VR Walkthrough of UTP's Village 3 Apartment Unit

by

Ilman Reza bin Mohd. Saheh

Dissertation submitted in partial fulfillment of

the requirement for the

Bachelor of Technology (Hons)

(Information Technology)

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CERTIFICATION OF APPROVAL

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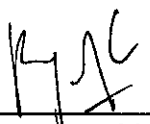
Approved by,



(Puan Rozana binti Kasbon)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH , PERAK

JUNE 2004

CERTIFICATION OF ORIGINALITY

his is to certify that I am responsible for the work submitted in this project, that the original ork is my own expect as specified in the reference and acknowledgements, and the original ork contained herein have not been undertaken or done by unspecified sources or persons.

LMAN REZA BIN MOHD.SAHEH

ABSTRACT

/ith the vast usage of VR technology today, ventures into VR applications by companies are ıpidly growing. VR walkthrough as a branch to Virtual Reality has been used by many sectors ıd field of work to visualize and represent their work in a more elaborate way. The advantages ıat it entails are proved to be very effective and practical. With VR walkthrough, means of ısualization such as images are a thing of the past. VR has enhanced not only the presentation ıt also the utilization of human sensors. By incorporating a VR walkthrough in UTP's website, will reflect its advancement in technology as a whole. It will also give the competitive edge to TP against its competitors.

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ABBREVIATIONS AND NOMENCLATURES

- VR = Virtual Reality
- UTP = University Technology PETRONAS
- VE = Virtual Environment
- 3D = 3 dimension
- RGB = Red , Green and Blue.
- HIS = Hue , Intensity and Saturation
- CYMK = Cyan , Yellow and Magenta.
- API = Application Programming Interface
- WWW.= World Wide Web

CHAPTER 1
INTRODUCTION

Virtual reality is a new technology that is advancing rapidly worldwide. Although it is new, this technology has been used widely in many fields. VR is now a new medium used for visualization. It is used in military training, scientific studies, industrial designs, entertainment and many more. The rapid utilization of this technology reflects its effectiveness in the field which it has been applied to. Despite its obvious upsides, the utilization of this technology has not yet come close to its maturity. With this, the use of VR in certain sectors or companies would give a distinct advantage against their competitors.

1. BACKGROUND OF STUDY

The purpose of this project is to further utilize VR technology in University Technology PETRONAS apart from merely a course in its syllabus. In this project, an extension of VR technology is going to be incorporated in the UTP website to provide better visualization and presentation of UTP's infrastructure, specifically the accommodation provided by the university to its students. It will be an expansion of UTP's readily available website for the public.

This expansion will incorporate a VR Walkthrough of one of many apartment units available for student's accommodation. A VR walkthrough is an extension of VR technology which provides an immersive VE that allows a person to move around defined space in 3 dimensions. It will also incorporate other VR properties such as interactivity and realism where a person could interact with the objects in the VE that looks and feel realistic.

To complete this project, knowledge on the basic concept of 3D graphics needs to be acquired and understood. 3D graphics defines a 3D space in a 3 dimensional system. A 3 dimensional system has 3 axes, X,Y and Z or width, height and depth as shown in Figure 1:

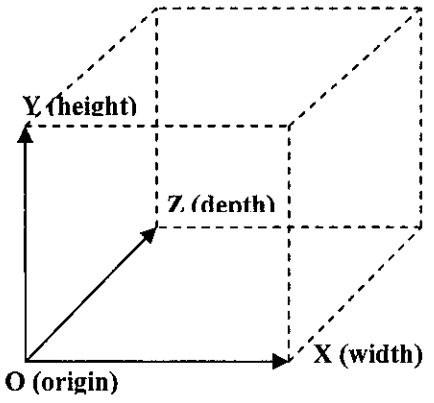

Figure 1.0: 3 dimensional axes

With O as the origin or center point of the 3D space, each of the axes has a positive and negative value passing through the origin. A 3D objects in a VE are actually coordinates in the 3D space relative to the origin that are joined together by lines to form a certain shape. These shapes look 3 dimensional due to angles to which the coordinates are joint that creates an effect of perspective. This is when an object is further, it looks smaller. With this reduction, a sense of space is built. This is the most common technique of producing perspective in 3D graphics on a 2 dimensional medium.Techniques used to create the effect of perspective are cabinet projection or isometric parallel projection. Cabinet projection shortens the lines that shows perspective by half and are drawn in 45 degrees angle. Isometric parallel projection displays width, height and depth by reducing the true length of a line by percentage.

Colour and shading are also aspects of 3D graphics. By applying colour to the object, shapes that are only connected by lines or are also called as wireframes will have a have the perception of a solid object. Colours are different quality of lights reflected by an object and are measured by its HIS (hue, saturation and intensity). Intensity is the

brightness of the colour. Saturation is the purity of colour or the amount of white light reflected by the colour. It is presented by percentage where a 100% red will be seen as red and 10% red will be seen as pink. Hue represents the amount yellow purple or green in a certain colour. Different categories of colours such as, primary colour (basic colours), secondary colour (mixture of primary colours) and tertiary colour (mixture of secondary colours) has different hues.

Colour models defines the way that primary colour should be combined to produce secondary colour. 2 other colour models that are commonly used on a computer monitor; RGB and CYMK. RGB colour model has red, green and blue as its primary colour, which explains the abbreviation. It starts with black and mixing all 3 of its primary colours with no impurities (full saturation) to produce white. With saturation ranging from 0.0 to 1.0 where 1.0 is full saturation refer to Figure 2.

Red (1,0,0) + Green (0,1,0) + Blue (0,0,1) = White (1,1,1)

Figure 1.1: RGB colour

If only 2 components of its primary colour, secondary colours are produced. They are Yellow (Red and Green), Cyan (Green and Blue) and Magenta (Blue and Red). Mixed colours are colours that are mixed with various saturation levels.

CMYK colour model is made up of cyan, magenta, yellow and black. Cyan, magenta and yellow are its primary colours. If u have not noticed, these are secondary colours for the RGB model. Vice versa to the RGB model, red, green and blue are the secondary colours for the CMYK colour model. Figure 3 shows a simple formula which translates the RGB model to CMY model:

$C = 1 - R$, $M = 1 - G$, $Y = 1 - B$

Figure 1.2: Simple formula to translates the RGB model to CMY model

In 3D graphics, lighting plays an important role in defining the shade and depth of an object. It makes an object appear solid even with a single colour create a realistic

impression of the object. Illuminating an object at an angle and applying shadow at the right angle would also create a greater sense of depth.

Texture mapping is applying real images of wood, cloth or bricks to an object as oppose to plain material. This would increase the level of realism to the object.

Transformation is the process of manipulating an object in a 3D space. The orientation and location of these objects could be changed by manipulating its axes. The orientation could be changed by rotating the object on one or more of its axes. Figure 4, 5 and 6 shows the rotation on each axes.

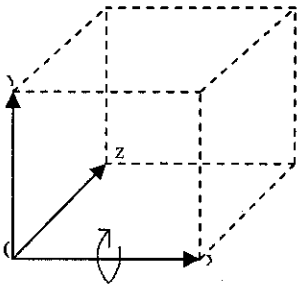

Figure 1.3: Pitch, X

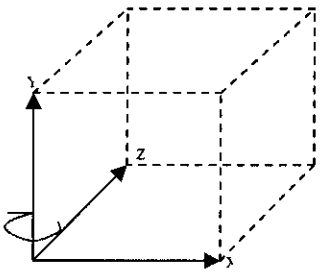

Figure 1.4: Yaw, Y

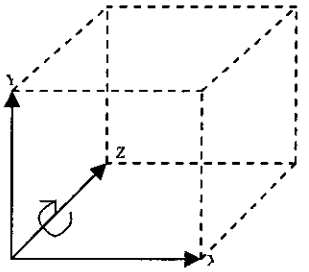

Figure 1.5: Roll, Z Rotation

Moving object from 1 point to another could be done by translation. Translation moves an object by translating the entire coordinate joint in the object similarly along the X,Y and Z axes.

Real-time 3D is the main attribute in VR walkthrough. This is to create the immersiveness and interactivity in the VE. This attribute would allow a person to explore a VE by controlling any selected peripherals such as the mouse and keyboard. To create a real-time 3D, 3D programming is required. There are 2 ways to programming APIs for real-time 3D; retained mode and immediate mode. The retained mode requires the description of the scene and objects to be provided to the API or the tool that is used to create the images on the monitor. The scene and objects could not be manipulated accept

for those which commands have been made such as the location and the view of the camera or the interactive objects.

In immediate mode a command is issued to the graphic processor to render in its immediate state and all its subsequent state. In this rendering state, properties and attribute could be changed. This approach is actually used in the retained mode internally to render the 3D graphics. In this project, the retained mode approach will be used to create the VR walkthrough.

For this project to be operational, several tools and components are required to be learned and acquired. To developed a VE, a 3D generating tool needs to be acquired. A web publisher is needed to develop a website as an interface of which the VE could downloaded from. A suitable 3D plug-in needs to be identified for the VE to be view via the WWW.

1.1 PROBLEM STATEMENT

UTP's utilization of the VR technology is strictly in its academia sector. Its usage is not applied in the different departments of the university. This project's purpose is to initiate a broader utilization of VR technology in the university. Currently, there are no promotions on the UTP website on its infrastructure using VR. To start of, VR could be incorporated in the UTP website as a mean of promoting the university through its infrastructures. As an initiation, the website could provide a virtual walkthrough of the student's accommodation facilities. This could give an advantage to the university to attract more and better students as oppose to the other universities that lack such promotions.

1.1.1 Problem Identification

Promotion and exposure of the public on the infrastructure and facilities provided by the university on the website could be improved. The only media available for such purpose are text and images. The images that are given are not sufficient enough to represent and describe the infrastructures. There are no information on the accommodation facilities that are provided for the students.

Problems faced by the author:

- Time constraint to built the VE
- Lack the skill and knowledge to work with a never been used 3D generating tool and needs time to familiarize and learn how to use the software.

1.1.2 Significant of the Project

By incorporating VR walkthrough in UTP's website to represent the accommodation facilities, a person will have the chance to see and sense the apartment in terms of its dimension and layout. Compared to merely pictures and textual description, a VR walkthrough would give a better feel of how the apartment would be like physically. A walkthrough will

give a sense of immersiveness to the user where the user feel as though he or she is in the actual environment itself.

Apart from that, a virtual walkthrough is an extension of VR technology that is growing fast and is widely used. With UTP incorporating it in its website, it will give a positive impression to the public for UTP's concurrency with technology. In an addition to that, it will give UTP an advantage against other higher learning facilities that lack such presentation.

1.2 OBJECTIVES AND SCOPE OF STUDY

1.2.1 The Relevancy of the Project

Two approaches will be taken in completing this project:

- Research on VR Technology specifically VR walkthrough
  The research on the advancement of VR technology and the future of VR. How it has helped the people now and how it could help the people in the future.
- Developing a VE of UTP's Village 3 apartment unit to be incorporated in a website as an expansion of UTP's website.

