass. The sky and the ground were defined with a *Background* node. Conceptually, these elements are represented by two infinitively large spheres which envelop the world (Ames et al. p. 448). Instead of a single shade of blue, this project uses a gradation of colours specified by the values of the *SkyColor* field to achieve the illusion of a horizon. The position of colours on the sky sphere was specified by the *skyAngle* field. The gradation occurs between the colour regions. An identical procedure is performed on the sphere which represents the ground but instead of *SkyColor* and *SkyAngle*, *groundColor* and *groundAngle* fields were used.

On either side of the front door a tree and its instance are *growing* from a single Indexed FaceSet node with rectangular geometry. A texture map wrapped around the node gives it an impression of thick foliage. The texture is in fact an image in PNG format referred to by the *TextureMap* node. PNG format was used to preserve transparency in the original image. When the tree is mapped onto the Index FaceSet node’s rectangular shape, the transparent areas become invisible. This makes the trunk and the leaves look fairly realistic from a distance. However, the flatness of the image would be apparent if a user is to *walk* around the building. To solve the problem, the *Billboard* group node was placed at the top of tree’s hierarchy in the

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scene graph. The *axisOfRotation* field in the node's syntax rotates the pair around the Y axis depending on the user's position. As a result, the trees always face the user.

The PNG format is superior to GIF and JPEG but is not supported by all web browsers ("Adobe Photoshop 6.0", 2001). Most VRML viewers, on another hand, do not impose this limitation because all three formats are intrinsic to the language's specification.

### **3.6.3 Modeling the Building**

Architecturally, instead of merely replicating the actual quarters, the building showcases another design alternative without the typical physical constraints dictated by budget, security and feasibility. Its entire exterior, except the floor, is *made* from glass to minimise the problem of obstructed view inherent to 3D environments (Nielsen, 1998, Shneiderman, cited in Dror, 2000). The glass is simulated by the transparency field of the Material node with the field value set to 0.239. This setting in combination with five other colour controlling fields renders into the translucent shade of deep blue, which allows visitors to see the interior with sufficient clarity. It must be noted that the quality of the effect will differ depending on the capabilities of the viewer's graphics card and the rendering abilities of the specific VRML browser installed on the host machine.

The building's walls and the ground floor consist of three octagons defined by the *Extrusion* geometry node. Ames et al. (1997, p. 251) comprehensively explain the extrusion procedure:

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The VRML Extrusion geometry node mimics the real-world extrusion process. The node enables you to specify a 2D outline, or *cross section*, for an extruded shape. The cross section is then swept along a 3D curve, or *spine*, to create extrusion geometry for a Shape node.

Its benefits include the ability to produce a variety of custom made objects without the need to employ stationary primitives and most importantly, the power to reduce polygon count so as “to streamline the scene rendering process in less powerful machines” (McCarthy & Descartes, 1998, p. 70). In this project the Extrusion node was utilised as the geometry field of the Shape node in order to free the design process from the limited range of primitives included in VRML.

To attract the user’s attention and to reflect the true meaning of the term *multimedia* defined by Jeffcoate (1995, p. 7) as “the interactive use of audio, still image and motion video in addition to text and graphics”, an animated *School of Communications and Multimedia* sign featuring the ECU logo is placed above the entrance. Due to its stationery position and easily recognisable nature, the sign is a *landmark* deemed by Hughes (1995) important for senses of location and bearing.

VRML enables animation through a *MovieTexture* node. The value of the *url* field inside the *MovieTexture* refers to an external source of the actual animated image in MPEG-1 format only. This format supports compressed storage and transmission of both audio and video (Ames et al. 1997, p. 313).

From an initial distant view, a visitor can be conveniently transported to the front of the building via the predefined viewpoint *Entry*. This can be found in the Viewpoints list maintained by the browser. The provision of “the default view” is necessary (Hughes, 1995) for orientation and exploration purposes (Crossley et al. 1998). Spatially, it fulfils Norman’s criterion for usability by enabling the user to locate the entry with “minimal attempts” (cited in Crossley et al).



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The front sliding doors controlled by the *Collision* group node automatically open and close behind the user. As the name implies, the Collision node senses when something collides with an invisible bounding box surrounding the doors. Upon collision, the animation clock represented by the *TimeSensor* node begins the animation through *wiring* of the two *PositionInterpolator* nodes. These nodes slide the doors open. When the user exits the region specified by the bounding box, the doors slide back driven by exactly the same formula.

“Sound can be just as important to the illusion [of immersion] as the visual simulation” (Raggett, 1994). Hence, to intensify the sliding doors effect, the Collision node also commands an appropriate sound to start playing via the *StartTime* eventIn. The sound is an external source file in WAV format specified by a *Sound* node. In addition to the source of the audio, the Sound node controls the audio direction, location and its intensity, which is set to a maximum.

### 3.6.4 Modeling the Reception

Upon entry, a viewer *walks* into the Reception area, shown in Figure 17. The reception uses Benedikt’s method (cited in Young, 1996) of *exclusion* “to avoid ‘crowding’ of data items”. Also, it complies with Norman’s requirement for effective “spatial organization” where “the number of different items at any single location should be small enough that they can readily be found” (1994, p. 177).



Figure 17: Distant view of the Reception

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The most prominent feature of the Reception is the notice board. Located in the centre, it always faces the user vertically with the help of a Billboard node. Apart from user orientation purposes, the rotation fulfils Nielsen's (1998) Internet principle of "being better than reality". This object is a second *landmark* proven by Chen and Czerwinski (1997) to foster "successful navigation of virtual worlds".

