

Virtual Heritage Building : Darul Ridzuan Museum

by

Sara Anis Binti Kamarazamam

Dissertation submitted in partial fulfillment of
the requirements for the
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- 2) Virtual reality
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CERTIFICATION OF APPROVAL

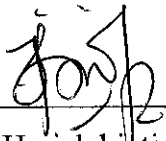
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A project dissertation submitted to the
Information Communication Technology Programme
Universiti Teknologi PETRONAS
in partial fulfillment of the requirement for the
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(INFORMATION COMMUNICATION TECHNOLOGY)

Approved by,



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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JULY 2005

CERTIFICATION OF ORIGINALITY

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

A handwritten signature in cursive script that reads "Sara Anis".

SARA ANIS BINTI KAMARAZAMAM

ABSTRACT

This research paper describes a development of virtual museum project. The objectives of this project are to create virtual heritage building (focus on the exterior design) as well as to create walkthrough for the user to navigate through the virtual museum. The scope of this project is to ensure the realism of exterior design of the building. Three vital phases of development are conducted, which involved Research and Analysis phase (data collection of virtual heritage building concept and modeling techniques), Design and Development phase (develop 3D model and walkthrough), and Testing and Evaluation phase (evaluation on important aspects, i.e. realism, navigation, collision detection, application suitability, application usability and user acceptance). The result for user acceptance is the highest percentage which is 90%. This indicates that this application is highly accepted by users. In conclusion, this project has met the objective and it can be enhanced in order to make the application more appealing to the eye of the user.

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Cultural heritage is becoming an important application for virtual reality technology. Virtual heritage applications use the immersive and interactive qualities of virtual reality to give students or museum visitors access to computer reconstructions of historical sites that would normally be inaccessible, due to location or fragile condition. They also provide the possibility of visiting places that no longer exist at all, or of viewing the how the places would have appeared at different times in history.

There are a lot of museums all over Malaysia but due to some reasons it is not the place where people usually visit. Therefore, some people may know about their existence but some may not. By applying a virtual reality technology, it can solve the problem and a useful way in preserving cultural heritage.

A museum is an institution devoted to care, research and display of artifacts and specimens of lasting interest or value. Museums produce exhibitions based on their collections, but also may have large collections used primarily for research

For this project, Darul Ridzuan Museum has been chosen to be developed in 3D model. Darul Ridzuan Museum is the first museum in Ipoh. Among the interesting artifacts on show are the history and development of Ipoh and the mining and forestry industry of Perak. Built more than a hundred years ago, the building has a colorful history. Among others it has been home to the Malay Chieftains of Kinta and the British rulers.

In this application field, virtual heritage is one way that VR can be applied. There are quite a few buildings that have been virtually-preserved, such as Virtual Notre Dame Cathedral. The main focused of this project is to develop architectural model of Darul Ridzuan Museum. This project will concentrate on designing exterior part of the building according to color digital photo taken. This virtual heritage reconstruction will be able to display architecture and artifacts same as the real one. Hence this is one of the challenges to be faced during the designing and developing phase.

1.2 Problem Statement

1.2.1 Problem Identification

There is no such a virtual heritage application in Malaysia develop a museum. Today's, when people want to see museum, they need to visit the museum. Unfortunately not all people are interested in visiting museum. People that usually go there are only school children and researchers who want to do some research on artifacts exhibited in the museum. Besides that, handicapped people have difficulties to explore museum and this limit their opportunity to see cultural heritage and acquire information. Therefore virtual reality technology is needed to create virtual heritage model which represents the museum that will be easily viewed by all especially handicapped people.

1.2.2 Significant of the Project

This project provides target user the opportunity to explore and feel the excitement of navigating through the Darul Ridzuan museum. This museum exists in a small virtual world, which the users "visit" from a desktop. It is also a new way to experience and explore virtual heritage model. The environment will be more interesting to explore without the feeling of boredom.

For this project, besides viewing the architecture, walkthroughs are generated for the user to control but in an easier way. Immersion can be achieved from this feature as the user get to feel the realism of the model.

1.3 Objective and Scope of Study

The aim of this project is to develop a virtual heritage for virtual museum model.

1.3.1 Objectives

The objectives of this project are:

- To develop the building in a 3D model.

This project is a new interpretation style using computer based technologies designed to give the citizens of Malaysia a better access and understanding of their heritage. It supports access for all citizens, and especially those with physical or mental disabilities.

- To preserve cultural heritage building.

This project is to present museum in the form of electronic media, in which it is a better method for current storage method. Parallel to the current technology, this project enables Darul Ridzuan Museum to be preserved virtually.

- To integrate collision detection.

Collision detection will be important in this project in order to get a believable and immersed virtual world. It would not be logical if the user uses the application and they go through walls as they walk around the museum.

- To create walkthrough for the user to navigate.

The user is able to interact in a virtual environment that works by the use of a mouse for navigation purpose. Walkthrough enable people to navigate around the museum in certain directions they desire.

1.3.2 Scope of Study

Scope of study for this project includes:

- Focus on architectural model of Darul Ridzuan Museum.
- To ensure realism of exterior design of the building.
- To ensure smoothness of the navigation.

1.4 The Relevancy of the Project

This project is relevant as virtual reality has been a method that proves to be beneficial in various fields for the recent years. Besides that, Virtual Reality is ideal in applications such as cultural heritage as this area shares a need for interactivity, realism, and user participation, relevant to this project.

There has always been a strong interest in using virtual reality for cultural heritage applications including education, entertainment, conservation and preservation. These indicate that virtual reality is a method that has been approved as beneficial in various fields.

Now, with the combination of virtual reality and cultural heritage, not only are new perspectives towards protecting international cultural heritage are being developed, but virtual heritage now immerses visitors directly into Malaysian world's past, encouraging exploration, discovery and interaction without fear of damaging the real thing.

1.5 Feasibility of the Project within the Scope and Time Frame

This project is targeted for the Malaysians, in which it can be used to provide knowledge for them and also to make them aware about one of cultural heritages in Malaysia .The scope is focus on modeling the museum through the implementation of virtual reality technology.

The time period given to complete this project is 14 weeks and it is feasible for this project as the work will only be focused on the modeling architecture of the museum.

CHAPTER 2

LITERATURE REVIEW

2.1 History of Virtual Reality

Virtual reality began popped into the headlines only in the past few years, but its roots reach back four decades. It was in the late 1950s, that an idea arose that would change the way people interacted with computers and make possible VR. At the time, computers were hulking Goliaths locked in air-conditioned rooms and used only by those conversant in esoteric programming languages. Few people considered them more than glorified adding machines.

Advanced Research Projects Agency Aircraft designers then began experimenting with ways for computers to graphically display, or model, air flow data. Computer experts began restructuring computers so they would display these models as well as compute them. The designers' work paved the way for scientific visualization, an advanced form of computer modeling that expresses multiple sets of data as images and simulations.

By 1970s, computer-generated graphics had replaced videos and models. These flight simulations were operating in real time, though the graphics were primitive. In 1979, the military experimented with head-mounted displays. These innovations were driven by the greater dangers associated with training on and flying the jet fighters that were being built in 1970s. By early 1980s, better software, hardware, and motion-control platforms enabled pilots to navigate through highly detailed virtual worlds.

By 1970s, some of Hollywood's most dazzling special effects were computer-generated, such as the battle scenes in the big-budget, blockbuster science fiction movie Star Wars, which was released in 1976. Later came such movies as Terminator and Jurassic Park. In the early 1980s, the video game business boomed.

Interactivity would have remained wishful thinking if not for the development of high-performance computers in the mid-1980s. These machines provided the speed and memory for programmers and scientists to begin developing advanced visualization software programs. By the end of 1980s, low-cost, high-resolution graphic workstations were linked to high-speed computers, which made visualization technology more accessible. All the basic elements of VR had existed since 1980, but it took high-performance computers, with their powerful image rendering capabilities, to make it work. Demand was rising for visualization environments to help scientists comprehend the vast amounts of data pouring out of their computers daily.

In 1992, the movie Lawnmower Man introduced the concept of virtual reality to the public. By the mid-1990s it was possible to reach out and touch virtual objects, to feel different textures and sensations; and perfume companies experimented with virtual smells to send odors electronically from lab to lab (A.Blattner, 1992).

2.2 Virtual Reality

Virtual reality means an interactive, self-directed, multisensory, computer-generated experience providing the illusion of participating in a synthetic 3-dimensional (3D) environment (A.Blattner, 1992). This means human can view and manipulate the contents of that environment which a person is immersed.

Several distinct types of virtual reality have now emerged such as artificial reality, augmented reality, immersive reality, telepresence, and CAVEs. All provide different degrees of immersion, interactivity, and unencumbered navigation (J.Isdale, 1993).

Virtual reality, Java, and the Internet make all that possible right now. We can re-create ancient built environments, and within them we can re-place the artifacts as they were found and link to those objects texts, photographs, and narrations to provide the virtual visitor with information tailored to specific grade levels or curriculum guidelines. Picture the new learning tool that results the virtual world itself becomes the visual index to an entire dataset. Should an instructor or student desire information about any subject, object, or space, just walk up to that item and click on it to retrieve links to the photographic archive or written descriptions about that item and associated items at the site.

View maps, plans, early travelers' drawings, previous excavators' notebooks, or museum records, all with a click of the mouse. Interactive inquiry need not proceed in the mostly linear fashion of standard books, educational materials need not be limited by the cost of printing color plates, searches need not be restricted to words alone, since links can be made to and from 3D objects or pictures or virtual locations. Add to that the capability of listening as an expert explains about the building's spatial organization, function, or date.

Three-dimensional, interactive, archaeological digital databases, if accessed using virtual reality, thus become dynamic media re-creating an ancient world in its original complexity creating a near firsthand experience. Data about a site that has become globally distributed can be brought back into a single virtual environment allowing students and teachers to view the objects in their original architectural context for the first time since antiquity. This is an unprecedented educational opportunity.

2.3 Virtual Heritage & Virtual Building

Virtual heritage (VH) is the use of electronic media to recreate, or interpret, culture and cultural artifacts as they are today or as they might have been in the past (J.Jacobson et al., 2004). By definition, VH applications employ some kind of three dimensional representations and the means used to display it range from still photos to immersive virtual reality. This is a very active area of research and development and most of it is intended for some kind of educational use.

Virtual heritage applications use the immersive and interactive qualities of VR to give students or museum visitors access to computer reconstructions of historical sites that would normally be inaccessible, due to location or fragile condition. They also provide the possibility of visiting places that no longer exist at all, or of viewing the how the places would have appeared at different times in history (B.Carter et al., 2001).

The majority of VH applications are architectural reconstructions, centered on a reconstructed building or monument. To the educator, a VR model can be an efficient means of communicating a large amount of information because it leverages the user's natural spatial perception abilities. This is especially important with architectural spaces that are “well-integrated” in the sense that information is encoded in the way the space looks to an observer.

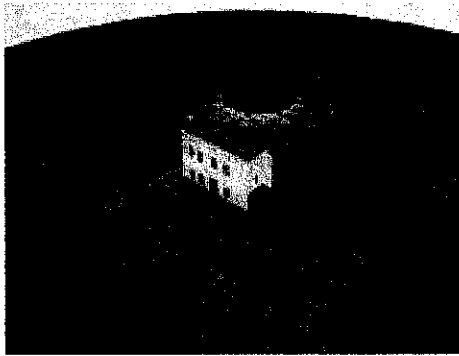


Figure 2.1: S.Sergius & Bacchus Byzantine Church

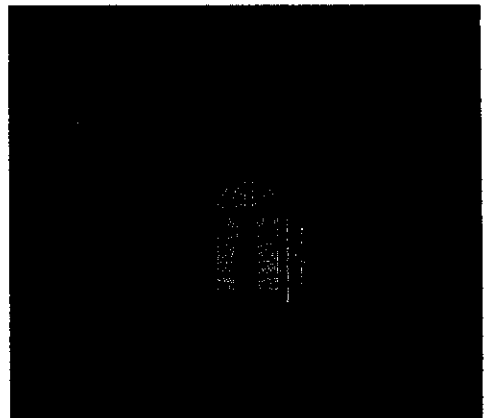
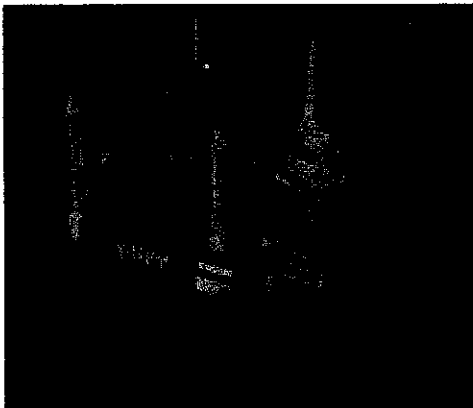


Figure 2.2: Hagia Sophia Ottoman Mosque

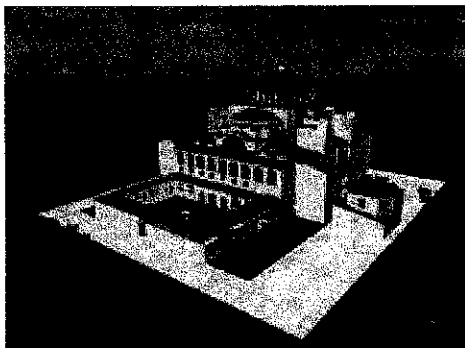


Figure 2.3: Hagia Sophia Byzantine Church

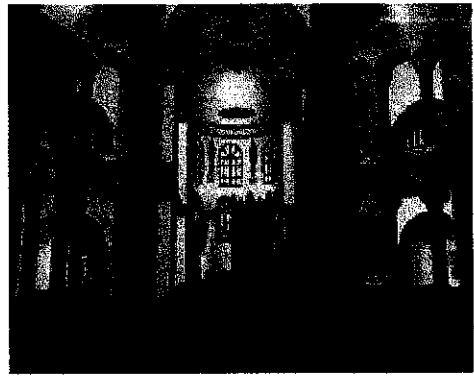
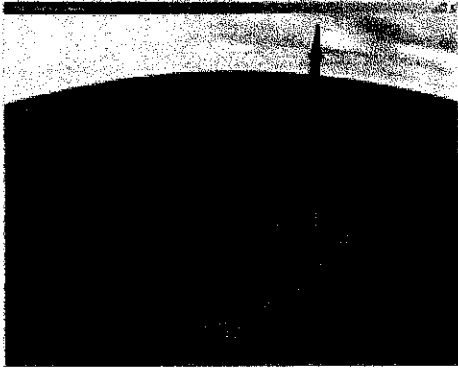


Figure 2.4: S.Sergius & Bacchus Ottoman Mosque

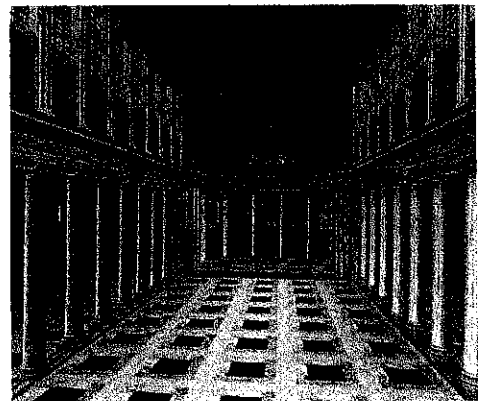
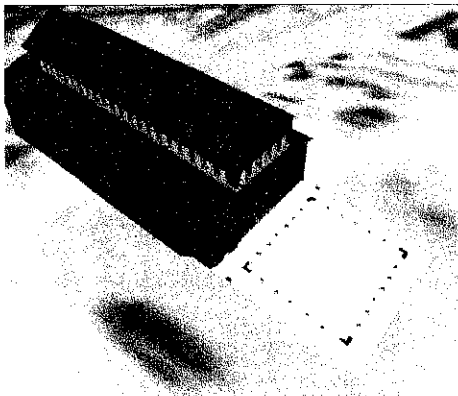


Figure 2.5: Basilica of Santa Maria Maggiore

2.3.1 Virtual Notre Dame

One of the most well known high quality virtual reconstructions and architectural walkthroughs is the one created for the Virtual Notre Dame Project, from Digital Studios (V.DeLeon, 2000). This project focused on an accurate reconstruction of the cathedral in as much detail as possible. They introduced photo-realistic real-time technology in the area of virtual heritage on desktop computers. Their technique deals with presenting a complex environment comprised of textured polygons. For the overall development of the real-time experience, Epic's Unreal commercial 3D game engine was used allowing for high-end visual effects, high performance frame rate and interactivity, showing lighting, shadows and all the texture properties on the fly.