1.2.2 Objectives

1. To develop an immersive VE of UTP's Village 3 apartment unit that is interactive and realistic.
2. To develop a website that would allow user to view the VE via the internet.
3. To expand UTP's website by incorporating a Virtual Walkthrough.

1.2.3 Scope of study

❖ **Research Articles**

- Research on how VR could help and improve various fields in its operations.
- Research on how VR could create an immersive environment.
- Research on how to create a realistic and interactive VR walkthrough (in technical aspect)

❖ **Development of the Virtual Environment**

The development of the virtual environment of the Village 3 apartment unit will include the following:

- Developing an immersive environment of the Village 3 apartment unit for a VR walkthrough.
- Creating object that are interactive and realistic.
- Posting the VE in a website for viewing of the public via the internet.

❖ **Feasibility of the Project within the Scope and Time Frame**

The final product of this project is a virtual walkthrough of UTP's Village apartment unit. It has to be posted on a website where it could later be viewed from it.

The website is then to be uploaded onto the internet or public viewing. However, the uploading will depend on the availability of the internet at the current time. If it could not be uploaded onto the internet, it will be accessed from a local server.

This project will be most time consuming at the development phase. This is because the tool that will be used is new and it must first be explored and learned. However, limiting the final product to only one VE would buy enough time to explore and develop the product on time.

CHAPTER 2
LITERATURE REVIEW

VR could help and improve various fields in its operations.

According to Diana Phillips Mahoney (1994)

> *"Architects and designers are increasing their use of computer-generated walkthroughs of their designs, and while the various types of walkthroughs, or flythroughs, differ, they all involve motion."*

From Penn Well Publishing Co.

"To provide clients with a better sense of spatial reality, architects and designers increasingly are turning to computer-generated journeys through their designs."

From the quotes above, it shows that one of the uses of VR is in designing. The phrase "*they all involve motion*", indicates that these architects and designer are using VR walkthrough in designing. Architects and designers use VR walkthrough to design the work and also to inspect their work, to see whether it is what they desire. With VR, they would be able to see and have a feel of the design when it is actually built. By giving them a better sense of spatial reality architects and designers will be able to see how their design will look even before it is even built. This will give them the edge to come up with more refined designs. Comparing to this project, this supports the notion that VR walkthrough could help in presenting a design of an apartment to a user. The VR walkthrough that is built in this project will result with the same effect that of the one used by the architect, thus giving the users the feel of the actual apartment unit.

From Penn Well Publishing Co.

> *"These digital tours are commonly referred to as architectural walkthroughs or flythroughs, and depending on the technologies used to create them, they can differ dramatically, ranging from non-interactive to interactive to immersive applications. Despite the differences, all walkthroughs do share a fundamental feature: motion. Each relies on some type of animation capability to move a viewer through a space."*

This quote shows how there are many variations of VR technology that has been taken into the perspective of professionals to improve their work. All the VR technologies that are considered has the same purpose. The only difference is the approach which is taken to represent the virtual environment.

As it is mentioned in the quote, *" architectural walkthroughs or flythrough"* are 2 different ways of exploring the virtual environment. Architectural walkthrough is a walkthrough that represents the user as someone that is walking through the virtual environment, and his or her motions are governed in by the law of gravity. On the other hand, as it is implied, a flythrough represents someone that is flying through tha virtual environment. Some VR walkthroughs has both approach for the benefit of the user. However, it all depends on the objective of the walkthrough itself.

Relating this to the project, VR is used to enhance the UTP website by giving the users the ability to explore the apartment unit as though they are the occupants of the apartment. Therefore an architectural walkthrough is sufficient enough for them as a mean of exploring the virtual environment. Motion as a fundamental feature of a walkthrough will be ideal by just giving them the ability to walk through the apartment. This is because, different from the architects and designers who are well versed with the dimension and layout of the environment, if the users are given a flythrough, the sense of dimension may be thrown of by the height of they eyesight when they fly above the preferred height.

From Penn Well Publishing Co.

> *"In The Netherlands, the Calibre Institute at the University of Eindhoven developed virtual-reality models of three homes for a new housing develpoment using the Provision virtual-reality system from division Inc. (Redwood City, CA) to give prospective purchasers an opportunity to explore their future homes. During the two days that the VR system was in use, more houses were sold than in any previous two-day period."*

This is a study that took place In The Netherlands, the Calibre Institute at the University of Eindhoven where they are developing a relationship between sales of homes with VR walkthrough as a mean of promotion an homes with out a VR walkthrough. Three VR walkthrough models of homes are made. First they took the sales of the homes before introducing the VR walkthrough, then the sales after introducing it. After two days of introducing the VR walkthrough, sales of the homes increased to more then any two day period before the VR walkthrough was introduced. This is because, investors or future home owners are able to explore the homes and get a better feel of the homes that they are interested in. this encourages them to see further the actual house. Depending on the likeability of these buyers on the house that they explore, the VR walkthrough will definitely give them the edge to actually make a purchase on such an investment. This proves the effectiveness of VR in the field of real estate.

From Penn Well Publishing Co.

> *"Architect/computer animator Andrew McLeary used 3D computer animation to re-create ancient structures from Greek, Roman, Egyptian, and Neolithic periods for a CD ROM called Exploring Ancient Architecture (Medio Multimedia; Redmond, WA)."*

The 'Exploring Ancient Architecture' takes users on self-guided tours through the structures, and can access optional text and narration features. According to Richard Buday of Archimage in Houston, a crucial element to all walkthroughs is their ability to tell an interesting story. It is said that architects are so amazed that they are able to represent anything onto the screen and onto videotape that they forget what it is they are doing. Beautiful images moving on a screen alone are sometime not enough to

represent a virtual walkthrough. The best VR walkthrough should combine these images with narrations in forms of voice or even words.

As a deduction from this, it could be said that having a walkthrough by itself is not sufficient enough to create a VE that could attract a user's interest and attention. It could be said that a VE needs to incorporate additional aspects that could stimulate the other human senses such as sound.

According to Diana Phillips Mahoney (1994)

> *"Zobel concluded that, of the technologies he considered, immersive media more closely match the human perceptual system in terms of being able to understand what it means to actually walk through a building. "You're a direct participant; you can look up and you'll see what's above you, whereas in a screen-based walkthrough, you don't look up; you tell the viewpoint to look up.""*

Despite the varying levels of technological sophistication expressed in the different types of walkthroughs, the reasons for all of them to exist is to accommodate the users needs or requirement. The need for a virtual environment is to create a computer graphic system that allows users to explore the graphical information presented in the system. For this to be successful, users must be able to see the data in many different viewpoints and angles.This is what this project provide, "the ability to explore graphically representation of data in many viewpoints and angle". Users are able to look up, down and side ways.

However, such capabilities will not mean anything if the users themselves donot know their capabilities. Quoting Rick Zobel of North Carolina State University's Virtual Environment Laboratory, in an immersive walkthrough, a user needs to know their capabilities an constraints for them to achieve maximum utilization of the VE. Therefore in this project, the users are given a guide on how they are to explore the virtual environment. Nevertheless these capabilities must fall within the requirements of the user's own needs. It will be sufficient enough for the users to walk around and explore the virtual environment and obtain the information they need.

How VR could create an immersive environment.

According to Diana Phillips Mahoney (1994)

"Another consideration is camera perspective. "Humans have a big peripheral vision; we can see a lot to the side as well as above and below us."

Looking at a computer screen, a users view is cut off by the frame of the monitor itself. This eliminates the peripheral view. To compensate for this, animators often resort to a wider-angle lens. The normal human eye is equivalent to about a 50mm lens, and people will generally do walkthroughs inside buildings at about 35mm lens setting. This technique distorts the view of the users, however it is a compromise between having a very skewed view compared to what looks normal and feeling too boxed in. To create a realistic immersive scenario, the user's must have a realistic panoramic view of a human's eyesight in the real world. The camera view, as used in a VR tool to represent the user's view, must be scaled proportionately to the size and dimension of the VE.

From David Waller,

" it seems likely that desktop VEs will not be able to account adequately for a portion of the variance in people's environmental spatial ability"

A limitation of desktop virtual environments is their lack of incorporation of body-based sensory modalities such as the vestibular and kinesthetic senses. It is the influence of these modalities on people's ability to acquire spatial information from large-scale environments.

Another related source of variance that the VR walkthroughcould not account for is individual differences in the ability to control one's navigation. Making the VR walkthrough more interactive represents another potential improvement. If, for example, the test allowed examinees to determine their own course of travel, it could potentially assess the influence of people's spatial strategies, intentions, and actions on their ability to acquire information from large-scale environments.

For a person to spatial sense, they must have knowledge of the VE. These knowledge include objects that are familiar, recognizable and could be remembered as landmarks.

By having such landmarks they would know where they are going and where they have been. Hence, they would not be lost in the VE.

Creating a realistic and interactive VR walkthrough

According to Anthony Steed, Mel Slater and Martin Usoh,

> *"Presence in an immersive virtual environment system differs from the sense of absorption, engagement or suspension of disbelief that may arise from a book or game in that after the experience many people describe the virtual environment as a place they have visited rather than an environment they have seen."*

To increase the sense of presences several different criteria could be considered. These criteria are to create a natural behavior of objects. However, the behaviors must be consistent to avoid confusion of the user.

1. The data presented to the senses should be of high resolution.
2. The data should not be obviously from an artificial source. For example the displays should be refreshed at a rate high enough so the user does not see flicker and the displays themselves should not be so heavy that this becomes a source of fatigue.
3. The data presented should be consistent. For example if an object in view makes a sound then the sound should appear to originate from that direction.
4. There should be a wide range of possible interactions that the user can make. For example if there is a virtual table in the environment then you should be able to not just see it, but touch it and feel its weight.
5. The operator can effect changes in the environment.
6. There is a direct visual consequence of each of the user's movements.
7. There should be an obvious mapping between the user's movements and the movements of the virtual body or slave robot.
8. The virtual body or slave robot should be similar in appearance to the operator, so there can be identification between the user's limbs and those of the representation.

9. Other objects or users in the environment recognizing and acknowledging the user in some way (such as a door opening as the user approaches).

According to Diana Phillips Mahoney (1994)

> *This metaphor we called the Virtual Treadmill. The walking on the spot is detected by using a neural net whose input is the position of the head. The neural net can distinguish between walking on the spot and any other motion by the pattern of up/down and left/right movements of the head.""*

A typical virtual reality system allows the participant to move around by pointing in the direction they want to go and pressing a button. The cues provided by this are not what would be expected from real walking around an environment, which is after all one what we are trying to simulate in a walkthrough application. In particular there are none of the proprioceptive signals from the body that it is walking.For kinesthetically orientated people this would decrease their sense of presence as they would get visual cues for motion but none of the haptic cues.

A virtual treadmill is a metaphor for kinesthetically orientated people to simulate a walking motion. The movement in a VE is indicated by the movement of the user's eyesight. This is the position of the user's head in the VE. This is the position of the camera in the VE. Hence, the movements are actually the movement of the camera.