The notice board enlarged in Figure 18 has been created from an extruded geometry to encircle the reception desk positioned at the bottom. Square shapes mounted on the board metaphorically represent paper based notices. The arrangement mimics icons and folders found in 2D GUIs with an aim to encourage "perceptual understanding" (Crossley et al. 1998). Clancy (cited in Crossley et al.) explains the concept: "users should not be thought of as learning where things are; rather, they learn how to behave, almost unconsciously when looking for things". The central row of notices named via the *Title* node corresponds to the headings located on the original home page of the SC+M site shown in Figure 13; *About SC+M*, *Course Information*, *Research* and *Awards*. It is anticipated that the viewer would click on each square *without thinking* so to speak, driven by prior knowledge of the web site and the 2D GUI. This action will open the relevant section of the original site in the right frame of the browser window.

Linking is facilitated by an *Anchor* node, which can connect the source to VRML and HTML files depending on what is specified in the url field. Beneficially, the interaction is encouraged by the VRML browser itself because upon rollover it identifies *active* objects with a *star* symbol. In addition, the value of the *description* field in the Anchor node may serve a similar purpose since it describes the link somewhat like the *Alt* tag in HTML. The only difference being that in VRML the

description is always positioned in the bottom left hand corner of the browser window.

While the central row of notices connects each major area of the SC+M web site to its 3D equivalent, subordinate notices on the left hand side of the notice board, map or “visualize” (Munzner, 1995) other pages within the original site’s architecture. The notices are demonstrated in Figure 18. Specifically, they show that the page *About SC+M* connects to the *Facilities* and *Staff Directory* pages. Similarly, the page *Course Information* links to the *Undergraduate*, *Postgraduate* and *International Studies* sections.

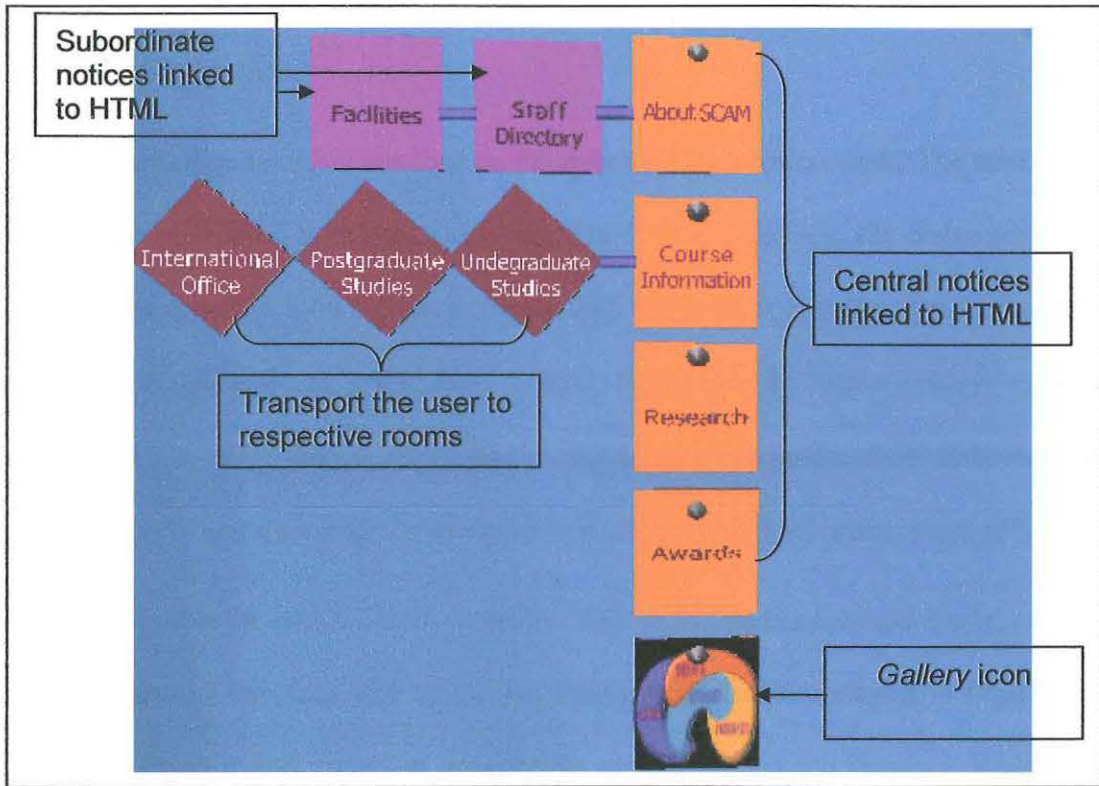


Figure 18: View and description of the notices

In addition to positioning, colour and rotation has been used in the notices to help the viewer distinguish among different levels of content. Furthermore, they imply diverse outcomes and serve as *mnemonics* or memory aids (Anders, 1998, p.



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28). For instance, the distinct look of three diamond shaped notices is expected to imply a different type of action because on click they transport the user to the front of undergraduate, postgraduate and international rooms respectively.

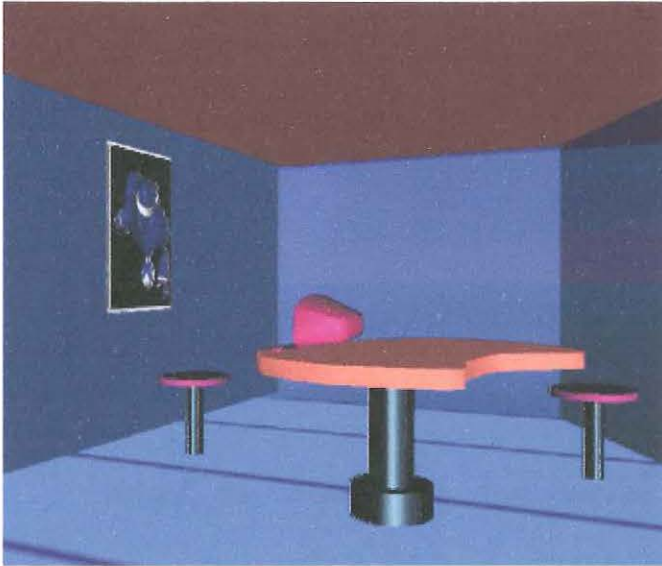
Similarly, the multicoloured *Gallery* icon positioned at the end of the first column is intended to transport the viewer to the first floor, with more efficiency and precision than manual navigation. The technique exposes the user to other areas within the building, especially to the undergraduate room, mostly hidden by the notice board. This works via a TouchSensor node, which senses a click on the shape's surface, that starts the animation clock defined by a TimeSensor node. The clock commands the viewpoint to change to a new set of coordinates over time, hence creating motion.