Figure 2.6: Virtual Notre-Dame Cathedral Project

2.3.2 The Siena Cathedral

Similar to Virtual Notre Dame project, there was another previous work of the Siena Cathedral simulation, in which it is an immersive virtual environment. It allows visitors to actually explore the site besides to experience its architecture and to obtain information on its architecture, culture and history.

The Siena Cathedral simulation is an immersive virtual environment that allows the visitors to virtually explore the site, to experience its architecture, dimensions, and atmosphere, and to obtain architectural, cultural, and historical information. A virtual guide, in traditional clothes, talks to the visitor giving explanations about the Cathedral. The presentation is done in real-time on a stereoscopic large-screen projection. In order to achieve a high degree of immersion, the visual representation is complemented by sounds and background music (E.Foni et al., 2003).



Figure 2.7: The virtual tour guide inside the Siena Cathedral

2.4 Virtual Museum

A virtual museum is a collection of electronic artifacts and information resources- virtually anything which can be digitized. The collection may include paintings, drawings, photographs, diagrams, graphs, recordings, video segments, newspaper articles, transcript of interviews, numerical databases and a host of other items which may be saved on the virtual museum's file server. It may also offer pointers to great resources around the world relevant to the museum's main focus (J.McKenzie, 1995).

The first thing that people may think of when they hear the phrase virtual museum is perhaps a collection of pictures of items, usually paintings or drawings, from a real life museum, placed on the world wide web for viewing. This is certainly a big part of what is included in the virtual museum concept, but the author found through his exploration of this topic that the definition of virtual museum is being stretched to include things beyond what we think of a museum.

There are many sites with representative samples of pieces from the collection of real physical museums, as well as sites which archive various pieces of real art as a museum collection, but which do not correspond to any real, physical location or collection. There are also sites which host collection of work by one artist, and sites which display only a particular exhibit from a real collection as well as some which are combination of these types, even less traditional and perhaps more interesting, are those sites which are combining elements of multimedia to create interactive electronic exhibits, on the order of a hands of exhibit in a real museum. There are also some sites, which are billing themselves a museum, which do not actually bear any resemblance to what we know as a museum.

2.4.1 Advantages of Using the Virtual Museum

While many developers develop their own Virtual Museum, there must be the advantages of building virtual museum compare to the physical museum. The advantages of using the Virtual Museum are (M.Saifudin, 2002):

1. Timeless environment.

The virtual museum provides the visitor a timeless environment. It means that visitor can take their time exploring the museum. The physically museum normally operated based on time. Therefore, some visitors may not be able to explore more and they had to come repeatedly. With the development of virtual museum, visitor can visit the museum at own preferred time and explore through the museum based on what they interested. It will make visitors more understand about the exhibition and gain more knowledge.

2. Keep the maintaining process of the items at the minimum level.

With the development of virtual museum, the items need to be in digital format and store it into the server or hardisk. This will reduce the maintaining time, place and process. The exhibitor only had to maintain the stored data. In the real museum, the cost of maintaining the object is expensive. The exhibitor must be careful when cleaning the item especially an ancient item. While in digital form, the item does not have to be clean.

3. Promote the actual/ physical museum inside and outside the country.

Realize or not, the virtual museum can be cooperating with the physical museum in order to promote the real museum inside or out side country. It is because some people like to see original item instead viewing form the virtual museum. With the development of virtual museum with cooperated with physical museum, visitors will get an abstract idea on what knowledge they can acquire when visiting the real museum.

4. Reduce time and cost.

The development of virtual museum will reduce cost and time. It is because with the building of virtual museum, the exhibitor does not have to find a suitable place to build a museum. The time taken in building a museum can be more than one year and the cost is more than hundred thousand. If the exhibitor wants to display their own private art or collection, they will not be able to do so because they need a large cost and more time. However with the development of virtual museum, they will be able to show or exhibit their own collection or an art in a matter of week.

2.4.2 Online Museum Available

There are many online virtual museums that available through the internet. There are some of them that available today.

1. Cyberspace Museum of Natural History & Exploration Technology

Website: <http://www.cyberspacemuseum.com>

Description: This museum categorized as an education museum. The purpose of this online museum is to provide access to the knowledge of the wonder of the universe and the human efforts to explore it. The museum provides a collection of a variety of in depth about science and technology topics, which range from dinosaurs and spacecraft. This museum was dividing into 5 sections. Exhibit Hall, Paleontology Places, Space Places, Sciencescan Update and Museum Bookstore. This museum used a simple html document with the link and many images in develop the museum.

2. Virtual Tour of Galileo's Room

Website: <http://www.imss.fi.it/vr/eavv.htm>

Description: This museum is developing by Institute and Museum of the History of Science, Florence Italy. This is actually the view of the Galileo's room and the object in this room. This museum uses the 360-degree Quicktime technology, which enable visitor to turn around to see the room. The visitors also can zoom in order to see an object with this technology.

3. Virtual Museum of Olympic Games

Website: http://www.olympic.org/uk/passion/museum/virtual/garden_uk.asp

Description: This museum is actually incorporate with the Olympic Games. The developer of this museum is Business Interactive. The museum is located in UK. This museum used the Quictime technology, combine website design in order to bring the interaction. Enable visitor to look the surrounding of the Olympic museum as well as what they can see in the museum.

4. VR Notre Dame

Website: <http://www.vrndproject.com/>

Description: Virtual Reality of Notre Dame (VRND) is actually an application that already been developed by VRND Project Team. The purpose is to embark on a monument endeavor in the real-time architectural reconstruction and cultural/world heritage preservation. The design of this application is 90% architecturally accurate, real-time 3d reconstruction and virtual reality model of the interior of the Notre-Dame Cathedral of Paris is almost impossible to imagine at least without a room of high-powered graphics supercomputers. This application used the unreal engine and it shows what low-end 3D engine can do. These efforts have been continuing at tireless pace yielding dozens of published papers and demonstrations at VR and 3D conferences across the globe. The VRND Project Demo already been exhibited at several major conferences worldwide including VSMM99, ICAT, IEEE, E3 and SIGGRAPH.

2.5 Modeling

There are several types of modeling techniques, which are Polygonal modeling, Patch modeling, NURBS modeling. Each of modeling techniques has their strengths and weaknesses. Just choose the right modeling type to use. The right tool for the right job still holds true in digital 3D world. (T.Boardman and J.Hubbell, 2002)

2.5.1 Primitives modeling

The basic method, in which one models something using only boxes, spheres, cones, cylinders and other predefined objects. One can also subtract, cut, and connect primitives together. For example, one can make two spheres which will work as blobs that will connect with each other. This is called blob-mesh modeling or balloon modeling.

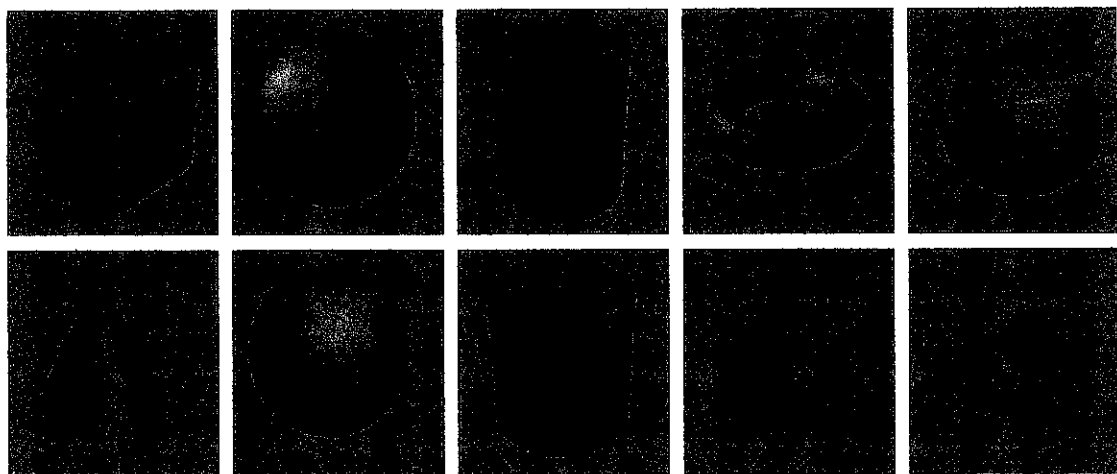


Figure 2.8: The Standard Primitives: Box, Sphere, Cylinder, Torus, Teapot, Cone, GeoSphere, Tube, Pyramid, and Plane

2.5.2 Polygonal modeling

It excels at low detail or architectural model. Because polygonal models are made up of faces, they're very easy to edit and animate when working on a relatively low-detail model. Usually, the modeller begins with a primitive, and using such tools as bevel, extrude, and polygon cut, adds detail to and refines the model. This technique is most often used for game design, as the very specific control over individual polygons allows for extreme optimization.

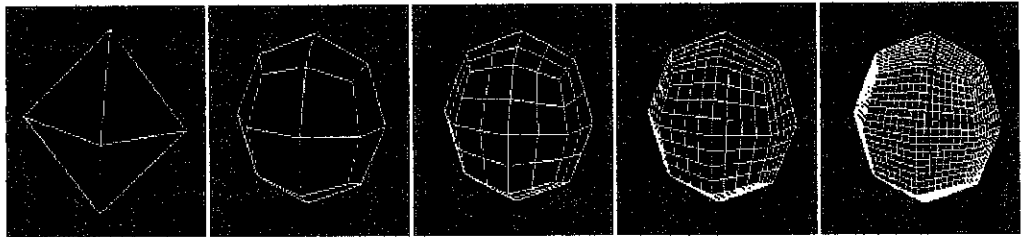


Figure 2.9: Using MSmooth reduces the sharp edges, and tessellating adds more editable faces.

2.5.3 Patch modeling

Patches are a modeling type that exists somewhere between polygon meshes and NURBS. They are essentially polygon surfaces stretched along a closed spline. Modifying the spline alters the surface of the patch. This technique suitable for smooth models that are built from the foundation outward. It works by attaching small grids, called patches, which are based on Bezier-spline technology. This provides for smooth surfaces with relatively low detail geometry in the viewports.

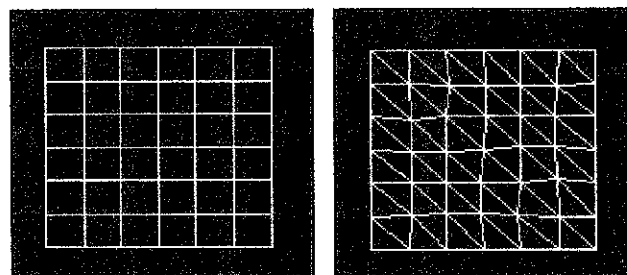


Figure 2.10: A Quad Patch and a Tri Patch

2.5.4 NURBS modeling

Works best for complex, smooth, or organic surfaces. Because NURBS models are just smooth as patches, they work well for complex models. Unlike patches, NURBS surfaces can be built from defining curves that allow construction of surfaces based on simple objects instead of simple patches. They are the ideal modeling tool for creating organic characters because they are easy to work with, they give good interactive control, they blend together seamlessly, and the surfaces remain smooth even when distorted.

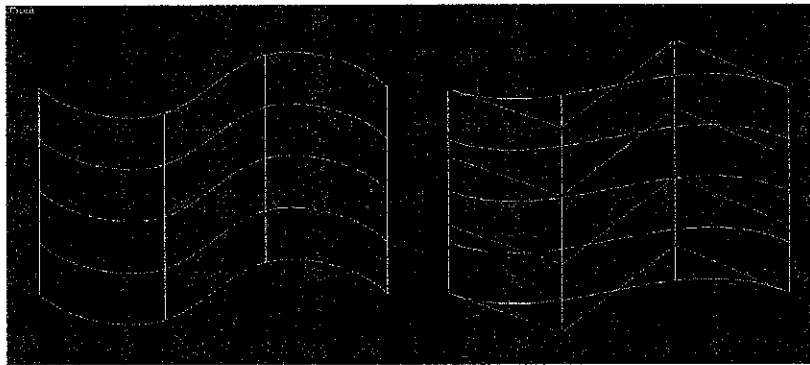


Figure 2.11: NURBS surfaces also come in two different types: point and CV surfaces.

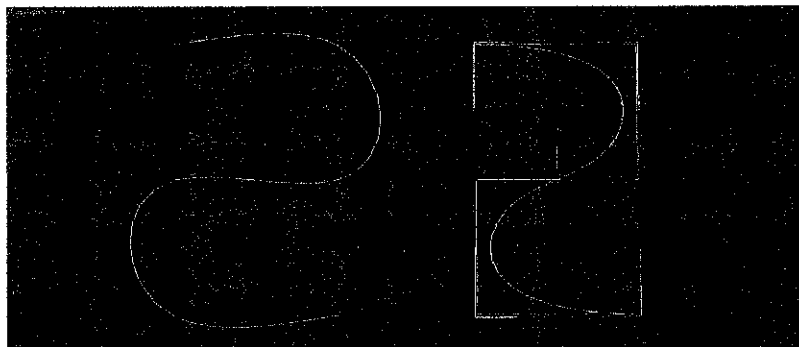


Figure 2.12: NURBS curves come in two different types: point and CV curves.