According to Rick Zobel

> *"The problem is, in a system where you're coming very close to matching your perceptual system, any variation from normal becomes very obvious,"*
>
> *"You can fly through a building--basically click the mouse or the 3D cursor and move through the building like Superman--but we, as normal people, don't experience architecture by flying,"*

To make a kinesthetically orientated people VR walkthrough to look and feel real is to make the orientation of the user similar to what is in the real world. If in the real world a person walk on the ground, his or her view will be at about a constant level all the time. A system must allow the user to retain a single point of view above ground level. This is because it simulates how people perceive the world. If otherwise, the user's perception

will be unrealistic. By simulating this perceptual view, users will not only be correctly oriented when walking but also, they will be able to relate themselves with the environment that they are in.

According to Dave Hileman of A.J. Diamond, Donald Schmitt & Co. in Toronto

> *"We've found that many people we work with are less convinced by wood grain and marble and all of those things that computer graphics guys get so excited about than they are by realistic lighting."*

In providing a sense of presence, accurate lighting simulation is crucial. Lights make the environment visible to users. Without lights, users will be walking in the dark. It also illuminates the objects in the environment. As in the real world, lights are reflected from objects into the eyes which then make it visible.

With computer graphics, lights are represented by the brightness on an object. If an object is bright, it means that there is light pointing at it. It also creates shadows and tones which create a sense of dimension in the virtual environment.

The tones that are created by lights will make an object look real. As in the real world, an object can never be perfectly lighted. There will always be shadow that intersects with it, which creates a tone of colors on the object. This is how people perceive objects to look real. Therefore, by applying lights correctly, a virtual environment will appear more realistic to the user's eyes.

According to Diana Phillips Mahoney (1994)

> *"t's clear that the ultimate test of any walkthrough, whether it's interactive or not, is the extent to which it allows a viewer to imagine the environment it represents. It would seem that this would directly related to the level of realism an animation provides"*

In an VR walkthrough users are able to walkthrough the virtual environment and explore the space that they are in. however, to make a presentation of a virtual environment more elaborative users should be able to do other things besides just walking through the space.

There has to be other senses of presence in the virtual environment. By using the sense of sight, users are able to see the environment. With the sense of hearing, users are able to hear sounds in the environment. now with the sense of touch users will be able to interact with the environment.

The sense of touch is made by enabling users to do things in the environment. They are given the ability to interact with the objects such as opening doors and window. This interactivity are made possible by just clicking on the desired object for interaction. Interactivity is important in developing a sense of immersions. If a user is able to open a door in an environment it would imply that he or she is in it.

This also helps in presenting the information in the environment by telling that a door opens inwards or a window is opened by sliding it to a certain direction.This shows that interactivity is crucial in determining the effectiveness and success of a VE.

CHAPTER 3
METHODOLOGY / PROJECT WORK

3. WORK PROCEDURE

I have chosen the waterfall model (as shown in Figure 7) in as the system development lifecycle (SDLC) in conducting this project. This methodology was chosen because it provides systematic and orderly approach in solving system problem.

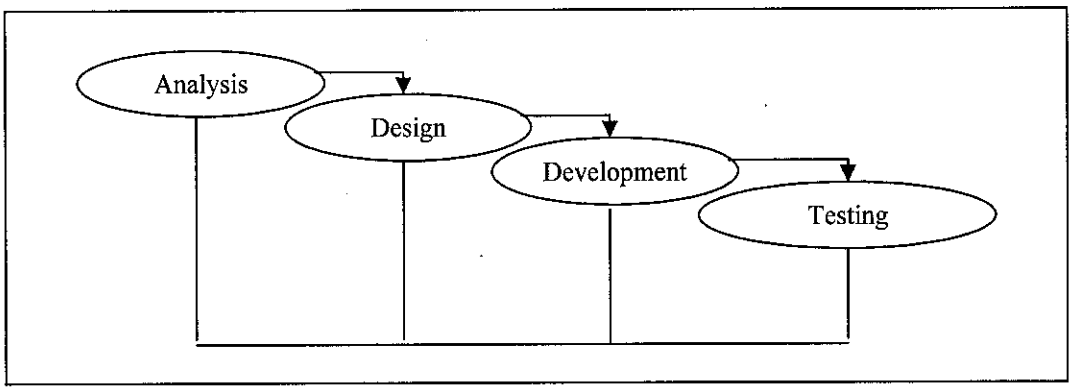

Figure 3.0: Waterfall Model

3.1 ANALYSIS

In this project, I will be creating a VR walkthrough which could be viewed by the public via the internet. Hence, it will require a VE for the walkthrough and a web page from which it could be loaded or viewed.

3.1.1 Creating the Virtual Walkthrough

The main part of this project is creating a realistic and immersive virtual environment of the apartment unit. First the plan of the apartment needs to be drawn out according to the actual dimension of the apartment (Appendix A). After drawing the floor plan, the

furniture and appliances needs to be measured to its actual size. The actual location of the furniture and appliances in the apartment needs to be determined.

After acquiring all the size and dimensions, the process of constructing it in 3D graphics could start. Each object and construct will be developed separately. First, the main construct of the apartment will be developed. The main construct will be the walls and ceiling of the apartment which will include void for the windows and doors. Next is the floor followed by the other objects such as furniture and appliances. Objects that are the same could be duplicated. To save time and effort, some of the object would be downloaded from the internet and imported into the VE. Developing these objects, include assigning its material and textures. When all the objects are completed, it will then be compiled in one file where they are placed at the location where it is in the real world.

After the virtual environment is complete, elements of interactivity will be added. These elements are such as opening and closing the door, closing and opening the windows and turning the light on or off. Effects of sound would also be added. Next, the blender game engine will be used to create the virtual walkthrough of the VE. Finally, a stand-alone executables containing interactive 3D content or play back with the 3d web browser plug-in will be created and embedded into a web page.

3.1.2 Developing the Web Page

A simple web page will be developed. This web page has to be uploaded onto a server from which it could be viewed by the public. In any circumstances that it could not be done, it will be uploaded to a local server instead. A 3D web plug-in will be embedded into the web page. From this web page, the users or public will be able to save the VE and view it locally or load it and view it from the server itself. To view the walkthrough, the users must first have the appropriate 3D plug-in. Therefore, for those users who does not have the plug-in must first download and install it on their local computers. User will be told on which plug-in they would need and appropriate links will be given for them to install the required plug-in.

3.1.3 Tools / Equipment Required.

From researches that have been made, two 3D programs have been short listed. They are VRML and Blender3D.

VRML is a scene description language. Though VRML is a computer language, it is not a programming language. VRML files are not compiled, but are simple ascii text files which can be parsed by a VRML interpreter. These intpreter programs (or parsers) are often called VRML browsers. Writing a VRML scenes is similar to writing an HTML document. The VRML codes are first written in an ascii text editor or notepad, then the file is saved as a VRML file (.wrl) and lastly viewed the with a VRML browser. In VRML, non-standard functionality to the language could be added using standard components of the language. If a browser can parse the extensions to the standard VRML language which it encounters in a world file, then the new functionality described by the extensions will be interpreted for the user as that scene is rendered. An example of a tool for VRML is Cortona VRML by parallel graphics.

Blender is an integrated 3D graphics tool that allows modeling, animation, rendering, post-production, realtime interactive 3D and game creation and playback with cross-platform compatibility.

- Modeling
  - A range of 3D object types including polygon meshes, NURBS surfaces, bezier and B-spline curves, metaballs, vector fonts (TrueType, PostScript, OpenType)
  - 'Smooth proxy' style catmull-clark subdivision surfaces
  - Boolean mesh functions
  - Editing functions such as extrude, spin, screw, warp, subdivide, noise, smooth Soft selection editing tools for organic modeling
  - Python scripting access for custom tools
- Realtime 3D
  - Graphical editor for defining interactive behavior without programming
  - Collision detection and dynamics simulation

- Python scripting API for sophisticated control and AI, fully defined advanced game logic
- Supports all OpenGL™ lighting modes, including transparencies, Animated and reflection-mapped textures
- Playback of games and interactive 3D content without compiling or preprocessing
- Audio, using the fmod toolkit
- Multi-layering of Scenes for overlay interfaces

❖ Rendering

- Very fast inbuilt scanline renderer
- Oversampling, motion blur, post-production effects, fields, non-square pixels
- Environment maps, halos, lens flares, fog
- Various surface shaders such as Lambert, Phong, Oren-nayar, Blinn, Toon
- Edge rendering for toon shading
- Radiosity solver
- Export scripts available for external renderers such as Renderman (RIB), Povray, Yafray, Virtualight
- UV texture editor with various mesh unwrap modes

❖ Interface

- Flexible user configurable window layout
- Powerful object-oriented data system
- Anti-aliased fonts with international translation support
- Windows for animation curves/keys, schematic scene diagram, non-linear video sequence editing, character animation action editor, non-linear animation mixer, image/UV editing, file/image selection and file management
- Inbuilt text editor for annotations and editing Python scripts
- Consistent interface across multiple platforms

❖ File

- Save all scene data in a single .blend file
- .blend format supports compression, digital signatures, encryption, forwards/backwards compatibility and can be used as a library to link to from other .blend files
- Read / Write TGA, JPG, PNG, Iris, SGI Movie, IFF, AVI and Quicktime GIF, TIFF, PSD, MOV (Windows and Mac OS X)
- Native import and export for DXF, Inventor and VRML files, with python scripts available for many other 3D formats
- Create stand-alone executables containing interactive 3D content or play back with the 3d web browser plugin.

Between Blender and VRML, blender is clearly more user friendly and easier to use and comparing the VR walkthrough produced by both Blender and VRML, the blender walkthrough is easier to navigate. Therefore, I have chosen the Blender 3D as the tool to create the VE for this project.

➢ **Hardware Requirement**

- PC running on Windows 95/98/2000/XP/ME/NT (i386)
- High Performance Graphic Card

➢ **Software Requirement**

- Blender Publisher 2.25 for windows
- Blender 3D Plug-in for Internet Explorer
- Web Publisher

3.1.4 Software Requirement Specification

❖ **Intended User Analysis**

The intended users are the public who are interested in obtaining more information UTP. Specifically, they are the future students of UTP or students who are planning to further their studies in UTP.

❖ **System Requirement Analysis**

To determine the user's needs and to identify infeasible requirements, omissions, ambiguities, vagueness and to distinguish between functional and non-functional, data and usability requirements, a requirement gathering and analysis was conducted.

❖ **Functional Requirement**

- **System Reaction**
  a. The walkthrough should allow the users to explore the VE within the constraints of the apartment unit.
  b. Users should be able to interact with the interactive objects in the VE
  c. Users should have an immersive feeling in the VE.
  d. Users should have a sense of dimension and space when going through the VE.
  e. User should be familiar of the apartment unit after going through the walkthrough.
- **Others**
  a. Users must have the appropriate Blender 3D plug-in either for Internet Explorer or Netscape Navigator to view the VR walkthrough.

❖ **Non-Functional Requirement**

- Product requirements

  - **SPEED**

  i) The loading of the plug-in depends on the network or internet connection.

  ii) The smoothness of the walkthrough has to be bearable by the user.