The notice board is attached to the cylindrical reception desk. The desk rests on a platform defined by a larger cylinder. For further emphasis, the entire structure is illuminated subtly by a spherical directional light and its instance created with a *DirectionalLight* node. In actual fact, "VRML lights have no form or shape" (Ames et al. 1997, p. 407). However, if placed inside a Shape node, their form can be simulated with any geometry. In this case, it is a sphere with a texture mapped look.

Opposite the notice board, in each corner of the main reception space, resides other furniture - two identical tables and four identical chairs shown in Figure 19. They add balance and create an appropriate atmosphere in the spacious Reception area. Most of all, they enable access to a pair of pink Macintosh computers. The iMacs equipped with mice and texture mapped keyboards represent the actual computing facilities in the School and a fun, creative, friendly ambience. The scene is complemented by two samples of student 3D modeling work attached to the walls as pictures. The computers *borrowed* (Popuyrev, 1999) from the real world and the

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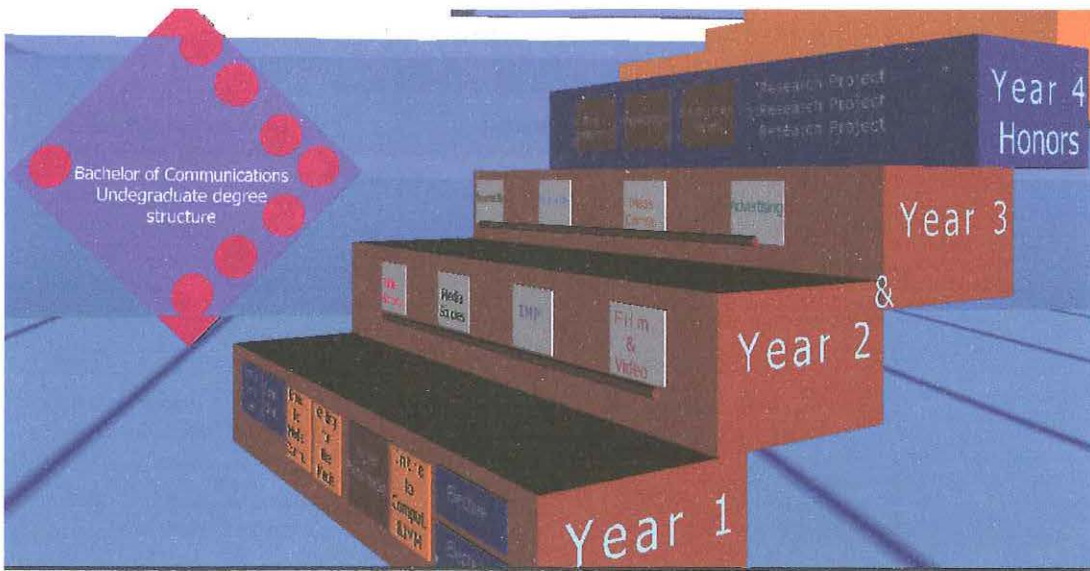
pictures taken from the original SC+M site are the alleged “personal artefacts” which make the environment familiar and help foster its understanding (Anders, 1998, p. 17).



**Figure 19: Right corner of the Reception with mini computing facilities**

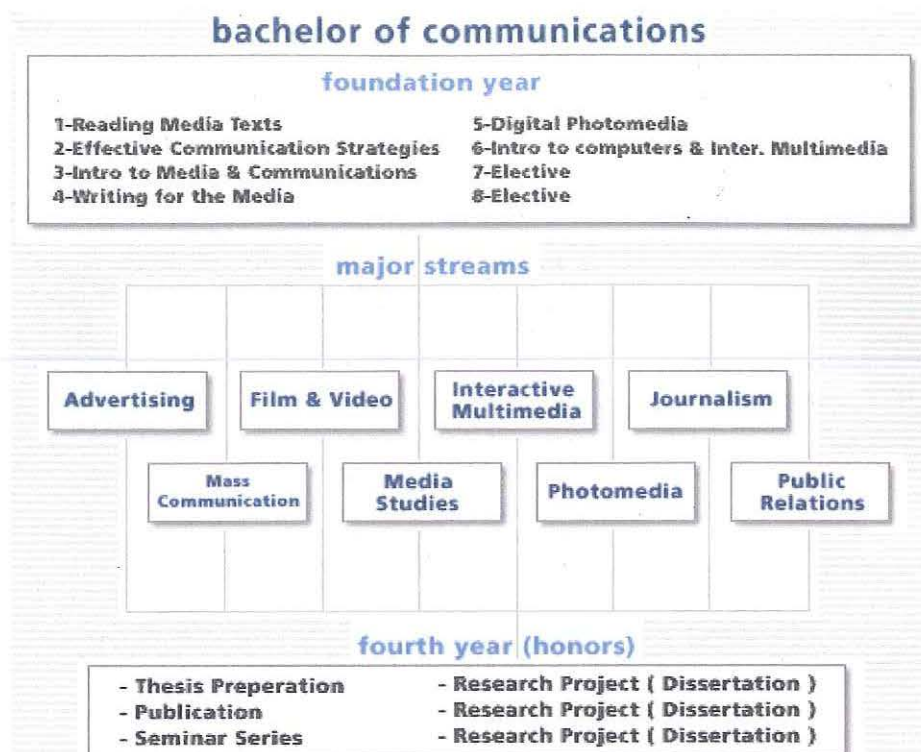
### **3.6.5 Modeling the Undergraduate Studies Room**

Entrance into the Undergraduate Studies room is located behind the reception desk and may not be apparent initially. However, it is exposed as soon as another viewpoint is assumed by the user due to the rotation of the notice board. An automatic transfer option is available, as discussed in the previous section, which takes the user to the smaller version of sliding doors with sound in order to enable access. The undergraduate room contains two objects: a staircase and a rhombus shown in Figure 20. Their proximity indicates that the two structures are co-dependent (Shum, 1990) while, relative size and position imply that the stairs are of more significance.