2.6 Texturing

Texturing is a process that takes a surface and modifies its appearance at each location using some image, function, or other dataset. Huge modeling, memory, and speed savings are obtained by combining images and surfaces in this way. Color image texturing also provides a way to use photographic images and animations on surfaces (P.Malhotra, 2002).

Texture mapping is one of the most successful new techniques in high quality image synthesis. Its use can enhance the visual richness of raster scan images immensely while entailing only a relatively small increase in computation. The technique has been applied to a number of surface attributes: surface color, surface normal, specularity, transparency, illumination, and surface displacement, to name a few. Although the list is potentially endless, the techniques of texture mapping are essentially the same in all cases.

Texture is a good method in reducing the complexity in virtual environment and it is beneficial method to be learned. Texture mapping is a relatively efficient means to create the appearance of complexity without the tedium of modeling and rendering every 3-D detail of a surface. The study of texture mapping is valuable because its methods are applicable throughout computer graphics and image processing (P.Heckbert, 1993).

At the moment, the general benefit provided by the application of texture mapping is to add realism or reduce geometric complexity. The object material can be shown by wrapping a wood grain pattern around a rectangular solid to create a block of wood. By mapping an image of a house onto a few polygons, instead of drawing a large number of polygons to represent the house, the complexity is reduced.

2.6.1 Texture Mapping Process

The mapping from texture space to screen space is split into two phases, first is the surface parameterization that maps texture space to object space, followed by the standard modeling and viewing transformations that map object space to screen space, typically with a perspective projection. These two mappings are composed to find the overall 2-D texture space to 2-D screen space mapping, and the intermediate 3-D space is often forgotten. This simplification suggests texture mapping's close ties with image warping and geometric distortion.

There are three general approaches to drawing a texture mapped surface: a scan in screen space, a scan in texture space, and two-pass methods (S.Heckbert, 1986).

a) Screen Order

Screen order sometimes called inverse mapping, is the most common method. For each pixel in screen space, the pre-image of the pixel in texture space is found and this area is filtered. This method is preferable when the screen must be written sequentially (e.g. when output is going to a film recorder), the mapping is readily invertible, and the texture is random access. The algorithm is highlighted below:

SCREEN SCANNING

```
for y
  for x
    compute  $u(x,y)$  and  $v(x,y)$ 
    copy  $TEX[u,v]$  to  $SCR[x,y]$ 
```

Where TEX is the texture array and SCR is the screen array.

b) Texture Order

Texture order may seem simpler than screen order, since inverting the mapping is unnecessary in this case, but doing texture order correctly requires subtlety.

Unfortunately, uniform sampling of texture space does not guarantee uniform sampling of screen space except for affine (linear) mappings. Thus, for non-affine mappings texture subdivision must often be done adaptively; otherwise, holes or overlaps will result in screen space. Scanning the texture is preferable when the texture to screen mapping is difficult to invert, or when the texture image must be read sequentially (for example, from tape) and will not fit in random access memory. The algorithm is highlighted below:

TEXTURE SCANNING

```
    for v
      for u
        compute  $x(u,v)$  and  $y(u,v)$ 
        copy  $TEX[u,v]$  to  $SCR[x,y]$ 
```

c) Two-pass methods

Two-pass methods decompose a 2-D mapping into two 1-D mappings, the first pass applied to the rows of an image and the second pass applied to the columns (E.Catmull et al., 1980).

These methods work particularly well for affine and perspective mappings, where the warps for each pass are linear or rational linear functions. Because the mapping and filter are 1-D they are amenable to stream processing techniques such as pipelining. Two-pass methods are preferable when the source image cannot be accessed randomly but it has rapid row and column access, and a buffer for the intermediate image is available. The algorithm is highlighted below:

TWO-PASS

```
for v
  for u
    compute x(u,v)
    copy TEX[u,v] to TEMP[x,y]
for x
  for v
    compute y(x,v)
    copy TEMP[x,v] to SCR[x,y]
```

Where TEX is the texture array, SCR is the screen array, and TEMP is a temporary array.

2.7 Walkthrough

Walkthrough is another feature that is included in this project. Walkthrough is known as the technique which involves building scenes using geometric objects and enabling users to navigate between the objects. This technique enables the user to get the feel of the environment and to explore the design of the mosque as a whole, both interior and exterior(B.Giddings et. al, 2002).

The existing walkthrough techniques can be divided into roughly two categories (T.Igarashi et al., 2000) One is *driving*, where the user continuously changes the camera position using advancing and turning buttons (arrow keys, joysticks, or button widgets on the screen). The other is *flying*, where the camera automatically jumps to the goal position that the user had specified using a pointing device automatically calculates the moving path in the 3D world by projecting the stroke onto the walking surface, and presents the movement of the avatar and the camera in an animated manner. The avatar's direction is fixed to the tangent of the projected stroke. The user can draw a new stroke during the movement to modify the path, which is important because the far end of a stroke can easily get out of control (T.Igarashi et al., 2000).

There is a technique for 3D walkthrough called Path Drawing. It is an extension of the flying technique. It allows the user to draw the desired walkthrough path directly on the screen using a free stroke. This technique can ease the user in navigating through the 3D environment.

Another technique is to design a walkthrough that have a shorter refresh rates, mostly for interactive walkthroughs of very large architectural models. The researchers find that realistic-looking building models with furniture may consists of huge amount of polygons, resulting in usage of gigabytes of data. The walkthrough will have some part of it visible and other parts invisible; some objects appear larger and some smaller to the observer. To get a reduced amount of data rendered in each frame, they found out two techniques, which are (T.Funkhouser et al., 2000):

2.7.1 Visibility Analysis

To compute the subset of objects, which are visible to the observer using the real-time visibility analysis based on the results of the precomputation phase. (Precomputation phase is the second phase involved in the particular project. The first phase is the modeling phase and the third phase is the walkthrough phase.)

2.7.2 Object Hierarchy

To choose an appropriate level of detail at which to render each visible object from the object hierarchy constructed during the modeling phase.

2.8 Collision Detection

Virtual Reality (VR) refers to the use of computers to simulate a physical environment in such a way that humans can readily visualize, explore, and interact with the "objects" in the environment. Since physical environments are inherently geometric, many of the computational problems involved in designing and building a VR system are geometric in nature. One particularly important problem that must be addressed in order to make VR a reality is the problem of real-time interactive collision detection (CD): Determine if two virtual objects intersect each other.

Collision detection is essential for many applications involving simulation, behavior and animation. However, it has been regarded as a computationally demanding task and is often treated as an advanced feature.

There are two classifications of collision detection which includes (G.Burdea et al., 2003):

2.8.1 Approximate or bounding-box collision detection

A bounding box is a prism which encloses all the vertices of a given 3D object. Bounding-box collision detection is to test whether two (or more) bounding boxes collide with each other in 3D space.

There are two classifications bounding boxes, which are explained as following:

a) Oriented bounding boxes (OBB)

It is a prism, which is aligned with the object's major axes, and which changes the orientation dynamically as the object rotates. OBB is more accurate compared to AABB as OBBs are a tighter fit to the objects they enclose.

b) Axis-aligned bounding boxes (AABB)

It is a bounding box which is aligned with the world systems of coordinates. A special case of AABB is a fixed-size cube. It can not only accommodate any orientation of the 3D object it encloses, but also are computationally faster than the variable-size bounding boxes, and also compared to OBB. However, it also has its own drawback, in which it tends to be larger than the variable-size ones.

2.8.2 Exact collision detection

Exact collision detection algorithm's performance is usually degraded in amount to the complexity of the virtual scene. There was a fast algorithm which has almost constant performance against the number of object vertices. The algorithm developed uses local features (such as vertices, edges or facets) of convex polyhedra, which is also extendable to concave ones.

2.9 Techniques and Softwares used

The modeling of the museum is conducted for the interior and the exterior of the building. For the 3 D architectural point of view Polygonal modeling techniques are mainly used in order to achieve:

- a) The best trade-off ratio between the precision of the 3D representation of the model
- b) The maximum amount of displayable polygons for a real time platform at an acceptable frame rate.

To best achieve this goal, 3D Studio MAX 5 software package is chosen due to its flexibility in polygonal mesh editing, and for its features regarding VRML exporting capabilities.

For the walkthrough, VRML is selected for the conduction of the walkthrough. It is because VRML have the great advantages which are: the sense of "being there" - of being able to move in and around the building or site; the user is in control, and can manipulate the software at a convenient speed and in desired directions; and additional "hooks" provide a multi-layered, potentially rich learning environment.

For texturing, it is done by editing the textures collected through various sources, and by editing them using Adobe Photoshop 6. The texture-mapping process is completed by mapping it on different sides of the geometry shape in order to get the desired design. This can be done through:

- a) The node `TextureCoordinate`, in which one can map the texture according to desired coordinates to form intended tiles on the shape.
- b) `TextureTransform` node on the other hand allows one to create a repeating, rotated or translated texture according to ones liking.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This section of the report describes the methodology that has been developed which contains the process involved from the very beginning of the project until the end of four months period. The following is the methodology for this project, which includes three main stages. The initial stage is to do Research and Analysis, followed by Design and Development. The final stage is Evaluation stage. By using this methodology, developer can go back at the previous stage whenever needed. Especially, when in the phase need to make a modification or changes, so this needs to look at the previous phase.

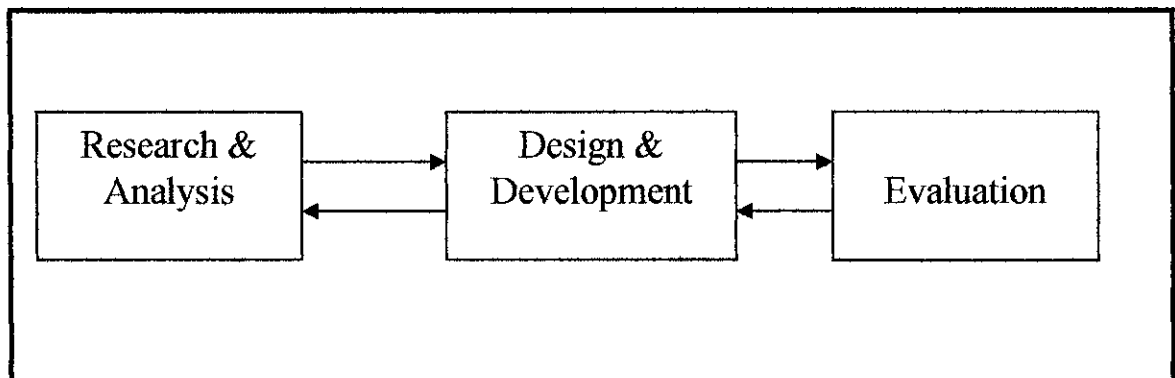


Figure 3.1: Methodology Framework

3.2 Research and Analysis

3.2.1 Research

The first stage in initiating this project is to do research and analysis about the project title. This phase is important as the initial stage of the project. The flow of this project is being planned for make sure it runs smoothly. Discussions with the supervisor are needed and necessary as part of the research and analysis stage, in which requirements of the project are pointed out.

In this stage the research information about the project is gathered from the journal, books and website Besides that, research is carried out by referring to senior's dissertations in obtaining relevant information. Through these studies the ideas and overview regarding the project requirements become clear. The main objective of the project are also being studied and explored, whereby in this case possible existing techniques of modeling are searched and studied. Techniques of modeling are found, such as Polygonal Modeling, NURMS Modeling, NURBS Modeling, and Patch Modeling. Apart from that, the appropriate 3D softwares are also found such as 3D Studio Max, 3D State and VRML.

3.2.2 Analysis

Analysis is done to keep necessary information relevant to achieve the objectives of the project. The suitable software to develop virtual museum is 3D Studio Max. 3D Studio Max is powerful software for 3D Modeling, Texturing and Rendering. There are many kinds of techniques found through the research; the useful technique is being chosen. The techniques are Polygonal Modeling. During this stage preliminary report and literature review document is prepared that gives an idea about virtual heritage and techniques of modeling.

3.3 Design and Development

During the design and development stage, Darul Ridzuan Museum is modeled. This stage is the most time consuming as it involves a learning process and understanding of each technique applied in modeling. Modeling is done based on digital-photos taken by author when she visited the museum. 3D Studio Max 5 is used to model the object and the surrounding environment. Basically, the museum is built parts by parts, starting from the walls, to the roofs till the surrounding environments.

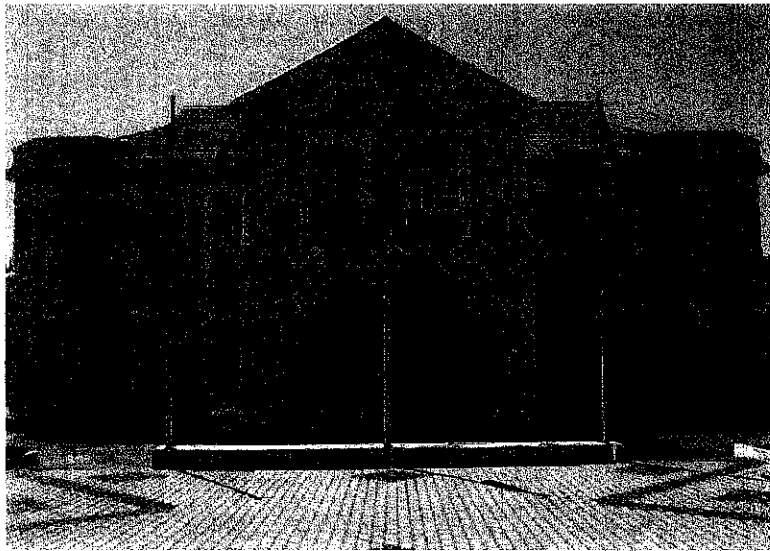


Figure 3.2: Photo Image of Darul Ridzuan Museum

3.3.1 Build the walls

Design and development stage starts with creating the wall. Start with a box. Most of the complicated object designed in 3D Studio Max starts with standard primitives shape such as box, sphere, cylinder, and so on.

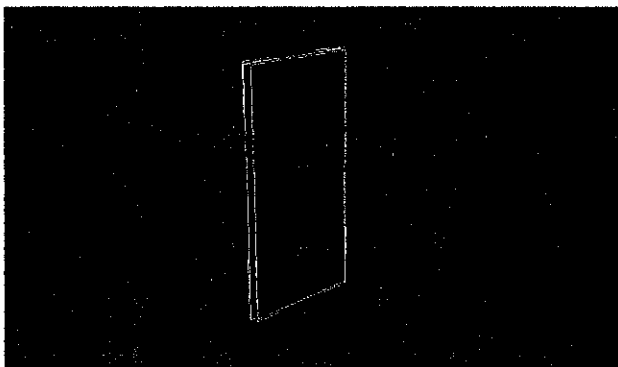


Figure 3.3: Box as a starter

Wall is developed block by block which means wall is modeled as several separated boxes and will be joined together to create the wall of the museum. The main reason of creating the wall part by part is to ease the creation of internal design later on.