  - **USABILITY**

  i) The navigation for the walkthrough should be easy to understand and used.

  ii) There should be a guide on the navigation keys used for the walkthrough.

- **Organizational requirements**

Implementation

Blender is an open source software, its plug-in could be downloaded and installed for free.

- **External requirements**

  - **LEGISLATIVE**

The system shall meet the legislative requirements to ensure that the system operates within the law.

  - **ETHICAL**

The requirements places on the system will be acceptable to its users and the general public.

❖ **Usability Requirements**

The components for testing usability could be expressed in terms of:

- **Learn ability**

The time and effort required reaching a specified level of use performance, which also described as ease of learning.

- **Throughput**

The tasks accomplished by experienced users, the speed of task execution and the errors made also described as ease of use.

- **Attitude**

The positive attitude engendered in users by the system

3.2 DESIGN

3.2.1 Use Case Diagram

The use case diagram describes the interaction between user and the application. As illustrated in the diagram , the main interaction is between the user and the website is the walkthrough. The user will load the walkthrough on to the website and view it from the server. Users will be able to download and save the walkthrough in their local computer. For user that does not have the Blender 3D plug-in, they could install it from a link given on the website.

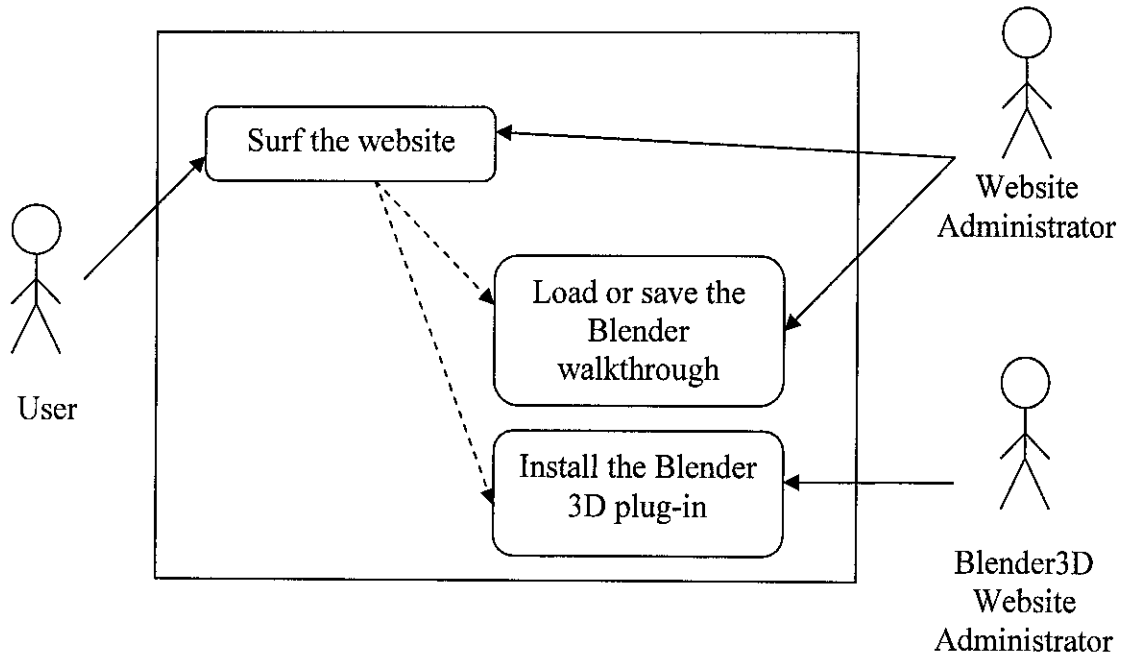

Figure 3.1: Use Case Diagram

3.2.2 Storyboard

This storyboard shows the basic interface of the website and the arrangement of the functions display on it.

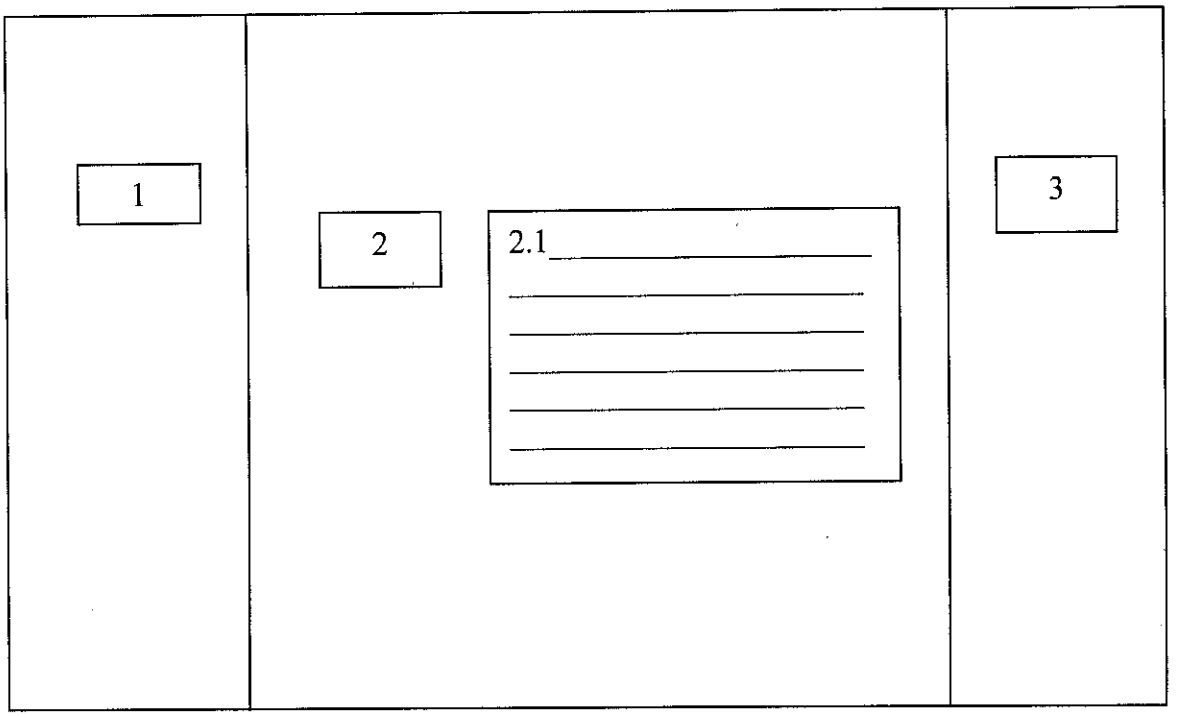

Figure 3.2: Storyboard

1: link from the website to the student facilities page on the UTP website.

2: link to download the walkthrough executable

2.1: description of the walkthrough

3: link to the blender3d website to install the blender 3D plug-in.

3.3 DEVELOPMENT

3.3.1 3D Modeling

❖ Creating 3D Objects

Before creating the 3D objects, measurements are taken and sketched as a guide for the development (Appendix A). The 3D objects are created with Blender Publisher 2.25 in the 3D main window as shown in Figure 10.

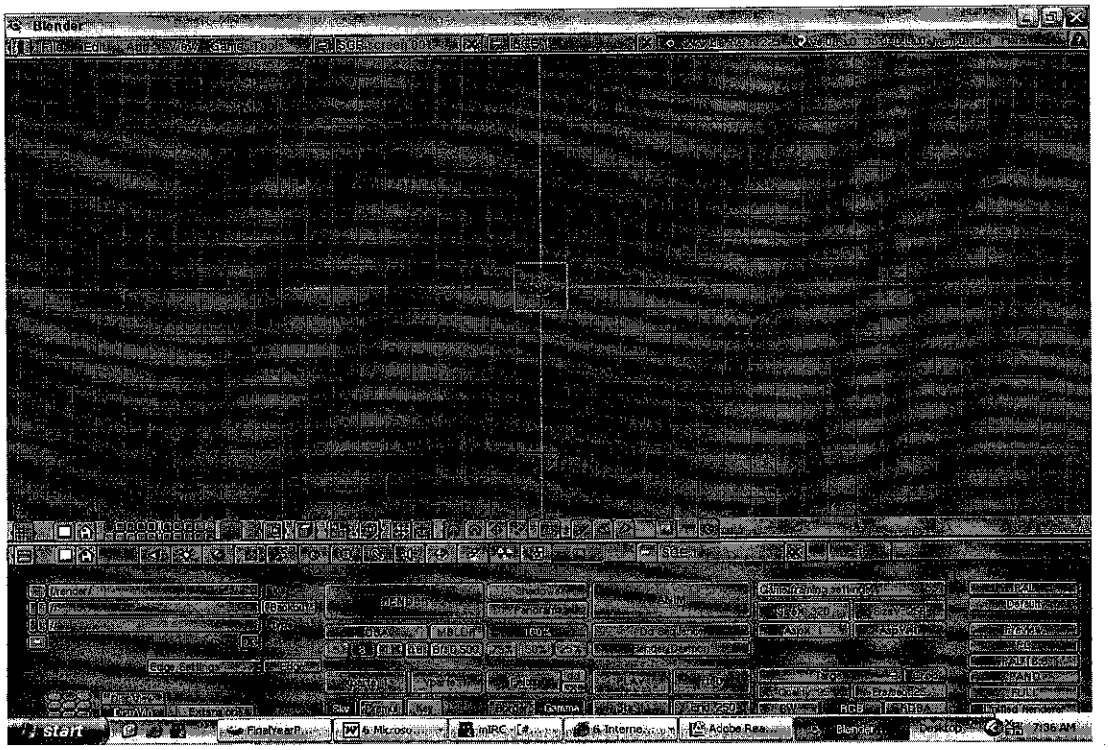

Figure 3.3: User Interface of the Blender Publisher 2.25

Developing objects starts with adding primitive objects in the scene from the menu in Figure 11. These primitive objects are basic shapes such as circles, cubes, cylinders and cones. Shapes are added by selecting them in the meshes option on the main menu. Selected shapes are placed on the 3D window at the point where the red and white circle is situated.

After an object is selected, various manipulations could be done to its shape. Blender has two basic modes of operation; Edit and Non-edit mode. When an object is in Edit mode, all the vertices that makeup the shape of the object are highlighted in pink. These vertices could be moved individually or in groups according to the developer's needs. In Edit

mode, the original shape of the object could be changed by moving selected vertices. The B key on the keyboard is pressed to select the vertices. Selected vertices will be highlighted in yellow.

When in Non-edit mode, the lines that make up the object is highlighted in pink instead of its vertices. Here, the object is manipulated as a whole. The object could be resized, rotated or relocated.