**Figure 20: The Undergraduate Studies room**

Indeed, the staircase has dual propose. Firstly, it gives *richer* spatial representation (McCahill & Erickson, 1994) to the structure of the Undergraduate degree, otherwise presented in 2D as shown in Figure 21. Depth, colour and stacking order are used to illustrate the relationship between programmes, their duration and organization. As a result, the user is “made dramatically smarter by providing external cognitive memory” (Mullet & Schiano, 1995) where all associations have already taken place. In superiority to text, “color-coding” (Vasilakis et al. 2000) makes it obvious that the course consists of 4 years in total and that the first three years differ from the last. Also, by reflecting the concept physically, the structure aids navigation (Shum, 1990).



**Figure 21: Bachelor of Communications undergraduate degree structure**

Before attempting the transformation, careful consideration was given to Nielsen’s stance against spatialisation of abstract information and the use of 3D, in general due to limited view and complexity (1998, online). In contrast, McCahill & Erickson (1994) dispute these concerns:

People understand a lot about space. For example, they know that any 3D object has other sides that aren’t immediately visible, and they have expectations about what to do to get a view of those other sides. They are familiar with manipulating and interacting with objects in 3D space.

In considering both viewpoints, the staircase metaphor provides a sensible solution because one knows its purpose and deployment – stairs have to be faced before ascending. The initial position of the viewpoint exposes the units allocated to each year, as notices attached to each step, shown in Figure 22. Motivated by



“previous experiences” (Swan & Allen, cited in Vasilakis et al. 2000) reinforced by the Reception, the user can click on each notice and access relevant information.

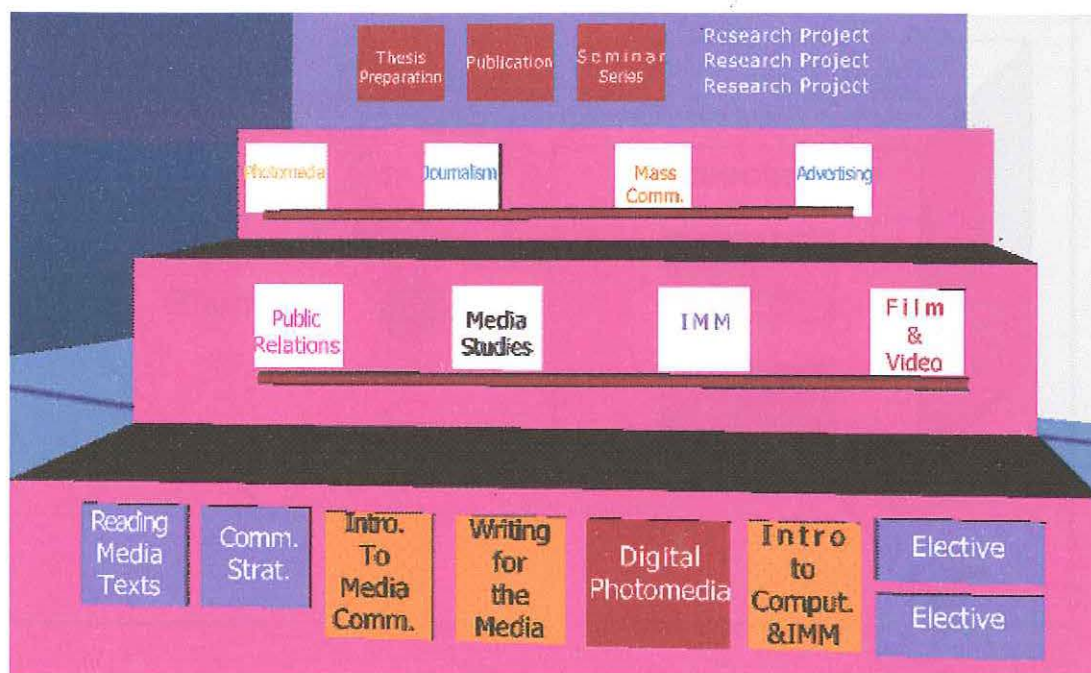
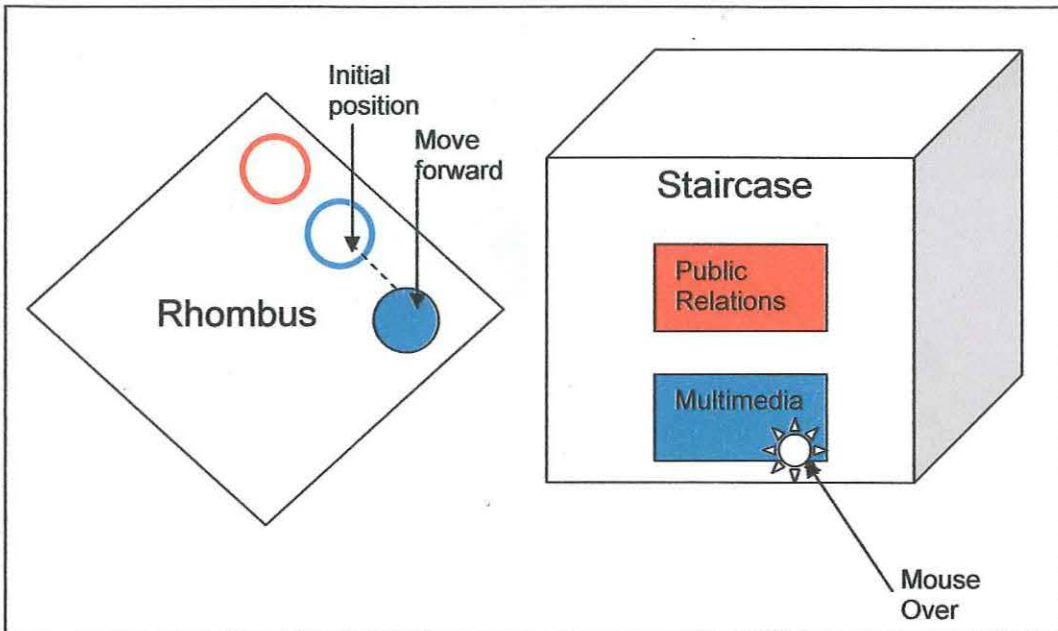