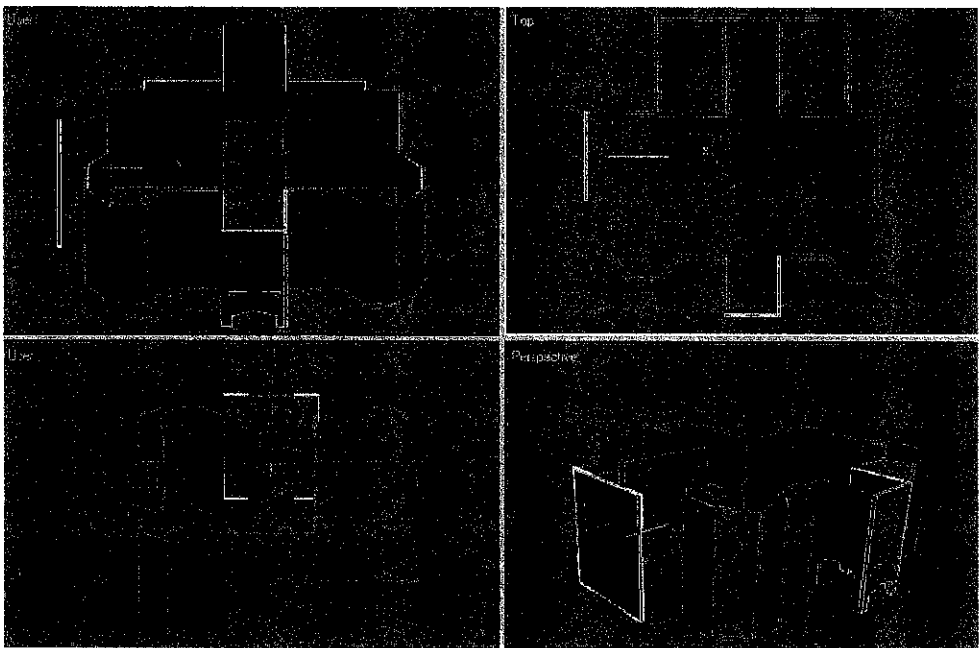


Figure 3.4: Development of the wall part by part.

3.3.2 Develop the roofs

Once finish with developing the walls, the next task is to develop the roofs. Similar to the wall, box is used to create the roofs. Then the width segment value of the box is set to 2. This adds more faces to the 'Roof' object.

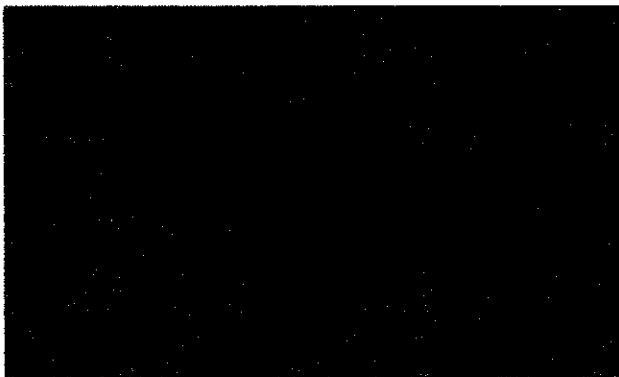


Figure 3.5: Box as a starter

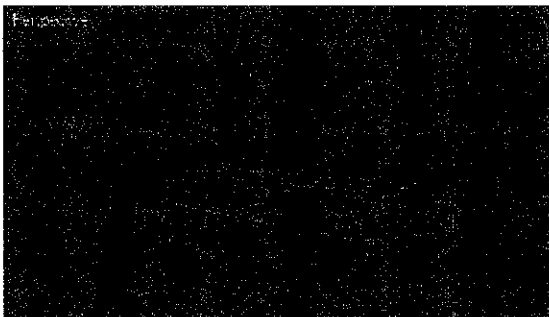


Figure 3.6: The width segment value of the box is set to 2

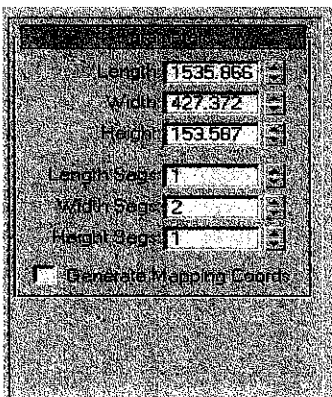


Figure 3.7: Segment parameter

The object is then converted to Editable Mesh to design the box into a desired roof shape. When the Vertex subobject mode is selected for an object, all vertices for the selected object appear as blue plus signs. Select and Move button on the main toolbar is chose to move one of the vertices away from the other in order to design roof shape.

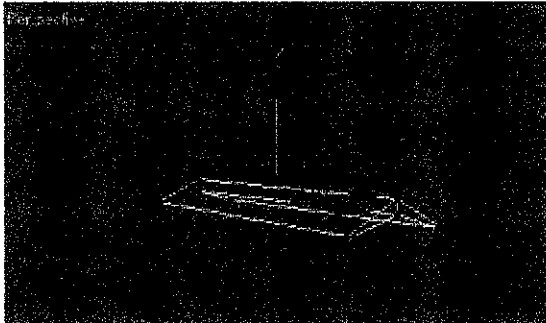


Figure 3.8: The Vertex Ticks option displays all vertices as small blue tick marks and red tick marks as selected vertices.

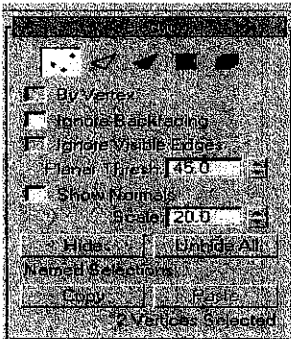


Figure 3.9: Edit mesh parameter

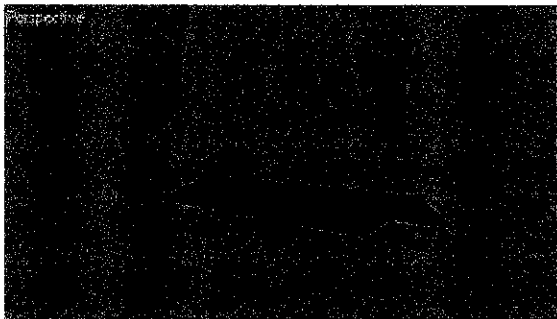


Figure 3.10: Completed Roof Shape

3.3.3 Create the windows

Box shape is used for creating the window. To create several boxes with similar width, length and height, a box with specified parameters is cloned to produce several boxes. By using select and move button, those boxes are arranged in sequence in order to create the shape of a window.

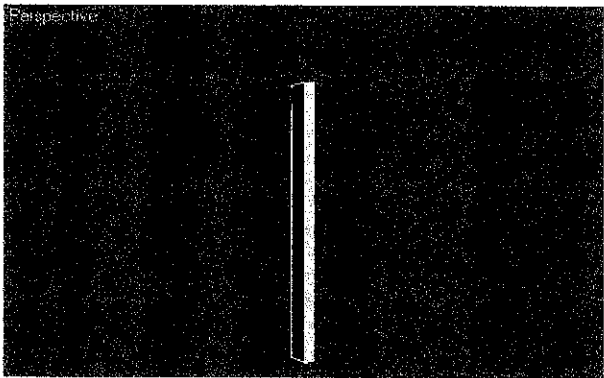


Figure 3.11: Thin Box as a starter

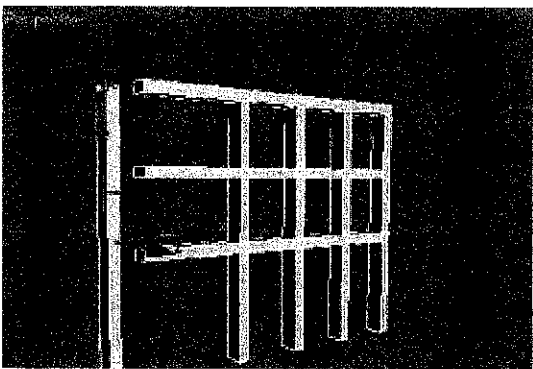


Figure 3.12: Arrange boxes to create window shape

There are 2 types of window created for this museum. The difference between these two windows is in term of their length. Windows at the ground floor are longer compared to the upper floor.

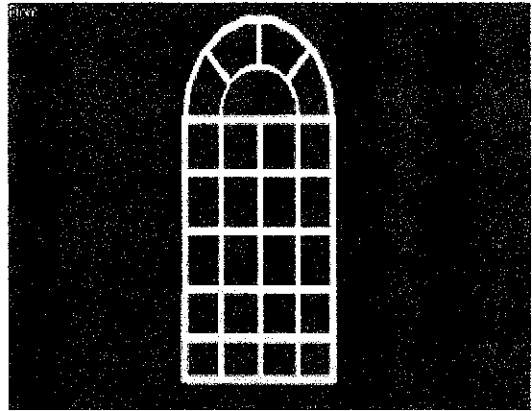
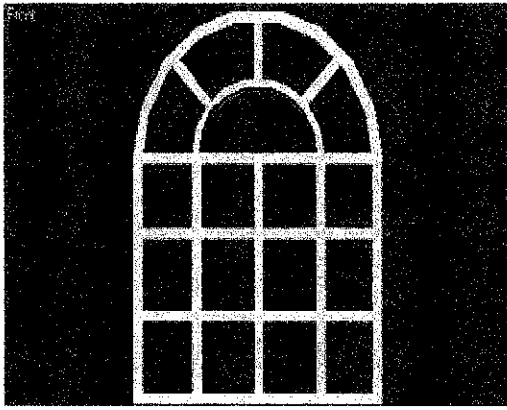


Figure 3.13 (a): Window at ground floor Figure 3.13 (b): Window at first floor

Once finish with designing the shapes of the windows, the next task is to create the window's frame. Similar to the window, box shape is used to create the window's frame. There are 5 kinds of window's frame that need to be created. Window's frames need to be designed differently because each of these window's frames has unique characteristics, which distinguish them from the others.

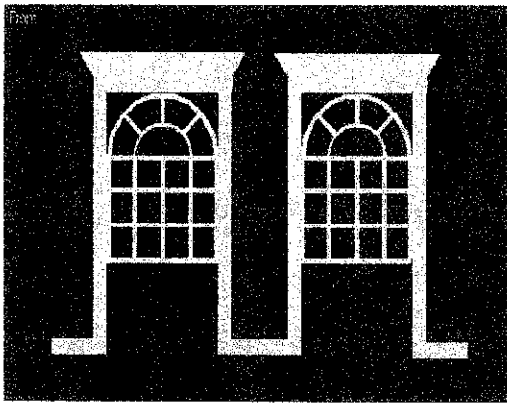


Figure 3.14 (a): First frame

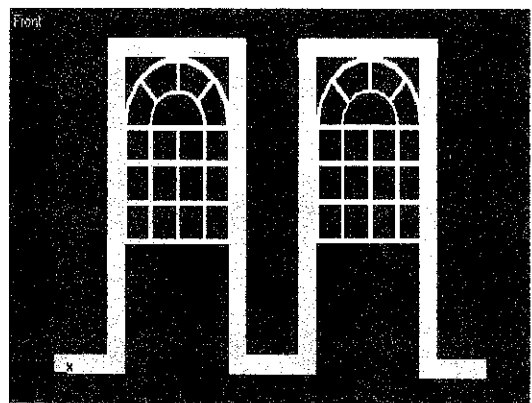


Figure 3.14 (b): Second frame

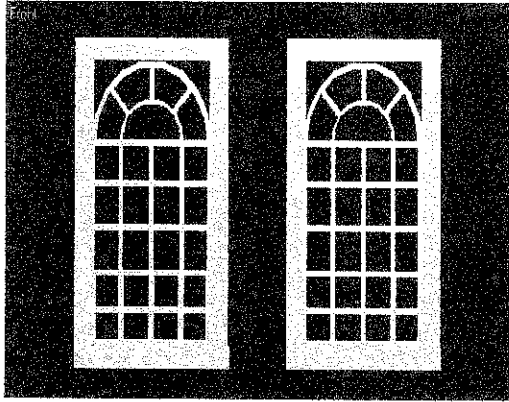


Figure 3.14 (c): Third frame

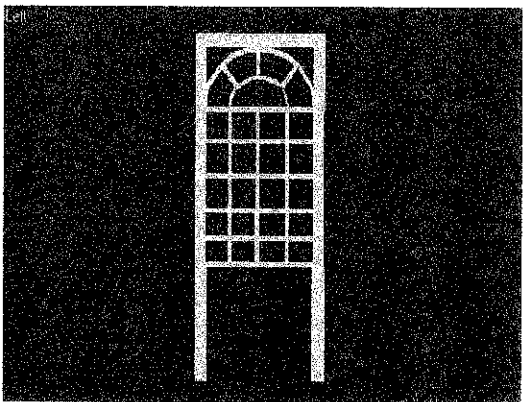


Figure 3.14 (d): Fourth frame

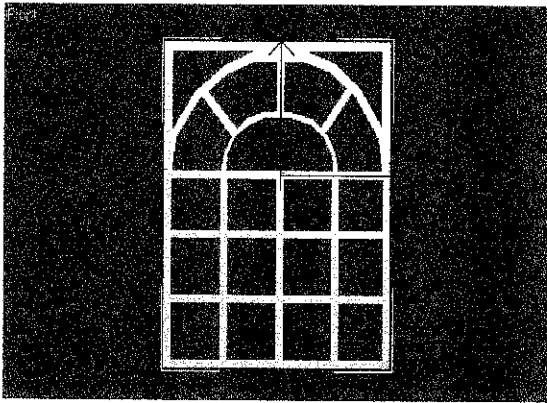


Figure 3.14 (e): Fifth frame

Figure 3.15 show the wall does not have holes for the glass window. So, in this case, Boolean Operation is used which is the Subtraction. A box with the size of the hole is created. Then, the blue box is positioned overlapped the desired point. The result of the operation is shown in Figure 3.18, whereby the blue box is subtracted from the wall. It is quite a simple method yet a lot of work and concentration need to be done.