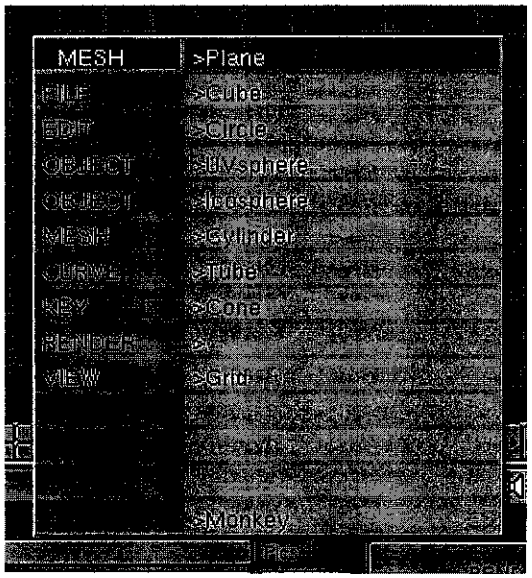

Figure 3.4: Mesh and Plan Edit Mode

These objects are then edited according to the measurements of the objects by resizing and extruding the primitive objects. This could be done from the tool window in Figure 12 shown below.

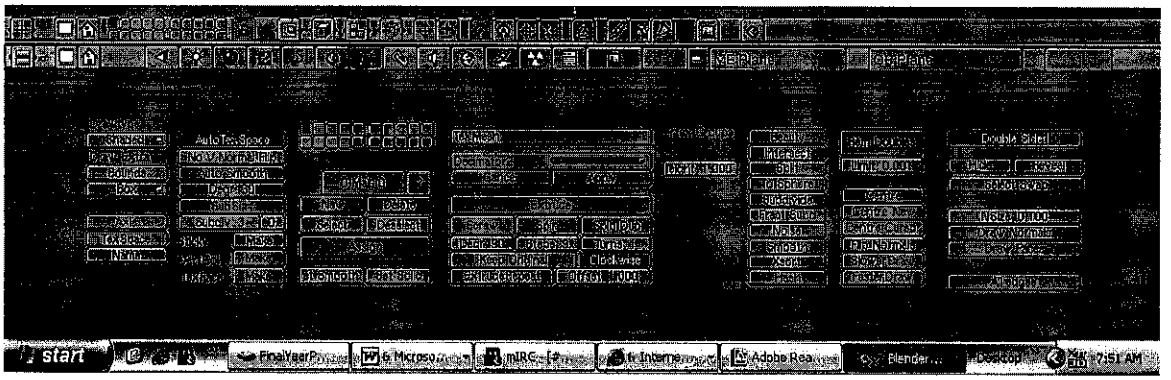

Figure 3.5: Edit Buttons

❖ Adding Material and Textures

Adding material to the objects is actually applying color to it. To make the objects more realistic, textures are also added. Textures are patterns of colors or images that has pattern. With blender, images could be loaded to be applied to objects as textures to create amore realistic look.

First, to add material to the object, the "Add New" button on the "Edit Buttons" in Figure 12 is clicked to specify a material for the selected object. Next, the material settings are set with the "Material Buttons" as shown in Figure 13. Here, colors are set by specifying the RGB colors with the slide bar. This will add the simple pigments to the object. Other settings such as specularity, hardness or strength of reflected light, emitted light, alpha or transparency of the object and reflected light are specified here as well.

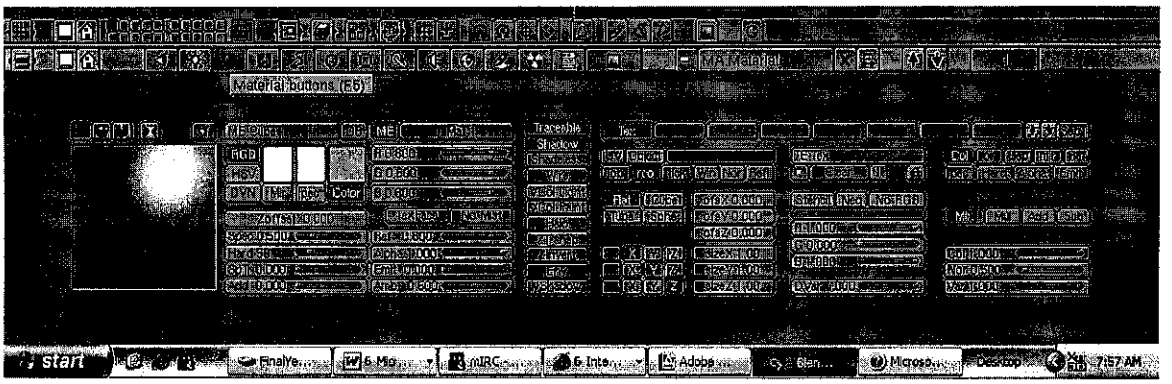

Figure 3.6: Material Buttons

Below is the texture buttons used to specify texture to objects.

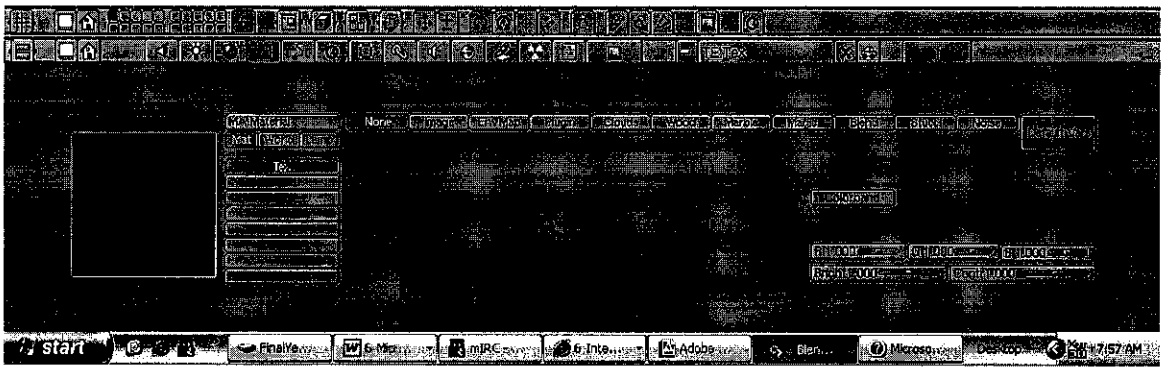

Figure 3.7: Texture Buttons

To configure a texture setting, a texture is loaded from the texture library. There are several textures that are provided by blender such as wood, marble, noise, images, etc. each texture has a different setting that has to be configured. Two main buttons to be configured are Xrepeat and Yrepeat. These buttons specifies the repetitions of the texture in each direction this is because textures are applied differently on different objects.

❖ Lighting

Lights are added by selecting Add and Lamp on the main menu shown in Figure 11. Lamp is the type of light source that is added on the scene. There are four types of lighting in blender; lamp, spotlight, sun and hemi light. There are a number of light settings (as shown in Figure 15) used to create a realistic atmosphere in the VE.

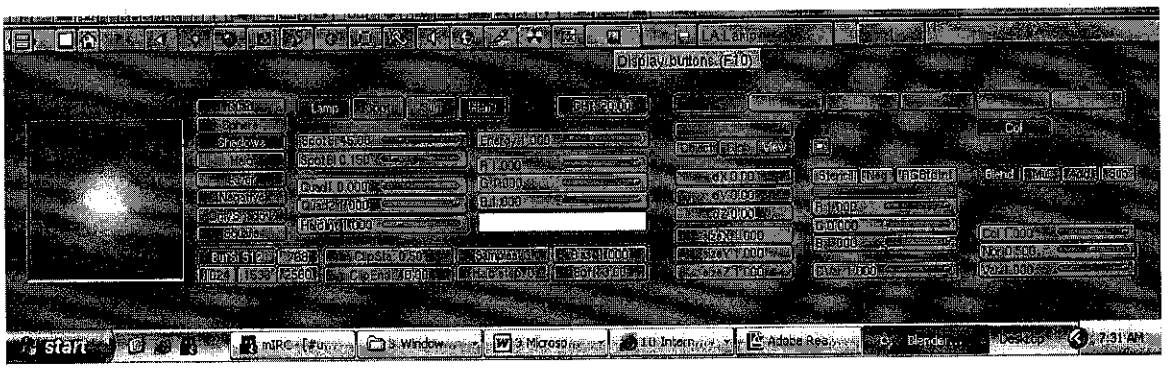

Figure 3.8: Lighting Buttons

Below are the 3D objects to be developed:

- Walls
- Ceiling
- Floor
- Furniture
    - Bed
    - Desk
    - Chair
    - Cupboard
    - Shelf
    - Kitchen cabinet

- Towel hanger
- Appliance
  - Ceiling lamp
  - Ceiling fan
  - Fridge
  - Switches
- Bathroom
  - Toilet bowl
  - Sink
  - Tap
  - Shower head

3.3.2 Creating Interactivity

The interactivity of object are defined in the tool window as shown in Figure 15 as shown below.

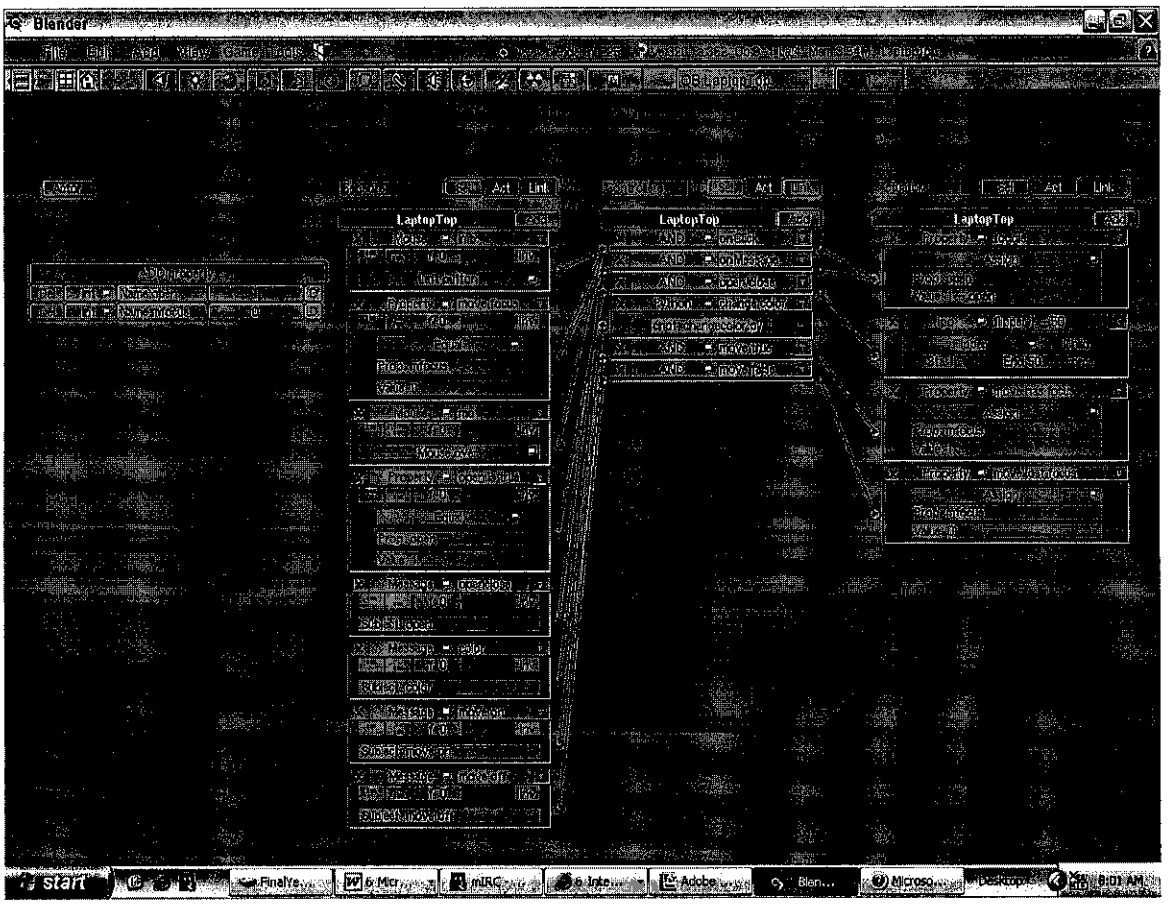

Figure 3.9: Real-time Buttons

There are 3 criteria of real-time animation in blender, sensor, controller and actuator. The sensor defines the input of the real-time effect such as keyboard or mouse input. The controller defines the arithmetic relation between the input and the output of the real time effect. The actuator defines the output or the real-time effect of the object upon triggering the sensor. The interactivity that will be created in the walkthrough are such as swinging doors, sliding window and turning lights on and off upon the click of the mouse.