Figure 22: Front view of the staircase

Such an outcome is straightforward when 1<sup>st</sup> and 4<sup>th</sup> years units are accessed. Years two and three, however, contain additional programming due to increased complexity of the message conveyed. They encompass the 8 major streams, which may be undertaken by students in order to specialize in such disciplines as Public Relations, Media Studies, Interactive Multimedia, Film and Video, Photomedia, Journalism, Mass Communications and Advertising. The rhombus mentioned at the beginning contains copies of 2D icons, which symbolize each stream on the original web site. The icons become apparent as soon as the viewer moves a mouse over the associated stream, newly represented by a square attached to a step. The “animated transition” schematically shown in Figure 23, “extends the representation from space into time, communicates transformation, and supports object consistency” (Mullet &

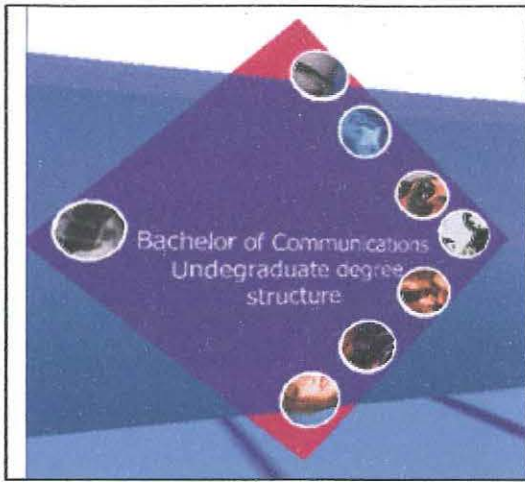
Schiano, 1995). It also “enhances memory for items” (Czerwinski et al. 1999) and conveys their difference from the rest.



**Figure 23: Mouse positioned over the Multimedia stream moves forward its representation**

The mouseover state, known in VRML as the *isOver* eventOut of a TouchSensor node, returns TRUE when it *senses* the pointer movement above the notice. The movement activates the animation clock, which then shifts the relevant stream’s representation icon forward. Consequently, the icons, otherwise hidden inside the rhombus, became fully visible as demonstrated in Figure 24. When the pointer is moved off any of the notices, the node returns FALSE and restores the icon positions.

The staircase also has the purpose of leading the user to the first floor Gallery. Proposed by Ragett (1994) gravity is maintained by the navigational setting, which allows climbing up and down with relative ease.



**Figure 24: Position of all icons is fully extended**

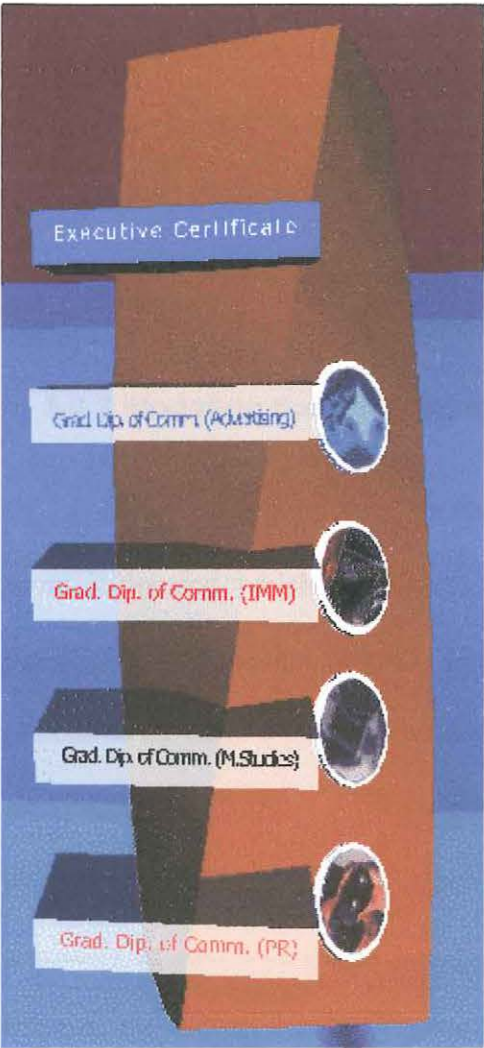
### **3.6.6 Modeling the Postgraduate Studies Room**

The Postgraduate Studies room is situated on the same level as the Undergraduate Studies room but on the right hand side. This linear layout utilizes the space to the maximum and forces the viewer to navigate it appropriately.

On entry, consistent audio enhanced sliding doors bring into view a solitary cluster, shown in Figure 25, which represents postgraduate courses. Each course is symbolised by a tinted bar. Tint and distance group courses according to their characteristics and show that the content of the white bars differs from the top blue wedge. The whole arrangement informs the viewer that the Executive Certificate is not the same type of course as the Graduate Diploma of Communication. Moreover, SC+M offers Graduate Diploma in four streams; Advertising, Multimedia, Media Studies and Public Relations. To convey this nuance and to help a student distinguish between them, *identifiers* in the form of currently used and well remembered icons are positioned next to them. This system uses “classical mnemonic research [which]



has documented that mental cues in the form of visual images are an excellent way to enhance memory for items” (Czerwinski et al. 1999).