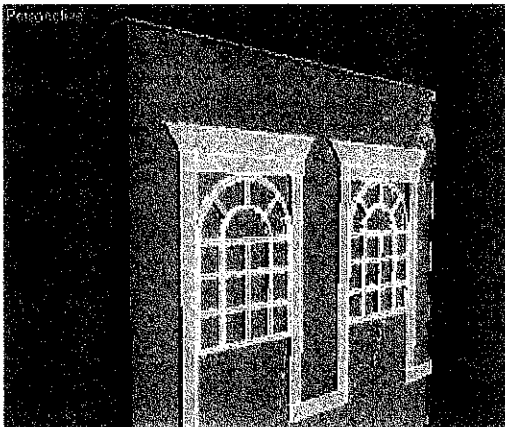


Figure 3.15: Wall with no hole for glass window

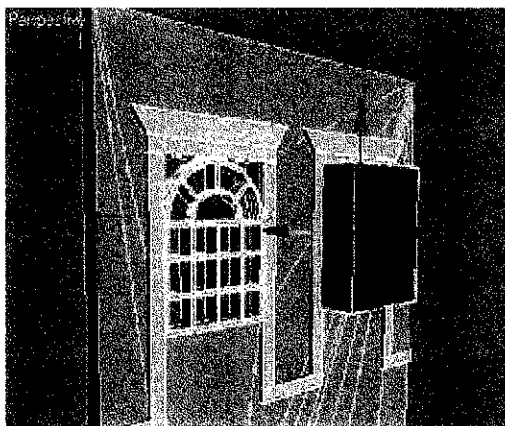


Figure 3.16: A blue box is positioned on the place that needs to be taken out

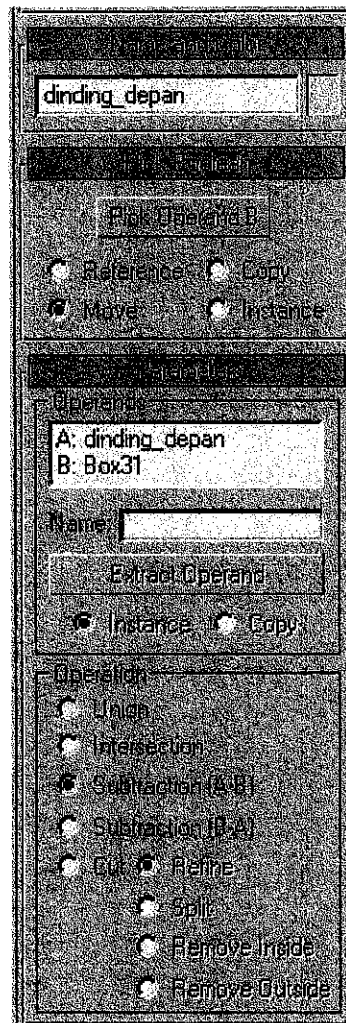


Figure 3.17: Boolean Operation option

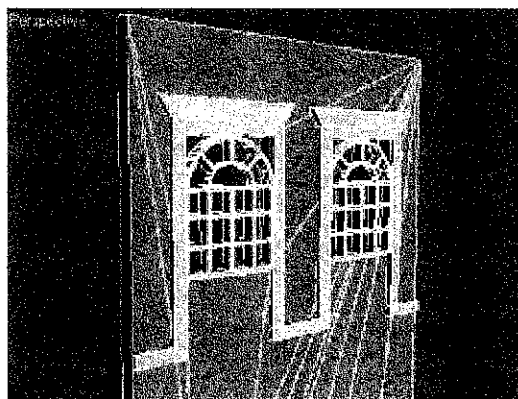


Figure 3.18: Result after Boolean Operation (subtraction) is enabled

3.3.4 Develop the columns

Box shape is used to develop the columns. This process starts with 2 boxes that have the same parameters. One box is positioned on top of the other box and it is rotated 90 degrees.

Rotation enables a shape to be rotated about the origin of a coordinate system or about a center point specified by using Transform grouping node and its rotation and center field. Figure shows how the box is rotated in 3D Studio Max. The rotation is done in the Top viewport, 90 degrees about its Z-axis.

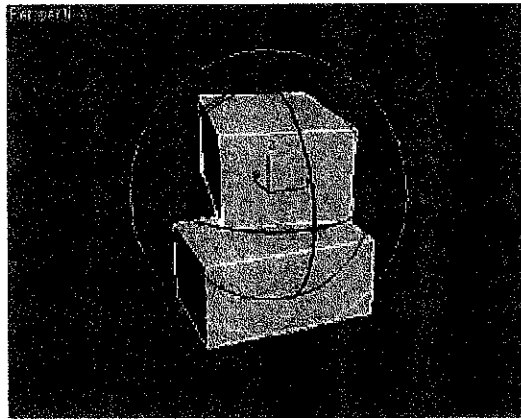


Figure 3.19: The box (top) is rotated 90 degrees

Once finish with rotating the box, the next task is to translate it overlapping into the other box. Translation is to position shapes anywhere in the virtual world. This is done using the Transform grouping node and its translation field, indicating the x, y, and z value.

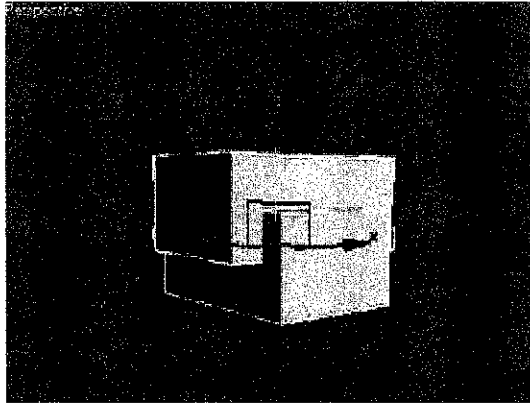


Figure 3.20: The box (top) is translated overlapping into the box (bottom)

Once the translation process finished, the shape is cloned to produce more similar shapes. Those cloned shapes then are positioned on top of each other in order to produce a column.

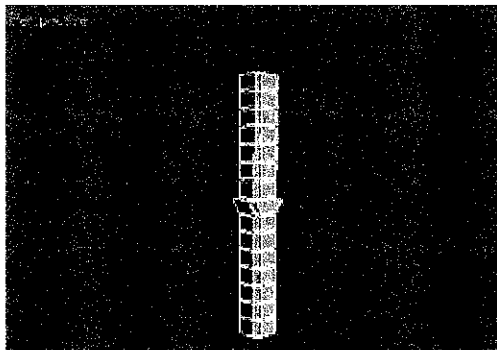


Figure 3.21: Completed column shape

3.3.5 Create the signboard

As for the signboard, it is created to be placed on the front wall of the museum. For this signboard, two basic box shapes are used. The first box shape is in black and the second one is in white. The size of the white box is slightly smaller than the black box and it is positioned overlapped the black box. In order to create the museum's name, text option is used. Then, the text is extruded to get the desired depth. Finally, the museum's name is mapped onto the boxes.

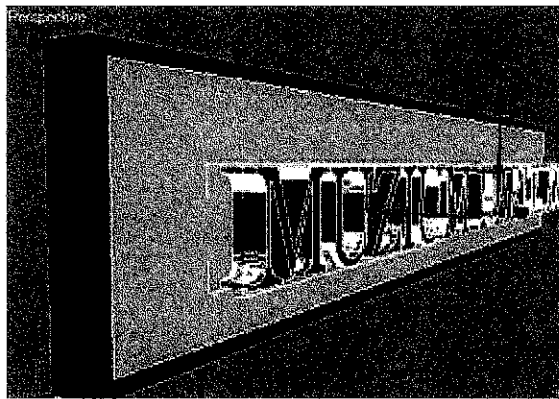


Figure 3.22: Map museum's name onto the box



Figure 3.23: Museum's signboard

3.3.6 Create the Artistic Features

Once finish with modeling the main building, the next task is more complicated and time consuming which is modeling the Artistic Features of the detail structure design. These objects were developed by using several operations and techniques that is available in 3D Studio Max such as Boolean Operation, Edit Mesh technique, Extrusion concept and Clone concept.

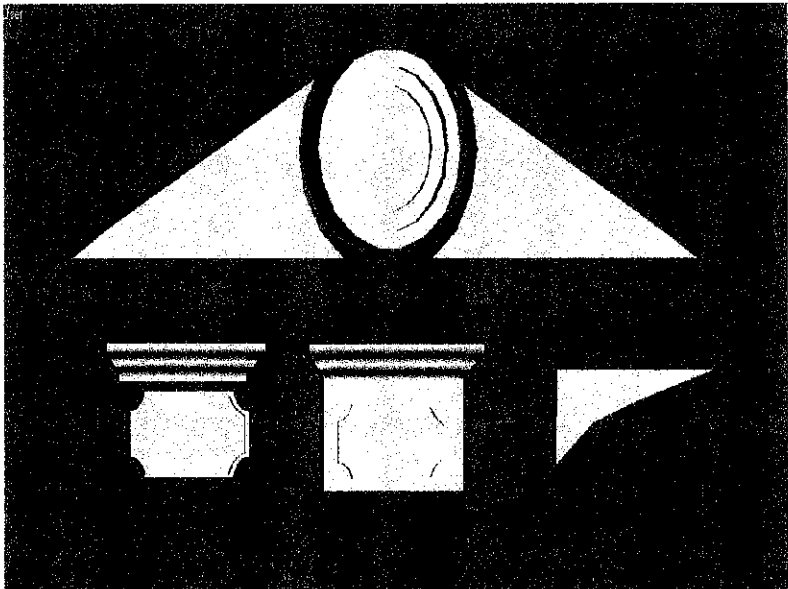


Figure 3.24: Artistic features at the front part of the building

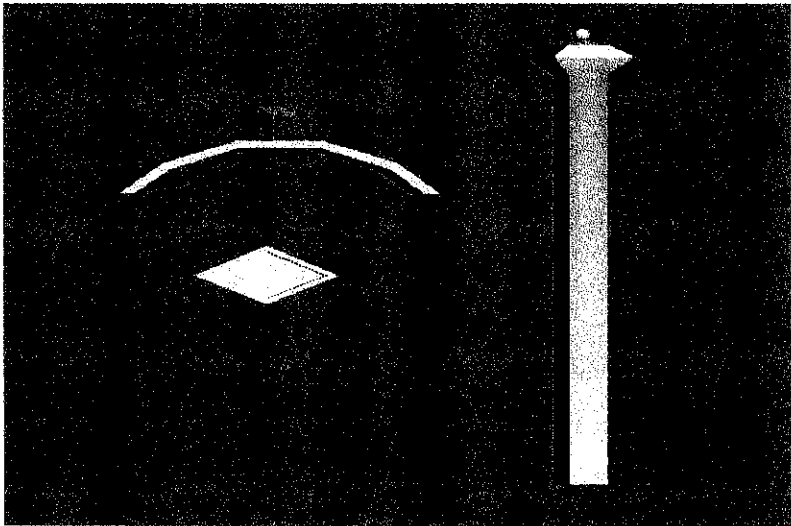


Figure 3.25: Artistic features at the right/left side of the building

3.3.7 Completed museum

Figure 3.27 (a) shows the front view of the museum. It is a 2D image view which perceived as to have x and y axis. From this view, user can only see the width and height of the museum. Besides that, it is the initial view when the user starts their navigation.



Figure 3.26 (a): Front view of museum

Figure 3.27 (b) shows the wireframe view of the museum. It displays the museum as a polygonal mesh (lines that make it look as though the objects are made from a wire screen mesh). Besides that, this view also displays the actual polygons comprising the museum including the polygons that would normally be hidden from view.



Figure 3.26 (b): Wireframe view of museum

Figure 3.27 (c) shows the 3D view of the museum. It is a 3D image view which perceived as to have x, y and z axis. From this view, user can see the overall look of the museum such as the width, height and depth of the museum.

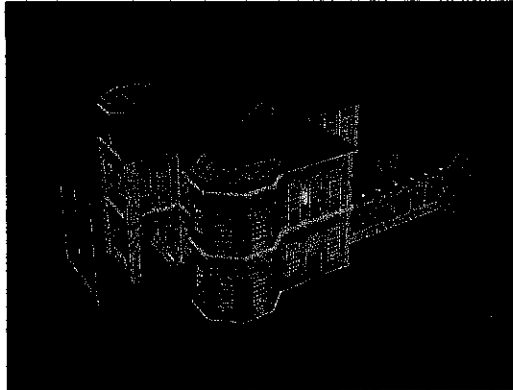


Figure 3.26 (c): 3D view of museum

3.3.8 Develop the walkthrough

Once finish with modeling the museum, the 3D model then is exported from 3D Studio Max format (.max) to VRML format (.wrl). The main reason for doing this is to project the virtual environment stereoscopically which is enabling the walkthrough feature. When virtual environment is in stereoscopic view, user can navigate the museum to get the feel of the environment and to explore the design of the museum as a whole, both interior and exterior.

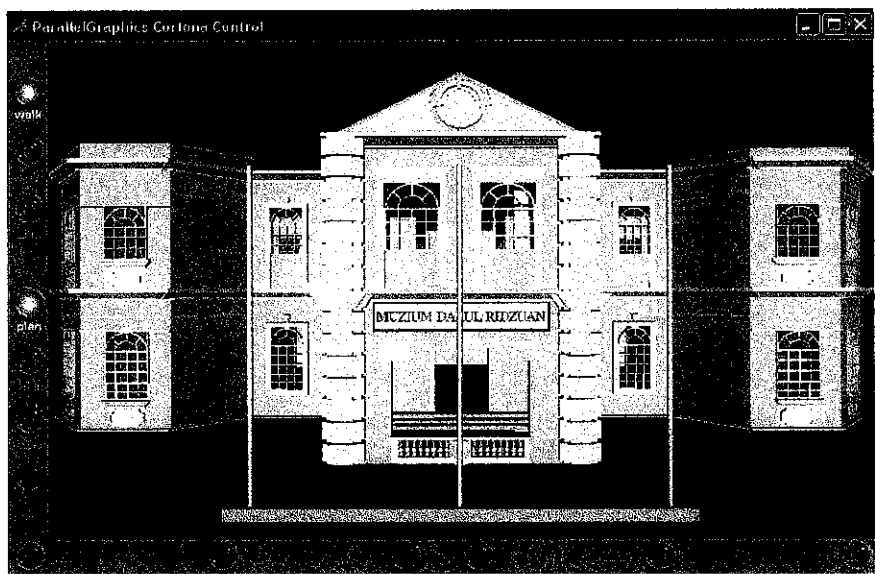


Figure 3.27: Front view of the museum in Cortona Viewer

In order for the user to get started with the navigation, viewpoint node must be defined in the coding of this application. Viewpoint node enables the position and orientation of the initial view. Some parameters for getting to that viewpoint are specified by the “aperture” or field of view of the camera at that viewpoint. Figure 3.29 shows the front entrance to the museum that will be the starting point for the user to start their navigation.