3.3.3 Creating VR Walkthrough

To create the VR walkthrough, a walkthrough template will be used.First, the scene file walkthrough_template.blend is opened. A 3D window with some objects displayed in wireframewill appear as shown in Figure 16. This will show a "viewer" which represent the viewer as the user walk through the model. Next, the environment model is loaded onto the template. The model data to the current scene of the VE will be appended. Hence, everything in the current scene and the VE that is loaded could be seen on the window.

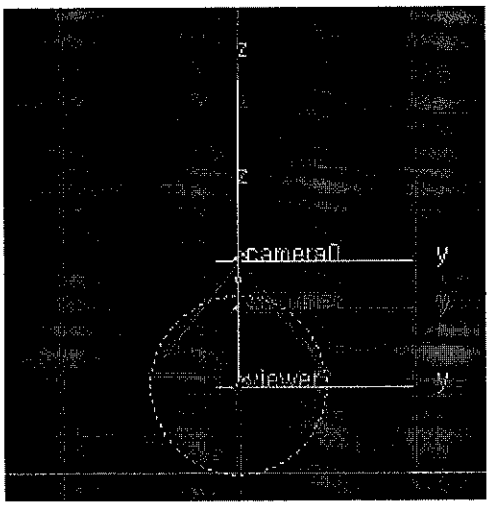

Figure 3.10: Walkthrough viewer

For the navigation system to work correctly, the model must have the correct orientation, scale, and location. This is easily accomplished using the orthogonal views available in Blender. The hotkeys for these views are located on the number pad of the keyboard.

With the NumLock key engaged and the object selected, Press **7** for a top view, 3 for a right side view, and 1 for a front view. To select objects, click on it with the right mouse button. Holding the Shift key will allow multiple selections. Pressing the B key will allow you to drag a selection box around objects. The A key will select or deselect all objects. To rotate, the R key is pressed and the mouse is moved. Rotation is viewpoint-dependent; the axis of rotation is parallel to the view port's line of sight. Holding the Control key constrains the rotation to 5° increments. Clicking the left mouse button applies the changes to the object. Pressing the Esc key at any time before applying the changes will cancel the operation, resetting the object's rotation.

The **S** key is used for scaling. When using this template, 1 meter of your model should be equal to 1 Blender Unit. If the scale is incorrect, the user will not have a human eye-level perspective and the navigation system may not work at all. The grid which is visible in the 3D window shows the size of these units in relation to your model. It could be used as a reference when scaling the objects. The **N** key will allow scaling by typing the scale factor into each of the SizeX, SizeY, and SizeZ number buttons. The VE should be positioned so that the object representing the viewer sits on the floor of the model in the part of the model where you want the tour to begin.

The positioning of objects has to be approximately on the floor or the viewer will experience some jerky movement as the physics system settles the object into place. The **G** key (think "grab") is used to position your model. Again, use the orthogonal views to get a clear idea of its position in all 3 dimensions. The Control key will constrain the movement to unit increments. The same methods could also be used to position and rotate the spherical viewer object so that the viewer begins with a very specific location and orientation.

Testing the Scene

By pressing 0 on your keyboard number pad a scene through the camera will be displayed. Pressing P will start the game engine. To navigate through your model, click on the plugin content. Then, drag with the mouse to turn left/right and look up/down, and

use the arrow keys to move forward/backward/left/right. The space bar will toggle flying mode. This will be in wireframe mode. To see the scene with solid faces, textures and lights press Alt Z. By removing the lamps and applying some vertex colors and textures will achieve the desired appearance. This is the way the scene will appear in the Blender 3D Web Plugin when the game engine is started again.

3.3.4 Embedding 3D Plug-in into Web Page

To embed the Blender 3D Plug-in on the web pages, some HTML code needs to be added to the web pages. A link to the Blender 3D plug-in page will also be added (http://www.blender3d.org/Download/?sub=Plugin) where users can install the plug-in if it is not already installed on their system.The following HTML tags are inserted into the web page:

```
<p>
<object
  classid="clsid:5DB05CB8-7751-469D-A1DD-45C8C201C013"
  id="Blender3DPlugin"
  width="640"
  height="480"
  codebase="http://plugin.blender.nl/
  Blender3DPlugin.cab#Version=2,24,4,0">
  <param              name="blenderURL"              value="http://www.reza
saheh.Ocatch.com/filename.blend">
  <param name="loadingURL"
  value="http://www.rezasaheh.Ocatch.com/yourloadinganimation.blend">
  <param name="ForeColor" value="65280">
  <param name="BackColor" value="255">
  <param name="useFileBackColor" value="1">
  <param name="frameRate" value="20">
<embed
  type="application/x-blender-plugin"
  pluginspage="http://plugin.blender.nl"
  name="NPBlender"
  width="640"
```

```
  height="480"
  src="http://www.rezasaheh.Ocatch yoursite.com/yourproduction.blend"
loadingURL="http://www.rezasaheh.Ocatch.com/yourloadinganimation.blend"
  ForeColor="65280"
  BackColor="255"
  useFileBackColor="1"
  frameRate="20">
</embed>
</object>
</p>
```

These tags work for both the ActiveX control and the Netscape plug-ins.

The code between the <object> and the <embed> tags relates to the ActiveX control.

- The classid is the unique identifier of the Blender 3D Plug-in.
- The id is the name of the plug-in on the page. This can be used to identify the plug-in from Javascript.
- The width and height parameters sets the dimensions of the plug-in on the page. In the example, width and height are given in pixels.
- The codebase is the URL the ActiveX control will be downloaded from when it is not installed on the system the page is viewed on. The version number after the hash sign (#) should read the minimum version of the ActiveX control needed to view the content. Internet Explorer will compare this version to the version of the ActiveX control installed on the system. If the ActiveX control installed is older, the newer version is downloaded and installed automatically.

The <object> tag is followed by a list of parameters:

- blenderURL (required) is the URL of the Blender file to be viewed.
- loadingURL (optional) is the URL of the custom loading animation. Please note that custom loading animations are only available to owners of a Blender Publisher license.

- ForeColor (optional) is the color to be shown when the custom loading animation is downloaded.
- BackColor (optional) is the color used to draw the extra areas when the aspect ratio of the plug-in does not match the aspect ratio set in the Blender file.
- useFileBackColor (optional) read the color to draw the extra areas with from the Blender file. If neither BackColor or useFileBackColor are set, the HTML background color is used to draw the extra areas.
- frameRate (optional) is the maximum number of frames per second. When the animation does not need to be viewed at maximum frame rate possible (e.g. web banners), set this value to a meaningful maximum. With lower frame rates the client system will remain more responsive. For other types of content (e.g. games) you probably want to set this value to the maximum of 100 or leave out the parameter in which case the plug-in will use 100 as well.

Color values should be passed to the ActiveX control in a format known as OLE_COLOR. The red, green and blue components of the color are stored in a single value. To determine a BGR value, specify blue, green and red (each of which has a value from 0 - 255) in the following formula: BGR value = (blue * 65536) + (green * 256) + red

Some parameters of the plug-ins can be dynamically accessed by adding the following to the HTML page:

```
<form>
<input type="button" value="load other production" onclick=
"Blender3DPlugin.blenderURL='http://www.rezasaheh.Ocatch.com/yourproduc
tion.blend';">
</form>
</p>
```

CHAPTER 4
RESULTS & DISCUSSION

4.1 Scene Graph

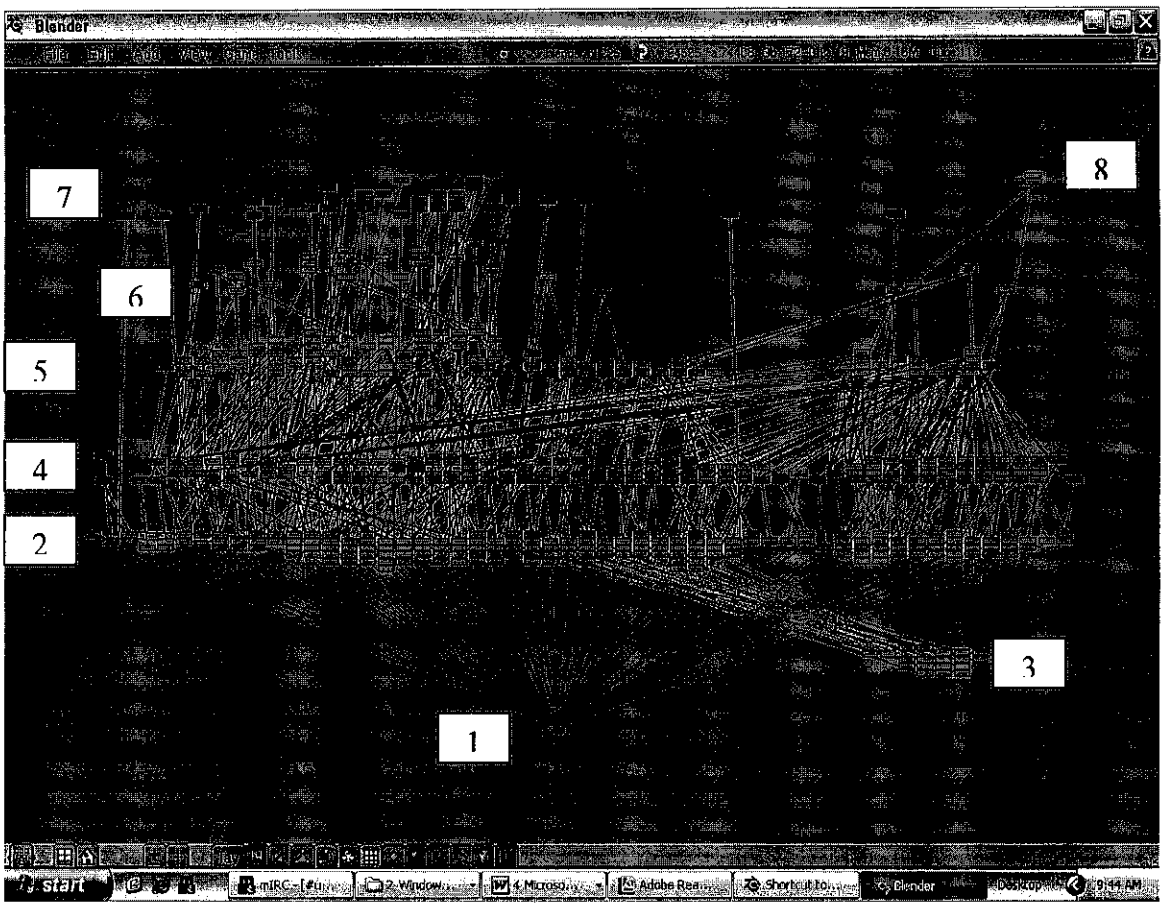

Figure 4.0: Scene Graph

Above is the resulting scene graph that was generated by Blender. The scene graph connects each object to its respective data blocks. The box indicated as number 1 is the represents the data of the whole scene of which the VE resides in. The scene data

encapsulates the object data (2), lamp data as (3), mesh data as (4), material data (5), IPO data (6), texture data (7) and image data (8).