**Figure 25: Postgraduate courses structure**

Information pertaining to each course is available via an Anchor node. In the case of the Graduate Diploma, the node links icons. In the case of the Graduate Certificate, the node links the bar itself. Inconsistency in linking was put in place specifically to reinforce the difference in the meaning of the two programs and to bring the icons into focus.

The cluster as implemented here is static in nature. However, it has the potential to realize Hughes’s idiom of *Liquid Architecture* (1995). Hughes explains:



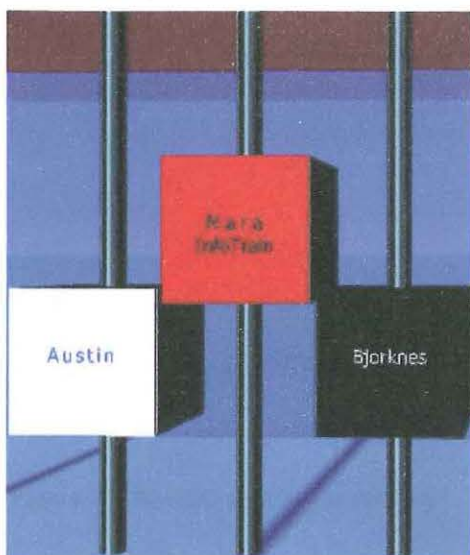
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“when it is possible for constructs to create new structures, one can imagine dynamic environments that change according to any number of criteria”. For instance, the bars would rearrange themselves, contract and expand on a viewer’s command. The texture appearing on the icons would be mapped onto the bars or one icon could become the main poll, et cetera. So, “the users can purposely explore these objects and interpret shapes and locations easily and naturally in terms of the concept in which they are interested [emphasis added]” (Crossley et al. 1998).

### **3.6.7 Modeling the International Room**

In line with the others, on the left hand side of the building an International room is located which facilitates access to the information about three courses designed for overseas students. Correspondingly, the room contains three cubes punctured by narrow polls as displayed in Figure 26. The cubes can be characterised as “Emotional Icons ... which perform varying behaviours in response to the presence of the user” (Walker, cited in Young, 1996). On mouse over their surfaces gradually become transparent and on mouse out they return to an opaque state. In this manner, the objects clearly respond to a viewer’s interaction and show “interaction traces” (McCahill & Erickson, 1994). Initially, the name of every course was placed inside relevant cube to be revealed during a mouse over but in the end was left outside to ensure perpetual visibility.

The Material node controls the shapes’ transparency. To make the animation work, white, red and black RGB colours gradually change from an opaque to a transparent state upon rollover. The change takes place over a period of time specified by the TimeSensor node.

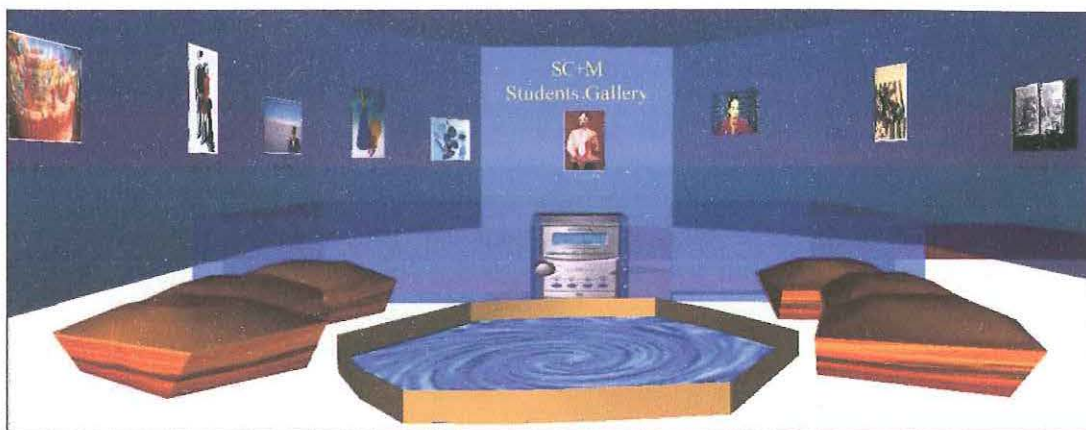


**Figure 26: Representation of international courses**

### **3.6.8 Modeling the Gallery**

The Gallery section shown in Figure 27 is situated upstairs in a big glass dome. It exhibits the work of undergraduate students and acts as a common area - the place of relaxation and socialising. What's more, it complies with two fundamental paradigms of cyberspace. Primarily, "human beings are social, communicative animals" so the ultimate cyberspace is first and foremost a social place (Damer, 2001, Andres, 1998, Strate, 1996); and that "cyberspace has proved its usefulness in various fields including museums and art galleries that have taken advantage of its features" (Shiode & Kanoshima, 1999).

The Gallery is entered by climbing the staircase located in the Undergraduate Studies room. A glass like balustrade made from extruded geometry seals off the gap at the entry point and prevents the user from an accidental *fall*. Encircled by the photographs, the space also contains two couches, a stereo system for listening to music and a central water feature for meditation.



**Figure 27: Resting spot in the Gallery**

Water is simulated with a MovieTexture node using an MPEG film loop. The stereo is covered with an image texture to emulate the small details of the device. It emits sound on a mouse down only instead of a constant playback, which can be annoying for the user (Lynch & Norton, 1997). The audio playback commences when the TouchSensor node sends TRUE to the TimeSensor node. After a few seconds of playing, the volume of the sound fades and eventually stops. An invisible sound emitter was placed inside the stereo to give a realistic spatial impression of the audio direction. VRML's ability to spatialize audio ensures that audio level becomes quieter with distance and louder as a user is closing in.