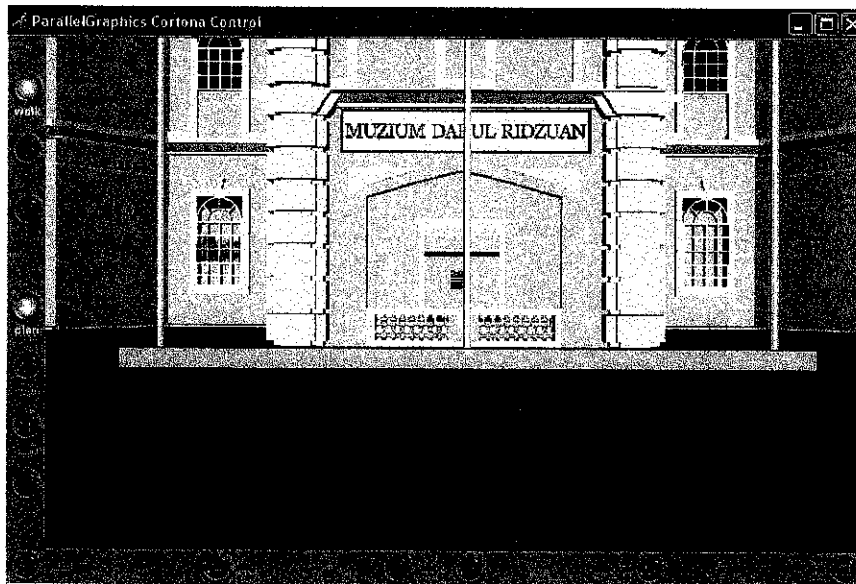


Figure 3.28: Museum's Initial View after implementing Viewpoint Node

The position of the camera when initially running up the application is also defined in the coding. The lines of coding for these aspects are shown in Figure 3.30.

```
DEF Camera01 Viewpoint {
    position -110 -177.7 855.2
    orientation -1 3.559e-005 0 -0.001864
    fieldOfView 0.6024
    description "Camera01"
}
```

Figure 3.29: Lines of coding on initial view of the museum.

3.4 Evaluation

The final phase is the evaluation part. Evaluation is carried out with the help of 30 users. The evaluation is conducted to analyze the application and to get some feedback from the users on a few scopes. Methods of evaluation include questionnaires and interviews. First, a set of questionnaires is developed. Users need to test and evaluate the application, and then they are required to answer questionnaires provided to them. After that, the interview session with users is to get their spontaneous feedback on the given open ended question.

3.5 Hardware and Software Requirement

3.5.1 Hardware

In developing this kind of project it required a high performance of personal computer. The performance is important, because it influenced taken to simulate and render the virtual human animation. The requirements for Windows are:

- Operating System- Windows 2000 Professional or XP
- Processor- 2.6GHz processor
- Memory- 512 MB system RAM (2 GB of RAM is recommended)
- 500MB free hard disk space
- 24-bit color display, 1024 x 768 resolution

3.5.2 Software

Software is a general term for the various kinds of programs used to operate computers and related devices. There are two softwares used in order to complete this project. They are:

- 3D Studio Max 5

3D Studio Max 5 software package is chosen in this project due to its flexibility in polygonal mesh editing, and for its features regarding VRML exporting capabilities. It is suitable for this project as it has many complicated and powerful features compared to other 3D software. It also provides very informative tutorials and user references for beginners. Besides, there is a wide variety of books available for 3D Studio Max. Plus, as it is very well known, it is easy to find the extra tutorials or references in the internet.

- Cortona 2.0 VRML Client

Cortona VRML Client is selected for the conduction of the walkthrough.

It is because VRML have the great advantages which are: the sense of "being there" - of being able to move in and around the building or site. User is in control and can manipulate the environment at a convenient speed and in desired directions. When virtual environment is in stereoscopic view, user can navigate the museum to get the feel of the environment and to explore the design of the museum as a whole, both interior and exterior. Furthermore, additional "hooks" provide a multi-layered, potentially rich learning environment.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Data is gathered through the evaluation phase. In the evaluation phase, there are 30 sample users being called to view the application. 30 respondents are called one by one to view and try out the application itself. From their testing on the application, the user is required to answer a set of questionnaires regarding the application.

The type of question used for this project is multiple choice questions which means there are several alternatives from which to choose. The considered scopes in the questionnaires are realism, navigation, collision detection, usability of application, suitability of application, and user acceptance. The purpose of this formation of questionnaires is to examine accomplishment each of the project main objective.

Results are plotted into pie charts and histogram to better analyze the data gained from the evaluation process. For the pie chart, the legend represents the scaling in the questionnaire, which ranges from 1 to 5, with 1 being the lowest and 5 being the highest. The use of chart in this survey result is to give a clear view on the evaluation's result in evaluation phase so any improvement can be done immediately. Sample questionnaires can be referred in Appendix A.

4.2 Results of Questionnaires

4.2.1 Realism

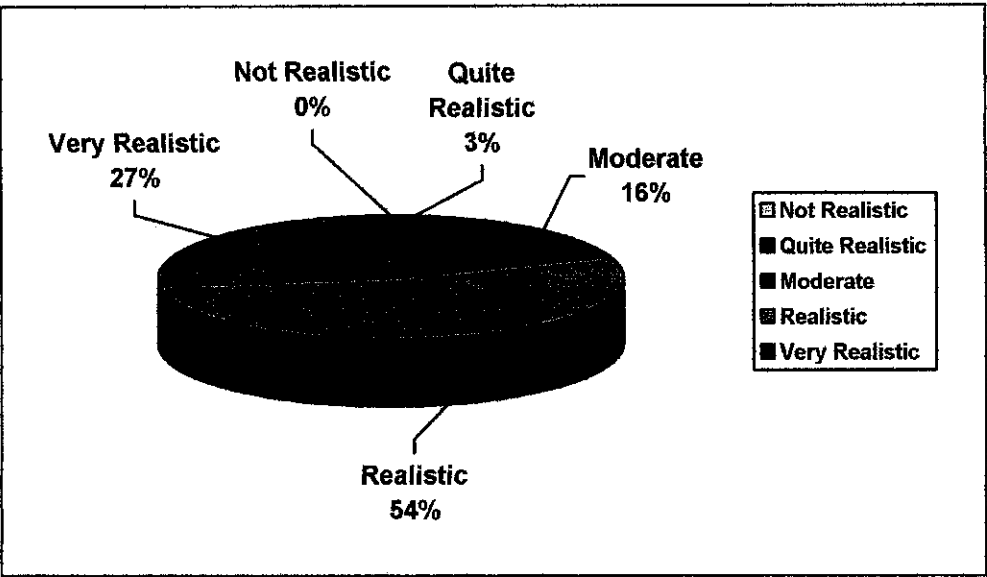


Figure 4.1: Pie Chart Evaluation Result for Realism of the Virtual Museum.

Figure 4.1 shows the result obtained from the survey handed to 30 sample users, which show the percentages of respondents giving grades to realism aspect.

A scale of 4 and 5 are considered a great respond from users. It shows that the percentage of responded scale of 4 and 5 are 54% and 27%. The percentage a user responded a moderate scale of 3 is 16%. Meanwhile, 0% and 2% of users responded a low scale of 1 and 2.

The highest percentages are very realistic and realistic level. This means that the overall virtual museum looks realistic.

4.2.2 Navigation

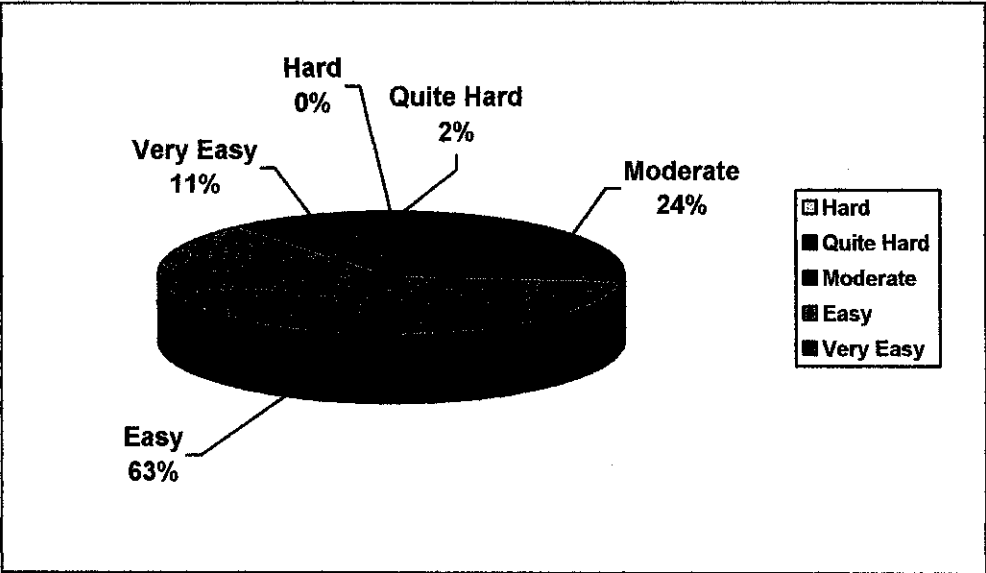


Figure 4.2: Pie Chart Evaluation Result for Navigation Aspect of the Application.

Figure 4.2 shows the percentages of respondents giving grades to navigation aspect.

A total of 63% and 11% are those who responded a scale of 4 or 5, agreeing that navigation is easy and very easy. Apart from that, 0% and 2% are those who responded a low scale of 1 or 2, rated as hard or quite hard.

The highest percentage is easy level and the second highest is moderate level. This indicates that this application is easy to navigate.

4.2.3 Collision Detection

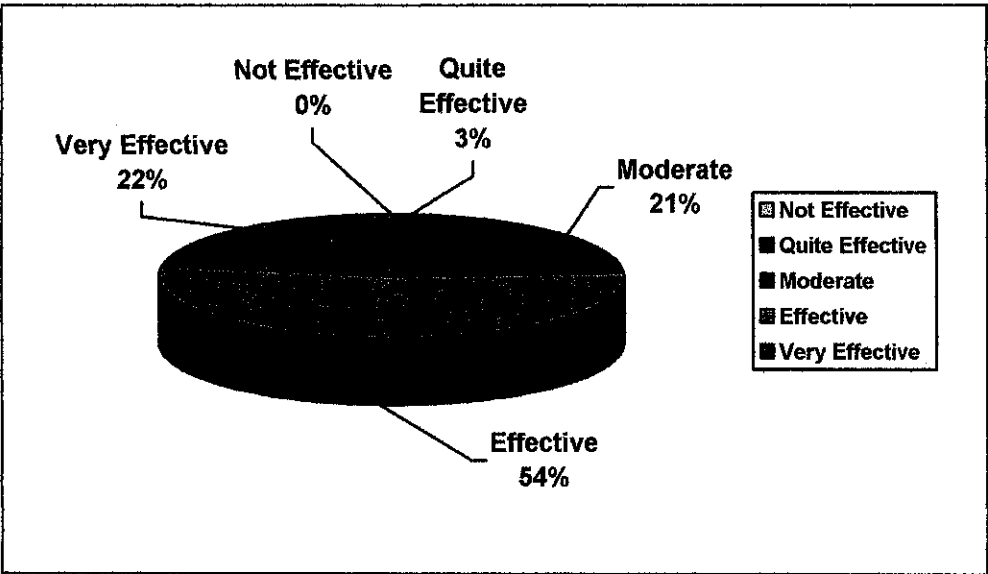


Figure 4.3: Pie Chart Evaluation Result for Collision Detection Aspect of the Application.

Figure 4.3 shows the percentages of respondents giving grades to collision detection aspect.

A total of 54% and 22% are those who responded a scale of 4 or 5 as effective or very effective. Apart from that, 24% rated a scale of 4 which is moderate level and 0% or 3% are those who responded a low scale of 1 or 2, rated as not effective or quite effective.

The percentage for this aspect is higher with a total of 76% of users agreed that collision detection is important, and that it is well-applied in this application.

4.2.4 Application Suitability

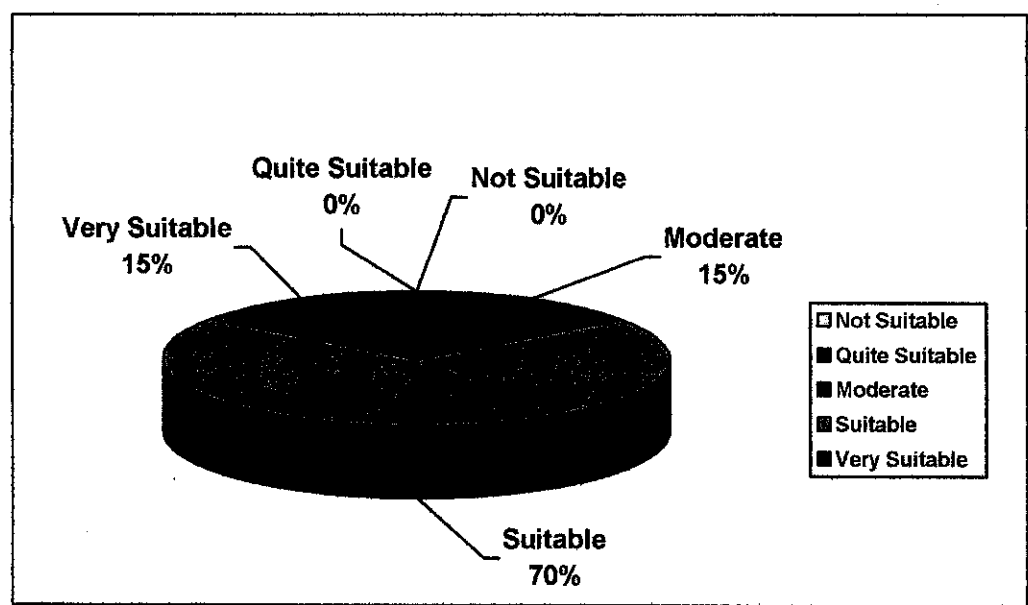


Figure 4.4: Pie Chart Evaluation Result for Application Suitability.

Figure 4.4 represents the respond from the user towards the suitability of application. The objective of this question is to know whether the application developed is suitable to be used as an alternative way of promoting museum instead of the real museum.

A scale of 4 and 5 are considered a great respond from users. It shows that the percentage of responded scale of 4 and 5 are 70% and 15%, who agreed to use this application as an alternative way. The percentage of user responded a moderate level is 15%. Meanwhile, 0% and 0% a users responded a low scale of 1 and 2.

The highest percentage is a suitable level. This means that the application is suitable as an alternative to the real museum.