4.2 Virtual Environment created using Blender3D

The walkthrough is saved as an executable file to be viewed by the public. Below are scenes from the walkthrough.

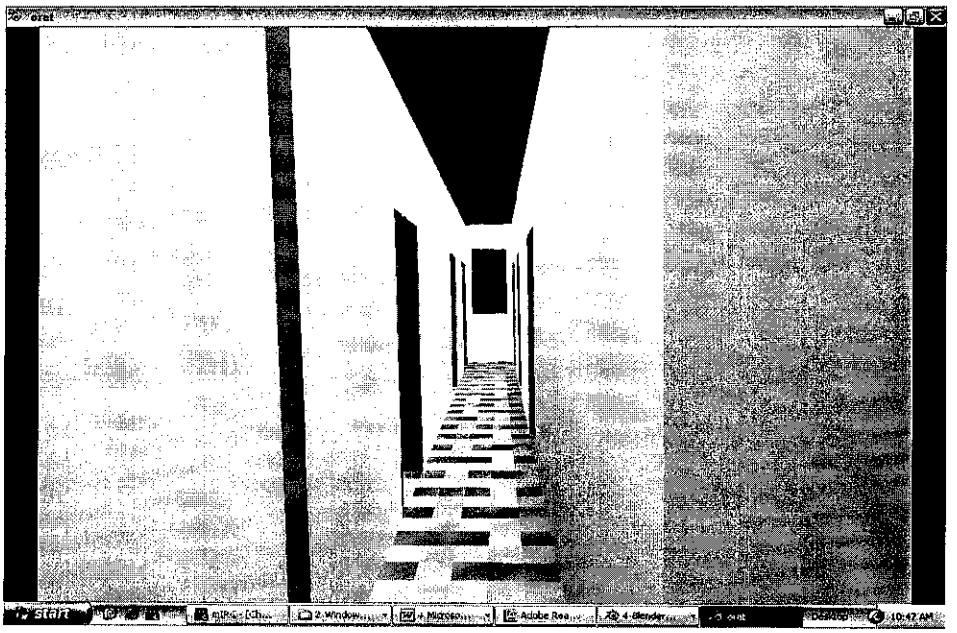

Figure 4.1: Hallway

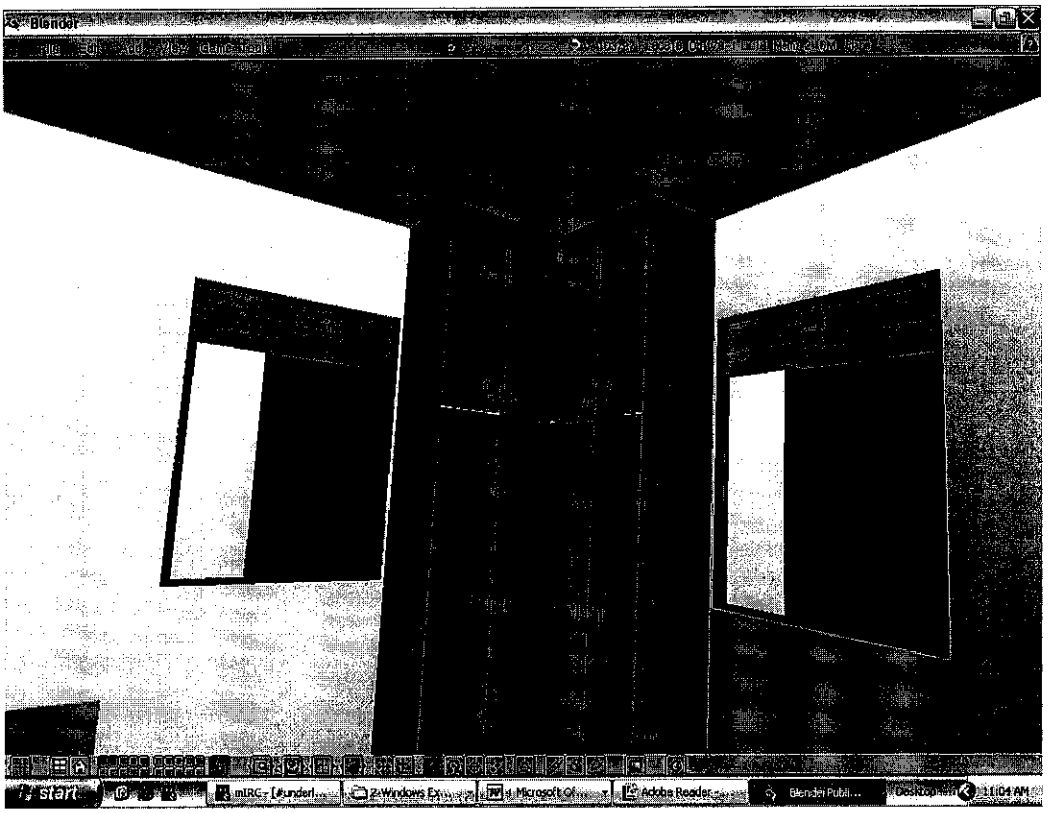

Figure 4.2: Corner Room Cupboard

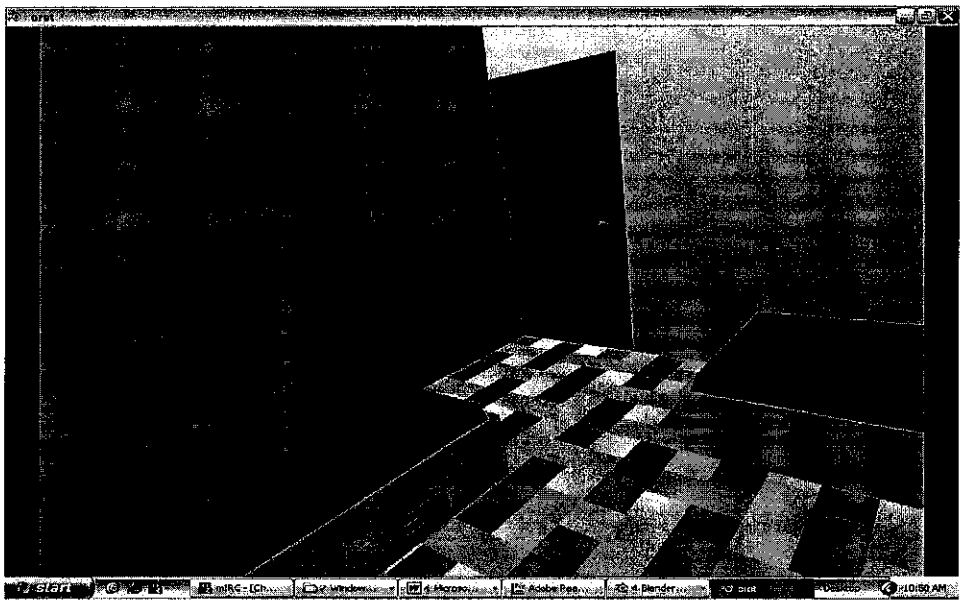

Figure 4.3: Corner Room

Figure 4.4: Bathroom

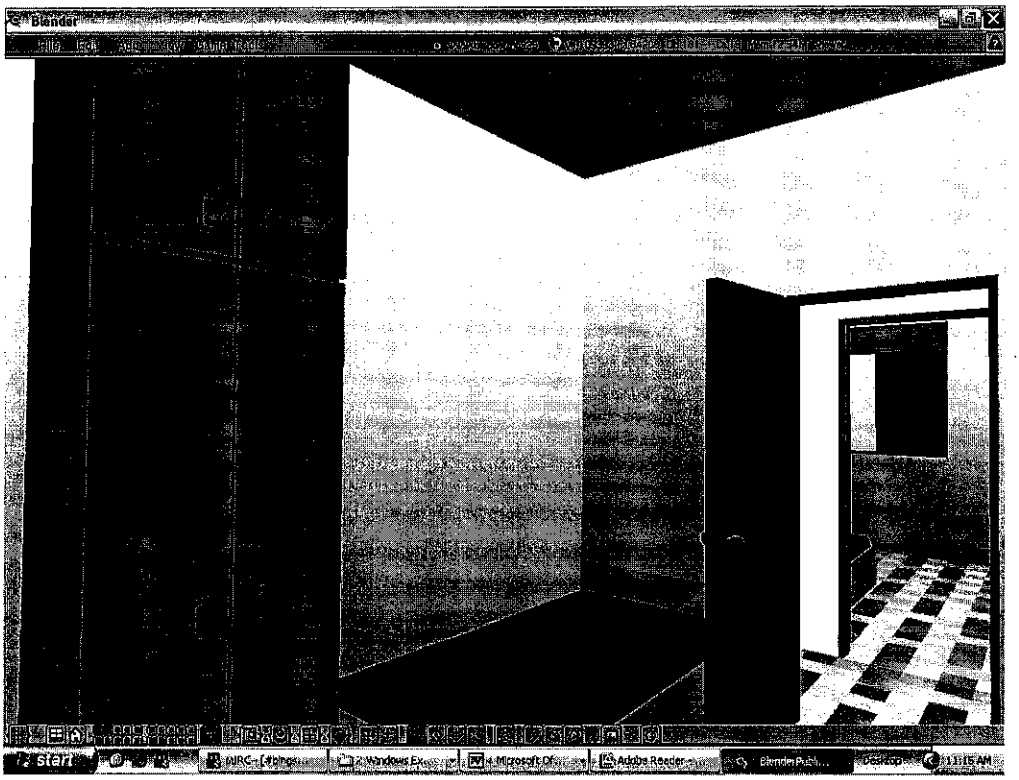

Figure 4.5: Middle Room

In the VR walkthrough, the user would be able to explore the apartment from room to room including the toilet and the hallway. Aspects of interactivity are included as the users will be able to open and close the doors to the areas that they wish to explore. They

will also be able to open and close the windows. To make the walkthrough more immersive for the users, sounds have been embedded in the effects of opening and closing the doors.