Although, the unwritten rule in cyberspace design seems to be "less is certainly more" (Hughes, 1995, Norman, 1994, Benedikt, 1991), the Gallery is one venue where it has not been applied due to so many possibilities. Nevertheless, VRML prevented their realisation through technological limitations. For instance, a showcase of the actual 3D models produced by multimedia students was cancelled owing to the poor conversion from Strata 3D to VRML. Projection of videos, apart from the bare minimum, was also dismissed because it is likely to cause the browser to crash (Ames et al. 1998, p. 312). Also, ever looming download time has to be

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accounted for due to the use of many textures. Damer (1999, online) summed up these limitations in the following paragraph:

I am so sorry all those millions were spent designing VRML for and by engineers working on fat pipes. If only a fraction had been allocated to create a real cyberspace version of the VRML community tuned for dial-up net use, we would have something substantial today, not just islands of innovation, a file interchange format, and a couple of huge overdesigned plug-ins.

In summary, the 3D interface utilizes a real world metaphor for access to the 2D content. Both 2D & 3D content has been placed into a single browser window. The 3D alternative to the SC+M web site has assumed the form of the two story building divided into the 5 distinct areas: the Reception, the Undergraduate Studies room, the Postgraduate Studies room, the International room and the Gallery located on the first floor. These spaces house the unique representations of relevant data, which can be accessed via an Anchor node. This node links 3D objects with the web information sources displayed in a 2D frame. While different 3D representations were used, consistency in color and shape was maintained for similar data sets, such as the units in one course. As far as the technology is concerned, VRML provided sufficient, at times quite successful, means of the project realization.

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## 4. FINDINGS

This project has demonstrated that it is feasible to create a three-dimensional interface based on the relevant research. To evaluate the outcomes, however, the original objectives of this study will be discussed one by one in conjunction with specific achievements.

The first objective was to determine *why 3D interfaces are not prominent on every desktop by evaluating the practical challenges and limitations, which face the 3D cyberspace developer*. Ironically, the biggest challenge that was presented by the research was the difficulty of accommodating inherent 3d properties within the rules of good interface design. At the outset, the interior of the virtual School of Communications and Multimedia had to be designed in such a way so that the navigational elements, at least, are instantly visible and easily accessible (Shneiderman, 2001, Crossley et al. 1998, Norman 1989). These requirements conflict with the depth factor and with the perpetually hidden side of 3D objects. The obvious solution was to use the front of the notice board with the 2D notices for navigational purposes but this limitation was compensated through rotation of the board.

The same situation occurred in the International room with the three cube interface. To be truly useful, it should contain the name of each program exposed upon rollover. However, the names are attached to the front for an instant visibility due to the importance of the information conveyed (Zikovsky, 1999). The building also features external transparent walls and transparent doors to enable the user otherwise obstructed look inside (Funkhouser, 1996). In the instances of the notice



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board, the access of the international courses and the building's design, 3D was not used or was made to be practically invisible. In fact, only the staircase in the Undergraduate Studies room can be attributed to the strict use of 3D even though it is positioned on a 45 degree angle to partially expose the hidden side.

The second obstacle was presented by navigation in 3D because it "challenges" the user (Carey & Bell, 1997, Nielsen, 1998, Alexandre, n d.). Therefore, pre-programmed viewpoints with the access to the entry into the building and to the front of the undergraduate, postgraduate and international rooms were put in place. The user has to point and click only rather than to negotiate and explore the space. Interestingly, Shneiderman (2001) prized the design of three-dimensional interface for the Windows OS Win3D for exactly the same reason.

In addition to the ease of use, 2D based navigation saves time and provides efficient means of access to the desired items of the SC+M web site. It appears that 3D on its own is too inconvenient to use on a daily basis. Taking these into account, Mullet and Schiano (1995) suggest limiting the implementation of 3D for visualization and utilize 2D for the simplicity of the navigation and layout.

Allocation of suitable 3D metaphors for the representation of abstract concepts, such as the variety of courses, caused another difficulty, especially since Nielsen (1998) argues against doing so due to likely confusion of the end user. Crossley, et. al. (1998), on another hand, assert that "3D ... offers the possibility of an intuitive and natural way to explore complex ideas, concepts and information". It may be so but the project made it very clear that physical concepts are much easier to work with. As a result, it was very *natural* to place the School of Communications and Multimedia into a building and to divide the building according to the major



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programs run by the school. Also, such arrangement makes sense because it imposes structure onto the one's thinking process (Shum, 1990).

In contrast, the usability of representation of the international and the postgraduate courses was questionable. From one perspective, the use of colour and geometry provided an effective organizational metaphor (Czerwinski et al. 1999). However, 3D added little to the same arrangement represented in 2D. This said, the stairs in the Undergraduate Studies room fully justify the use of 3D in terms of theoretical and practical concepts. They convey the structure of the Bachelor of Communications degree and allow the user to access the Gallery. Another positive note must be made about the requirement for the "freedom from clutter" (Hughes, 1995, Benedikt, cited in Young, 1996). It was fulfilled by using spacious rooms with mostly centered content, especially if it was of major importance. Hypothetically speaking, the same requirement can be problematic for large 3D spaces.

Next issue is that one's expectation or *hype* about 3D (Luber, 2001) tended to influence the design process more than the potential usability of the result. It is true that 3D spaces modelled on the physical world require trees, grass, sky, furniture and so on, and do indeed look more realistic (Hughes, 1995). However, a designer can go to exceptionally great lengths to accommodate these and disregard the actual reasons for doing so. During the construction process, it was difficult to set clear boundaries for the project completion due to so many possibilities. The building could sense the user's presence and turn the lights on, the Gallery can contain a virtual cafe, the two Macintoshes can be activated upon rollover, to name a few. Hence, the *whizzbang* nature of 3D is an important part of the design value rather than communication outcomes.

In relation to the above, VRML proved itself to be a well equipped

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technology for the construction of realistic virtual environments. Rather than restricting the design process to few primitives, it was possible to create smooth fluid shapes with the Extrusion node, wrap them in textures and attach behaviours. Regardless of the viewpoint, they can always face the viewer via a Billboard node, respond to user presence, output sound and be emphasised with lights. Incidentally, this project hasn't even touched the very powerful programming capabilities offered by VRML. The language contains a general purpose *Script* node which can be integrated with Java and JavaScript for a multitude of custom actions, and it has the ability to create new node types using a *PROTO* (Prototype) definition (Ames. et al. 1997).

In spite of the above, this technology and associated processes have many technological limitations. Perhaps, the most problematic one is the inability to display multimedia students' 3D modeling work as the actual models in the Gallery. Also, sole VRML does not have the capability to display HTML data inside the 3D space (Campbell, n d.). Hence, the information is accessed via the frameset instead of the anticipated display inside a notice board. In addition, VRML text is very hard to read, especially from the distance and geometry is quite coarse. Overall, VRML offers slow and painstaking methods of content creation and animation scripting. Without any doubt, undertaking a more advanced/easier to use technology, for example Adobe Atmosphere (2001), would have guaranteed much more efficient, perhaps richer project outcomes.

The second objective set by this study was *to find out if it is possible to create spatial metaphors for the representation of textual data as opposed to the usual 2D depiction*. In many ways, the answer was already given in the previous discussion. To repeat, only the data with distinct physical properties was able to utilize 3D in the

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strictest sense. This data included the original SC+M web site as a whole, the Undergraduate, Postgraduate and the International programs offered by the School, the Gallery, the Reception and the staircase depicting the structure of the Bachelor of Communications degree. In contrast, individual units and navigational methods used 2D representations because two-dimensional metaphors offered the most adequate and familiar solution. Therefore, the answer is *yes* depending on the information to be considered for visualization. In any case, the possibility of finding appropriate 3D metaphors for abstract concepts can not be ruled out but this project generally struggled to achieve this.

On the whole, the design of 3D spaces is much more challenging than 2D cyberspaces. In particular, the difficulty was reflected in the attempt to balance the design with the relevant user interface conventions, which are mainly based upon 2D experience. It is clear that to be truly useful; the third dimension requires an entirely different approach, only slightly touched upon by this project.

Considering the outcomes, the combination of 2D and 3D modes in one window currently offers a more effective deployment of 3D for the end user, who needs coaching in the use of this technology on its own merit (John Peddie Associates, 2001, online). This topic, however, goes beyond the boundaries of the dissertation.

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## 5. CONCLUSION

In summary, the design process has demonstrated that it is possible to build 3D interfaces, which offer a great deal for the representation of physical data. Undeniably, the fun aspect, reflected particularly in the creation of the Gallery, has the major impact on the richness and realism of the environment but can also work against the purpose.

The project generally struggled to utilise the extra dimension due to the attempt to make some elements, such as the navigation, immediately visible, easy to use and instantly accessible. This was often not possible due to the hidden view and the depth factor inherent to three-dimensional representation. Hence, the navigational elements and the access of textual data were represented and accomplished via 2D icons, and linked to a 2D frame.

Despite these limitations, the researcher strongly believes that the virtual School of Communications and Multimedia shows some potential. For instance, it could provide optional avatars for staff and students to enable social interaction and collaborative work, reflecting an expanded meaning of the term *cyberspace* (Damer, 2001, Pesce, Kennard, Parisi, 1994). Also, the environment could dynamically generate 3D representations according to the user requirements directly from the FileMaker Pro database, which drives the system. An input panel can be provided to fulfil this purpose. In addition, it is possible to echo Nielsen's paradigm of "being better than reality" (1998, online) through a navigational system which always follows the user. After all, the sophistication of any creative effort depends mostly on our imagination.

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## 6. FURTHER RESEARCH

To take this project into the next phase, formal evaluation of the interface is necessary with a group of experts in 2D/3D UI design and, most importantly, with a large sample of the target audience. The evaluation possibly conducted through a questionnaire and observation will determine the areas of refinement, success and failure in terms of usability, metaphors, interaction, aesthetics, the multi-modal view, navigation and information access. Explicitly, it ought to measure the level of difficulty in using 3D as opposed to 2D. It should also attempt to estimate the effectiveness of the prior knowledge activation as far as the 2D metaphors are concerned. Even if collected data will not be used for correction of this environment, it can be very helpful for still much needed further research.

At a broader level, relevant research needs to focus on the interface techniques, which actually use 3D and can still be palatable for consumers. Although, total exclusion of 2D elements may not be possible, some arguments against the implementation of third dimension “are fundamental in nature and would have applied to graphical user interfaces in 1970 or so” (Sitaker et al. 1998). Bearing this in mind, it is only a matter of time before spatial information spaces claim their well deserved position in the uttermost rank of an intuitive human-computer interaction.

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## 7. GLOSSARY

### *Avatar*

An avatar may be defined as the representation of one's self in cyberspace.

### *Cyberspace*

"Cyberspace ... refers to the emulation of space in electronic environments, particularly those of network computing. It is present in computer graphics, online social spaces and video games" (Anders, 1998, p.3).

### *Graphical User Interface (GUI)*

This is the interface, which takes advantage of the computer's graphics capabilities. GUIs are the essential components of Microsoft Windows and Apple Macintosh operating systems. They combine windows, icons, menus and pointing device (typically a mouse).

### *Metaphor*

The term is traditionally associated with language use. In relation to the computer interface, metaphors are used to define different elements of the screen and actions in order to form a meaningful association between them and analogies from the physical world.



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## *Virtual Environment*

A world that is simulated entirely within the memory of a computer. A virtual environment might consist of a three-dimensional model of a building, or a visualisation of a set of complex data.

## *Virtual Reality (VR)*

Probably, the most general description of virtual reality is that given by Jaron Lanier (who coined the term). "A computer-generated, interactive three-dimensional environment in which a person is immersed." (Aukstakalnis, cited in Kinross-Smith, 1996, p.14).

## *Virtual Reality Modeling Language (VRML)*

VRML is a specification for displaying three-dimensional worlds when used on the web. It can be described as 3D equivalent of HTML.

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