4.2.5 Application Usability

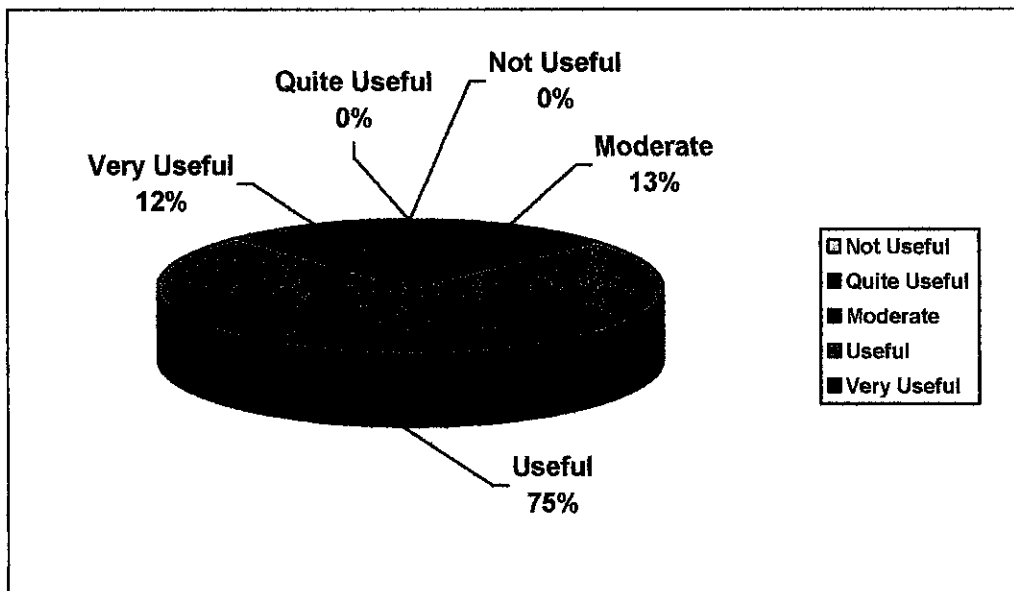


Figure 4.5: Pie Chart Evaluation Result for Application Usability.

Figure 4.5 represents the respond from the user towards the usability of application.

A scale of 4 is considered a great respond from users. It shows that the percentage of responded scale of 4 is 75%. The percentage a user responded a moderate scale of 3 is 13%. Meanwhile, 0% and 0% of users responded a low scale of 1 and 2.

The highest percentage is a useful level. This means that the application is useful to people because they can view the museum and its collection from their desktop. It also indicated the user agreed with the significant of virtual heritage application being applied for developing museum.

4.2.6 User Acceptance

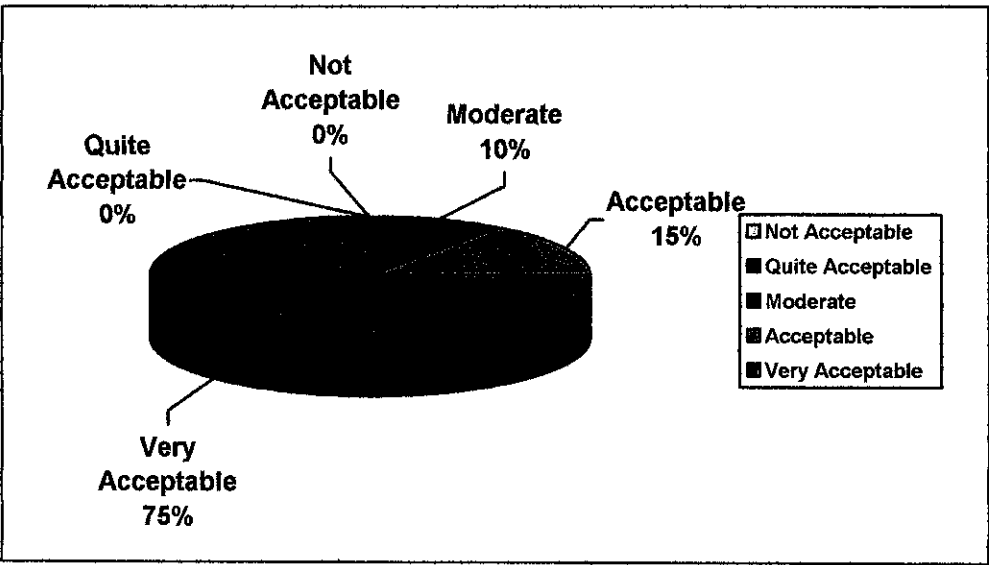


Figure 4.6: Pie Chart Evaluation Result for User Acceptance

Figure 4.6 represents the user acceptance towards the application.

A scale of 4 and 5 are considered a great respond from users. The pie chart shows that the percentage of responded scale of 4 and 5 are 75% and 15%. The percentage of user responded a moderate scale of 3 is 10%. Meanwhile, 0% and 0% a users responded a low scale of 1 and 2.

The highest percentage is an acceptable level. This indicates that the user agree to accept the existence of this kind of application.

4.3 Evaluation Conclusion

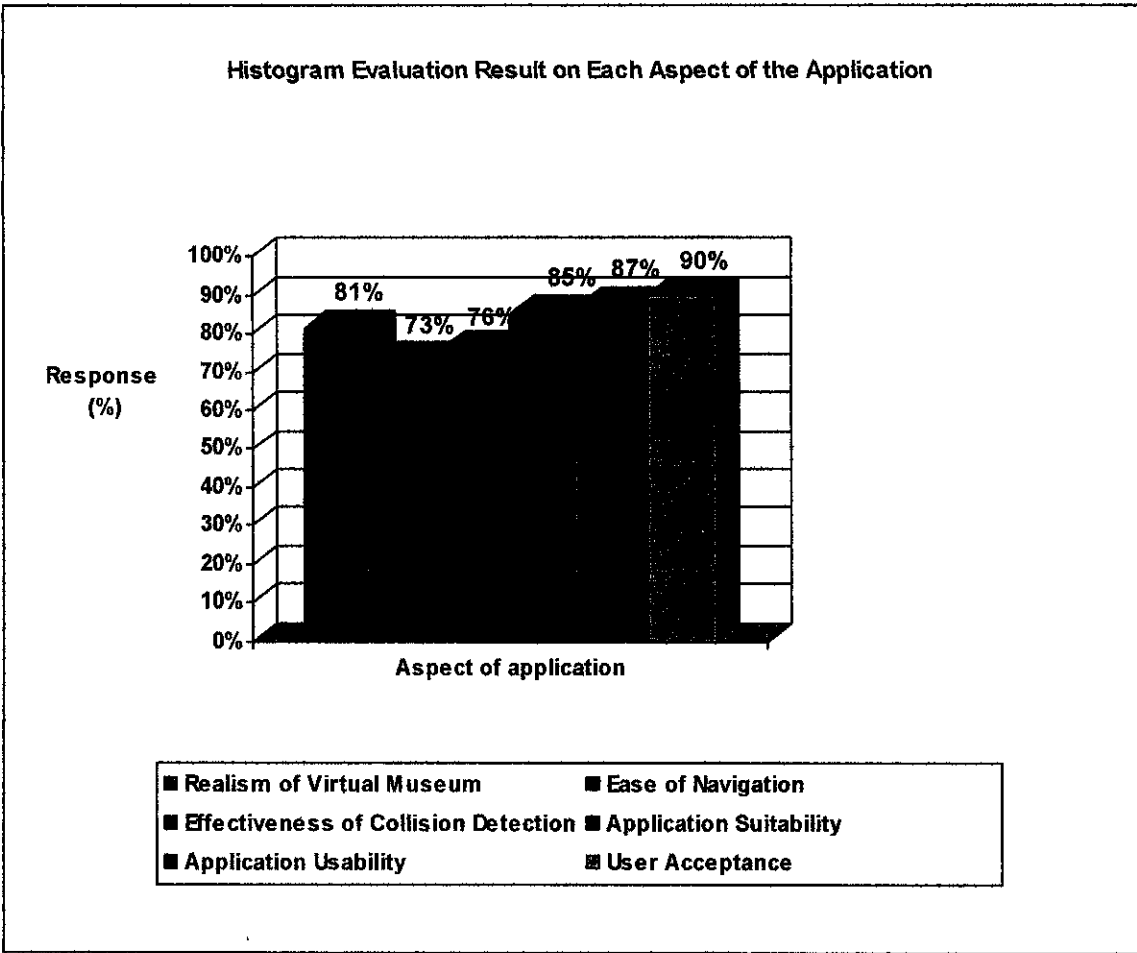


Figure 4.7: Histogram Evaluation Result on Each Aspect Defined

Figure 4.6 shows the evaluation result for all the aspects tested on user. The main reason of the survey is to analyze each aspect of the application. From there, the improvement can be made based on the responds.

The x-axis represents the aspect of application evaluated while the y-axis represents the percentage of response. According to the diagram the highest value is User Acceptance with the percentage of 90%. This shows that the application is highly accepted by users. Followed is the second highest value of percentage that is Application Usability with the percentage of 87%. This indicates that the application is useful to people because they

can view the museum and its collection only from their desktop. Moreover it is useful because there is no such virtual museum application in Malaysia. While the third highest of percentage value is Application Suitability with the percentage of 85%. This indicates that this application is suitable to be used to promote museum as an alternative instead of the real museum.

For the realism of virtual museum, the users have rated 81%. Realism is an important aspect to consider. This percentage can be increased more by doing some improvements on the virtual museum model in order to increase the realism. Next for the collision detection, most of the users gave a percentage of 76%. This indicates that they agreed that collision detection is a main factor to be considered when developing a virtual environment to get the feeling of immersion.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Project Summary

A virtual museum is developed parallel to the expansion of new technologies, focusing on Virtual Reality aspect. Since there is no virtual museum in Malaysia, so this Virtual Museum is a virtual 3D version of the existing real museum. This project applies the real museum to meet the objective of the project.

This project focuses on the reconstruction of the architectural design of Darul Ridzuan Museum. It concentrated on designing exterior part of the building according to colored digital photo taken of the real museum. For this project, besides viewing the architecture, walkthroughs are generated for the user to control but in an easier way. User can navigate through the museum to get the feel of the environment and to explore the design of the museum as a whole, both exterior and interior.

Collision detection is another main aspect that is looked into in this project, for the user to experience the feeling of realism of the virtual world. As the user navigates through the virtual museum, they will not go through walls with the availability of this feature, which is logical and necessary to be implemented.

5.2 Conclusion

On the whole, this project has met the scope of the study and objectives of the project which to develop architectural design of Darul Ridzuan Museum with concentrated on designing exterior part of the building. This virtual museum project is significant as a new alternative to present a real museum. Parallel to the current technology, this project enables Darul Ridzuan Museum to be preserved virtually. Moreover this virtual heritage application is to attract user attention to see the museum. The suitable techniques are applied in developing the model such as polygonal modeling techniques because it excels at low detail or architectural model. Meanwhile to increase realism, walkthrough are generated for the user to navigate and explore the museum. Besides, collision detection is applied for the user to experience the feeling of realism of the virtual world. From the evaluation, the realism of exterior design of the building is achieved, and this fulfills the project objectives. Finally any further enhancements discussed in the previous recommendation part will make this application more appealing to the eye of the user.

5.3 Recommendations

Upon the accomplishment of this project, limitations and constraints had arisen, whether in terms of time, resources, knowledge or technology. For example, time constraint limits the project from having other great and amazing features. There are a few problems faced throughout accomplishing this project, which include:

- An architectural plan of the museum is not available. Therefore this virtual museum has been designed according to the photographic data only that are collected by using digital camera. This result in no precise measurements performed in order to retrieve the exact dimensions of the main structural elements.
- Difficult to design the artistic features. This is because a lot of operations and techniques are required for creating each artistic feature. In order to make those artistic features similar to the real one, every single detail needs to be considered such as size, color and the position.

Since this project is the beginner because there are no other project about this topic yet, a lot of things can be improved. There are a few suggestions on the recommendations for next enhancement of this project.

First is to develop the interior design and collection of artifacts in the museum. The collection may include paintings, drawings, photographs, diagrams, graphs, video segments, newspaper articles, numerical databases and a host of other items. With more given time, implementing the interior design and collection of artifacts would be possible. This is because modeling the interiors is much more complex as it needs more concentration in developing the artifacts and realistic feel to it. Completing the interior part of the virtual museum will surely enhance the realism to a greater extent.

In addition to that, other element can be added such as create a database to put the information for every artifact so that the user can acquire information regarding the particular artifact easily. User can use this feature by clicking on the artifact then the information regarding the artifact will be automatically displayed. This feature is preferred by the user because user can see and know about the artifacts in more details

Besides that, to increase the level of realism to the virtual environment, animation can be included. Animations in this case can be in the form of virtual human walking around the museum. A virtual agent guiding the user for a walkthrough around the museum is another animation and amazing enhancement to do, as the users are able to follow the virtual agent and not getting lost.

In terms of technology, there is also a restriction in the navigation technique, in which mouse is used as the navigation device to navigate around the museum. Other devices can be used, for example those which enables user to use the movement of their body to explore the virtual world is a better way for navigation. This can be done by using a tracker. A tracker is a special-purpose hardware, which is used to measure the real-time change in a 3D object position and orientation. This can bring the user to a higher level of realism and immersion with such an improvement in its navigation.

Collision detection is the only interaction that the users have in this project. Adding more interactions with the objects in the virtual environment can increase the realism to the user. One way is to use a haptic glove which allows the user to touch, feel and move the objects within the virtual environment.

Future enhancement is needed to make this project more realistic. This project is useful as an alternative way to present real museum. So, it may be appropriate to upload this project into any specific website for other people to view the virtual museum with the presence of internet connection.

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APPENDICES

Appendix A: Evaluation Form

Appendix B: Photos of Darul Ridzuan Museum

Appendix C: Screenshots of virtual heritage building: Darul Ridzuan Museum

APPENDIX A

Evaluation Form

The questions below ask about your views toward virtual museum application. Please **bold** your answer for each question.

1. Realism of the virtual museum you have just experienced.

1	2	3	4	5
Not Realistic	Quite Realistic	Moderate	Realistic	Very Realistic

2. Comparison to the real museum.

1	2	3	4	5
Not Similar	Quite Similar	Moderate	Similar	Very Similar

3. Ease of navigation around the virtual environment.

1	2	3	4	5
Hard	Quite Hard	Moderate	Easy	Very Easy

4. Possibility of getting lost

1	2	3	4	5
High	Quite High	Moderate	Quite Low	Low

5. Importance of limiting users from walking into a wall.

1	2	3	4	5
Not Important	Quite Important	Moderate	Important	Very Important

6. Effectiveness of collision detection in this virtual environment.

1	2	3	4	5
Not Effective	Quite Effective	Moderate	Effective	Very Effective

7. Does this application suitable to be used to promote ‘museum’ as an alternative instead of the real museum?

1	2	3	4	5
Not Suitable	Quite Suitable	Moderate	Suitable	Very Suitable

8. If it is suitable, then is it useful to use this application?

1	2	3	4	5
Not Useful	Quite Useful	Moderate	Useful	Very Useful

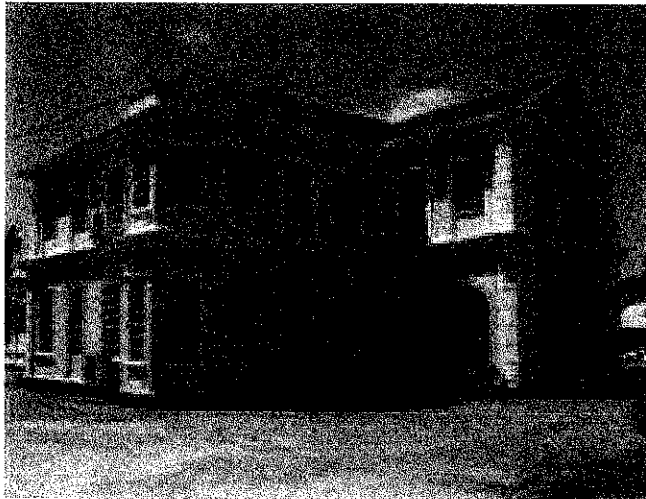
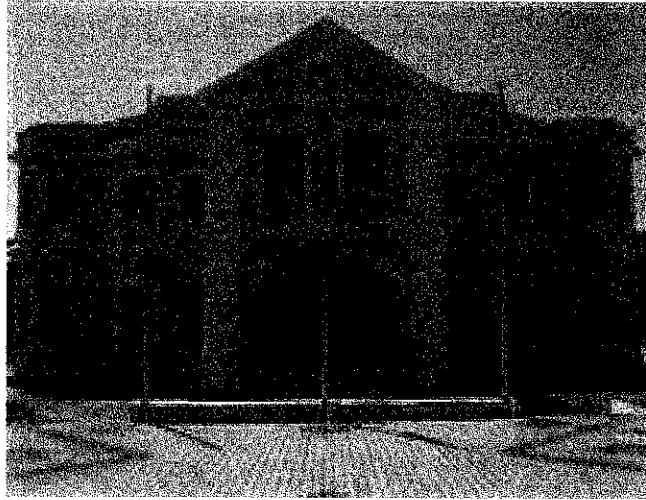
9. Does this application acceptable to you?

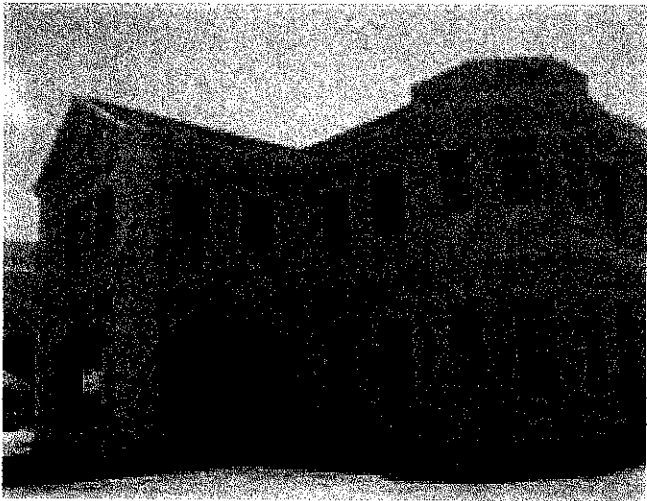
1	2	3	4	5
Not Acceptable	Quite Acceptable	Moderate	Acceptable	Very Acceptable

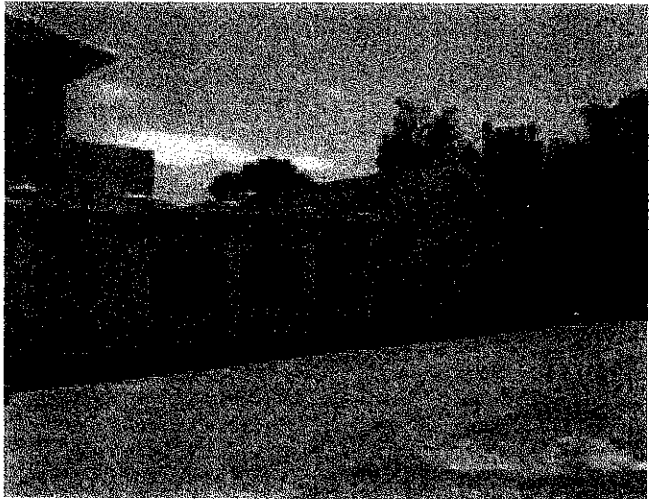
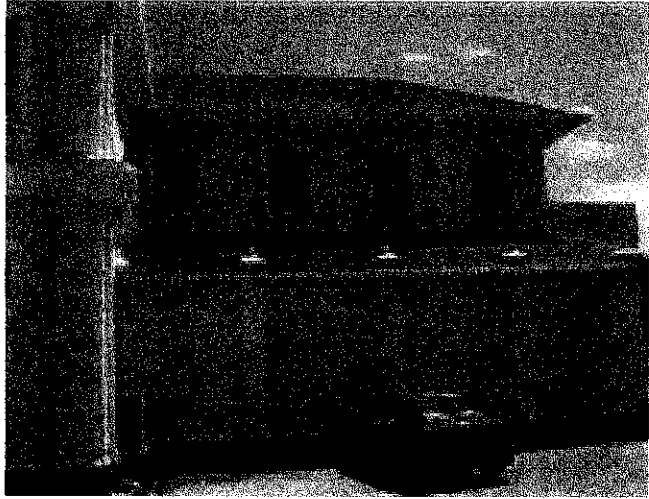
Thank you for your time!

APPENDIX B

Photos of Darul Ridzuan Museum





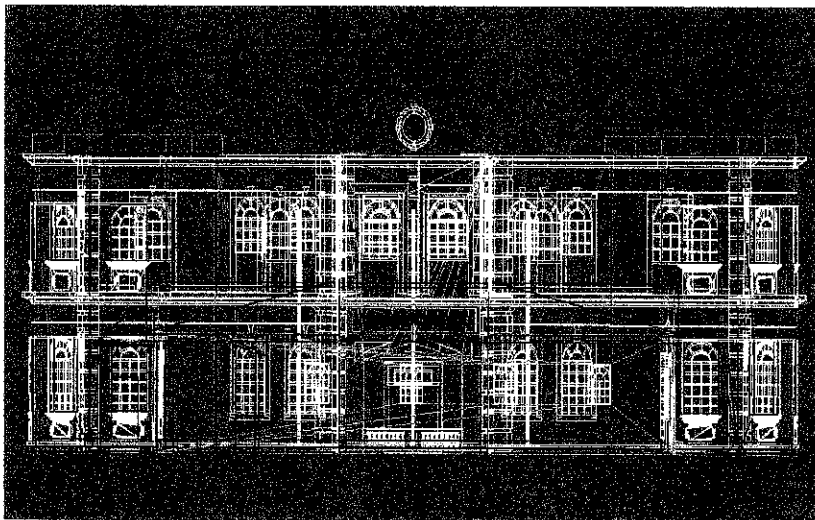


APPENDIX C

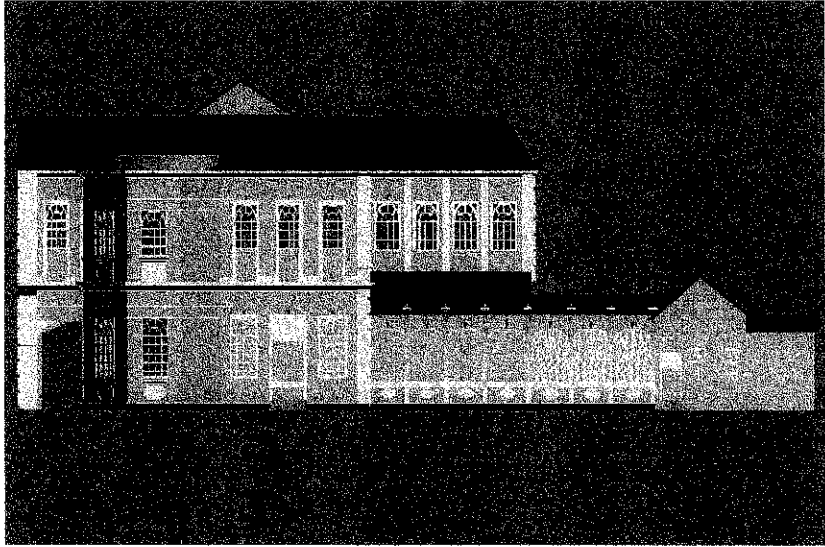
Screenshots of virtual heritage building: Darul Ridzuan Museum



Front view of the museum



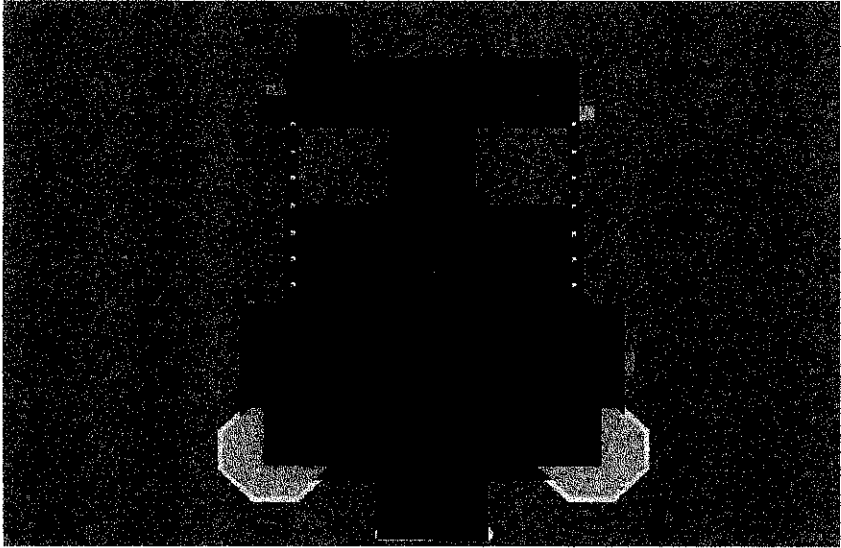
Wireframe view of the museum



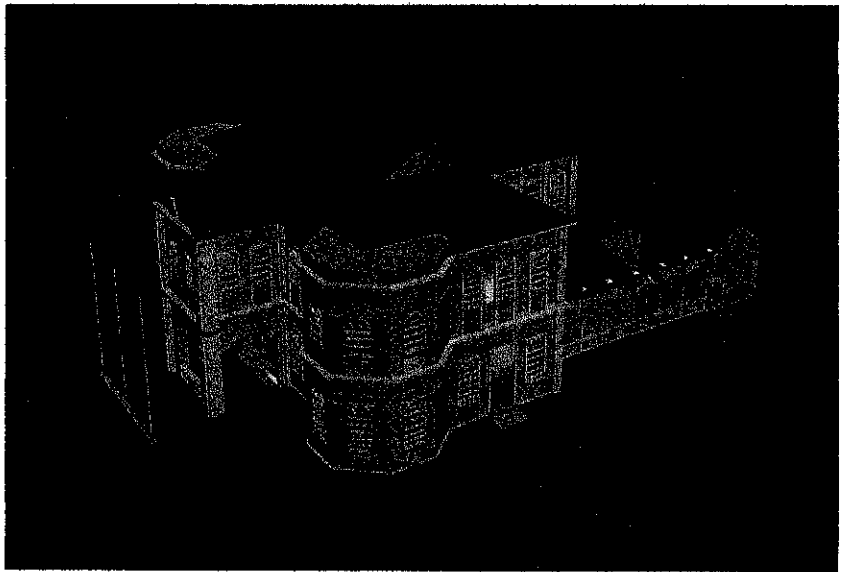
Right view of the museum



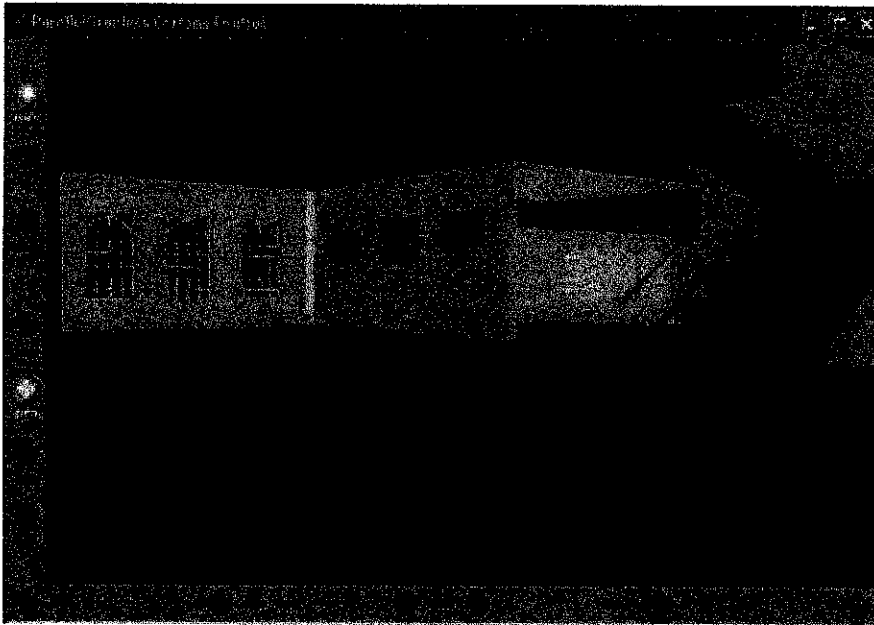
Left view of the museum



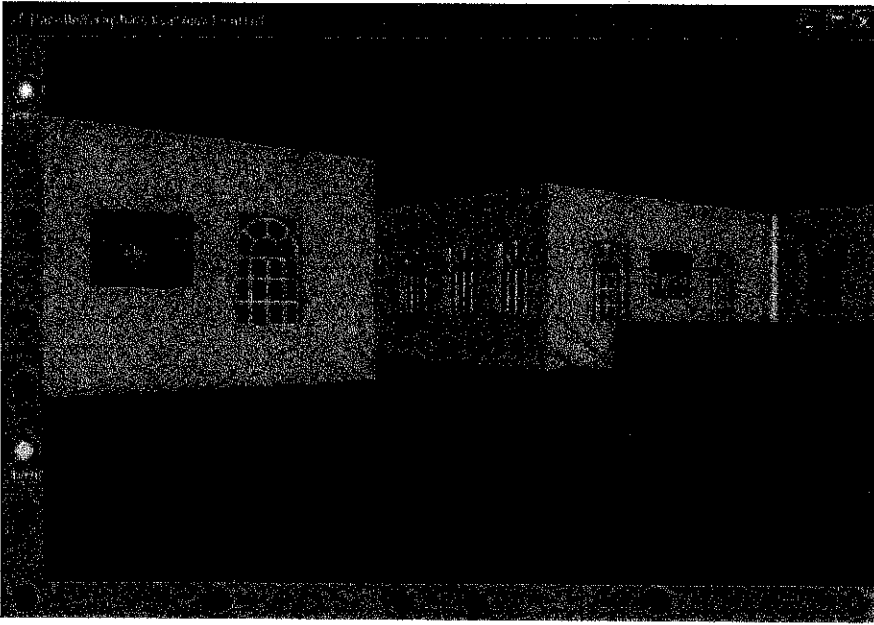
Top view of the museum



3D view of the museum



Ground floor of the museum



First floor of the museum