4.3 Effect of Texture Mapping and Lights

In the walkthrough, the effects of textures have been used to create a more realistic look for the objects. By applying real images as textures objects appeared more realistic compared to the ones which only use plain material.

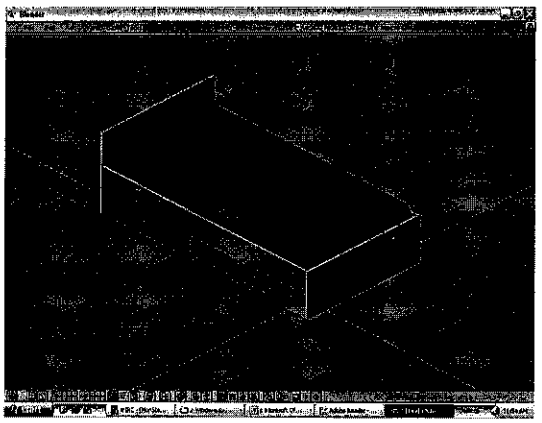

Figure 4.6: Bed sheet with image texture

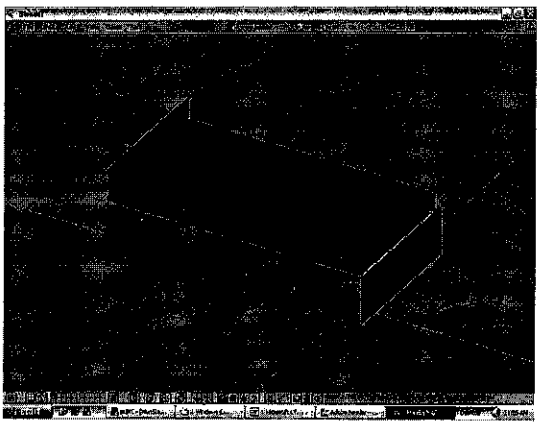

Figure 4.7: Bed sheet with plain material

Lights have played an important role in enhancing realism in the generation of this virtual environment. The effects of light create the shading and shadow effects in the environment. Shades on the object define its shapes and dimensions. This helps a user who is exploring the environment to recognize the objects and also to identify their position in the environment.

4.4 Advantages and Disadvantages of VR Walkthrough

Advantages of VR walkthrough

It is clear that VR walkthrough has significant advantages in visualization. With the help of a VR walkthrough, the apartment not only could be seen but also felt in terms of dimension and depth. In this project, users who will be the future tenants of the accommodation supplied in UTP will be able to get an initial tour of the apartment. It will give them a sense of how their lodging will be even before they arrive to the actual site. Interactivity in the walkthrough shows the users how the facilities work by simulating its movement.

Disadvantages of VR walkthrough

- Building a virtual environment require special and extensive training. The various knowledge of 3D modeling needs to be leant before hand.
- 3d modeling is very time consuming and it takes a lot of effort.
- Viewing a walkthrough via the internet may cause discouragement due to the time needed for loading the data in view.
- Other discouragement may cause by lack of resources such as the plug-in needed to view the walkthrough.
- Basic knowledge of mouse and keyboard navigation through the environment may be needed.

4.5 Limitations

To create high quality 3D models, high end equipment is needed. These equipments may deem to be very expensive. Such equipments are rarely owned for home or leisure uses. Powerful workstations or computer are needed to render the abundant data that is needed to create high quality models. In contras to the high-end machines the machine that is used to create this VR walkthrough is not sufficient enough to generate high quality modeling.

4.6 Problem Faced and Action Taken

Related to the limitation that has been discussed before, a problem was faced in this project where the VR walkthrough in the VE that was created could not run smoothly when to many objects were appended into the environment. This has caused the walkthrough to run in jagged movement. This problem is deemed to be caused by amount of data that resides in the VE is to much for the machine to render properly.

Hence, a point of action has been taken to separate the VE into smaller sections of the apartment. A walkthrough of the apartment will be developed with limited amount of objects to appoint where the movement is still smooth and fully furnished sections will be developed separately.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

By incorporating VR walkthrough of UTP's Village 3 apartment unit in a website, the facility could be presented in a more elaborative way. With this UTP is able to introduce to the public the facilities that are prepared with higher understanding.

In this project an immersive virtual environment was developed where it is interactive and considerably realistic. The VE is then embedded into web page whereby users or public could view. At the end of the project, the website is ready to be linked to the UTP website to be made as an expansion. With this the project undertaken is considered a success as it corresponds to the initial objectives.

5.2 Recommendation

It is recommended that this project does not end here. With the vast development of UTP's infrastructure, VR walkthrough maybe the best way to introduce PETRONAS University of Technology's world class facilities.

As this project only creates a walkthrough of an apartment unit, it is recommended that the walkthrough is expanded to the whole hostel building. The various selections of accommodation facilities could be presented to the public through the website with walkthroughs. In the future where accommodations are choices where students could pick, VR walkthrough could give them the power to make better decisions according to their preference.

It is also recommended that future developments of VR walkthroughs to be done on better more powerful equipments to get better and higher quality 3D models. Also to add more interactivity to the walkthrough so that the VE is more elaborative.

5.2.1 Recommendation for Future Projects

In terms of GIS (Geographical Information System), searching and query could also be done in a VE. In an environment that has a larger scope, such as an apartment block or the whole academic block, searching and query could be very useful for new students to find their way to a desired spot.

With searching, a user could find a desired location just by keying in the specific name for it, such as "Programming lab 1" or "Pn. Rozana's Office" as an example for searching locations in the academic block or "V3D-S2" to search for the apartment in village 3. These specific location names are actually the coordinates of the location in the VE.

With searching, it will not only take the user to the desired location, but also show them the exact route for them to use to get there. In VR, the user will be represented by the camera view from which the user uses to explore the VE. Therefore, with VR technology, a user will be guided through the route in a first person's view from a starting point to the desired location.

It is recommended that this is proposed as a title a future final year project.

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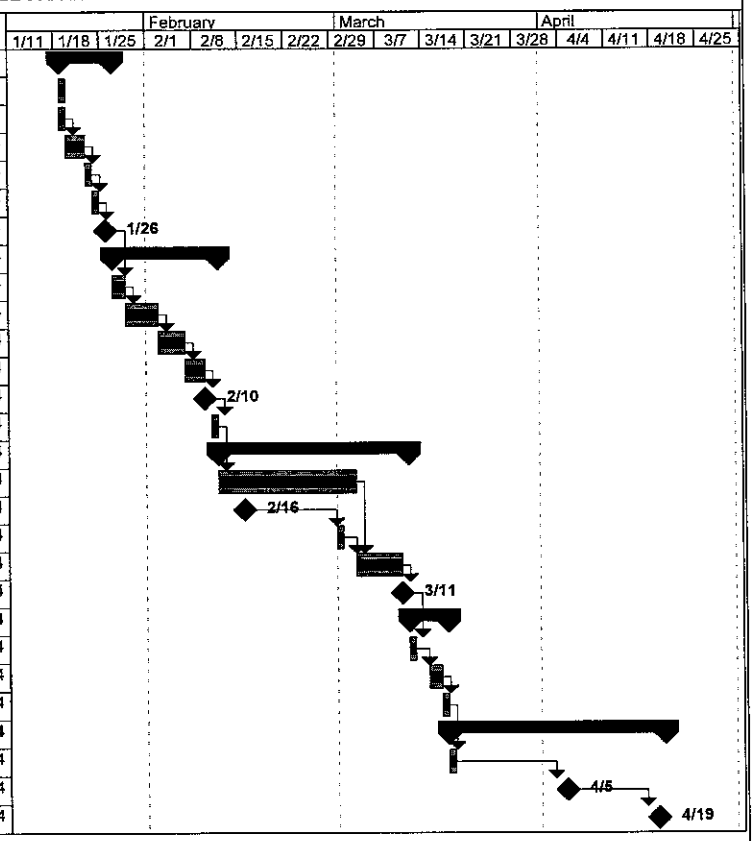
VR WALKTHROUGH OF UTP'S VILLAGE 3 APARTMENT UNIT

ID	Task Name	Duration	Start	Finish
1	**Analysis**	**7 days?**	**Mon 1/19/04**	**Mon 1/26/04**
2	Identify objective of the project	1 day	Mon 1/19/04	Mon 1/19/04
3	Identify needs and project constraint	1 day	Mon 1/19/04	Mon 1/19/04
4	Establish problem statement	3 days	Tue 1/20/04	Thu 1/22/04
5	Perform preliminary research	1 day?	Fri 1/23/04	Fri 1/23/04
6	Analyze research findings	1 day?	Sat 1/24/04	Sat 1/24/04
7	Submit preliminary project report	1 day?	Mon 1/26/04	Mon 1/26/04
8	**Design**	**13 days?**	**Tue 1/27/04**	**Wed 2/11/04**
9	Design village sketches	2 days	Tue 1/27/04	Wed 1/28/04
10	Hardware and Software requisition	3 days	Thu 1/29/04	Mon 2/2/04
11	Design system architecture and system flo	4 days	Tue 2/3/04	Fri 2/6/04
12	Design user interface	2 days	Sat 2/7/04	Mon 2/9/04
13	Conform system requirement with supervis	1 day?	Tue 2/10/04	Tue 2/10/04
14	Submit Weekly Report for week 1 - week 4	1 day?	Wed 2/11/04	Wed 2/11/04
15	**Coding**	**21 days?**	**Thu 2/12/04**	**Thu 3/11/04**
16	Design apartment unit using Blender	3 wks	Thu 2/12/04	Wed 3/3/04
17	Submit Progress Report	1 day?	Mon 2/16/04	Mon 2/16/04
18	Submit Weekly Report for week 5- week 7	1 day?	Mon 3/1/04	Mon 3/1/04
19	Integrate application with web-system	1 wk?	Thu 3/4/04	Wed 3/10/04
20	Test system requirement with supervisor	1 day?	Thu 3/11/04	Thu 3/11/04
21	**Testing**	**4 days?**	**Fri 3/12/04**	**Wed 3/17/04**
22	Test VR walkthrough	1 day?	Fri 3/12/04	Fri 3/12/04
23	Make correction and failure adjustment	2 days	Mon 3/15/04	Tue 3/16/04
24	Re-test application for final submission	1 day?	Wed 3/17/04	Wed 3/17/04
25	**Finalize Project Report**	**23 days?**	**Thu 3/18/04**	**Mon 4/19/04**
26	Submit First Draft and Weekly Report	1 day?	Thu 3/18/04	Thu 3/18/04
27	Submit Final Draft and Weekly Report	1 day?	Mon 4/5/04	Mon 4/5/04
28	Final submission of Project	1 day?	Mon 4/19/04	Mon 4/19/04



Project: ganttchrt
Date: Wed 6/9/04

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline