

Making Virtual Reality a Reality: Bringing CAD and Game Engine together

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Abstract

This paper describes the framework of developing a usable real-world Walkthrough-VR application with the utilisation of 3D Game Engine and CAD models. This application is concerned with the establishing of a prototype virtual modelling system utilising CAD and VR technologies. The integration between the two technologies enables the creation and sharing of a common database between them. By utilising VR technology, realistic virtual environment could be created from the CAD model for visualisation and evaluation purposes. The developed prototype can then be used by even low-end of present computer consumer market whereby its operator is normally the home/office and desktop PC user.

Keywords: CAD, Game Engine, Virtual Reality, Walkthrough

Introduction

In the last few years, our reliance on computers has remarkably increased. The rapid development of faster microprocessor has resulted not only faster central processing units or CPU but also faster and better graphics display cards to be equipped as standard items in the computers. The recurring result is computer graphics nowadays have been used in many ways to assist us in our daily routine tasks. In this early 21st century it is hard to envisage architects, interior designers, engineers and even surgeons working without the assistance of a form of a

graphic workstation. The encouraging growth in computer graphics has made it possible to even the average home-user to explore the world of computer graphics or commonly known as Virtual Reality (VR). This new virtual world often makes a start in the realm of computer games and from there onwards it usually lasts forever [6] in other types of computer applications.

This paper describes the framework of developing a usable real-world Walkthrough-VR application utilising 3D Game Engine and CAD model. The combination of the two technologies enables the creation and sharing of a common database between them. Starting with static 2D or 3D CAD model and then utilising 3D Game Engine technology, a 3-dimensional virtual environment is built for realistic visualisation and evaluation purposes.

In today's product development processes, computers and computer-aided-design (CAD) software play an important role in communicating the design intention of the designers and the clients. Computers can be used to create models that describe the objects' geometries and their physical properties within a 3-dimensional virtual space. The physical prototype is based on the computer model for validation of forms, fits, and functions are then built [4]. CAD is the standard abbreviation for Computer Aided Design and also sometimes being referred as Computer-Aided-Drafting. CAD describes the use of computers to produce drawings that would normally be prepared manually by pencils and papers. A CAD system is used to create 3D geometric models of objects, structures and assemblies [9].

A computer game is any game that requires the use of a computer. Computer games are simply computer programs with instruction to accept input from a controller (usually either from a joystick, mouse or keyboard) and feed it back onto the screen. Computer games are interactive programs, which accept inputs from the user and in return inform the user of one status in the virtual environment. When one is playing a computer game, one is immersed into a virtual environment and is abide to the rules provided and how to control aspects of the computer game [5]. The control aspect can be in the form of turns or real-time. Real-time computer responses usually exist in action games where the action happens in a non-stop manner. The user continuously controls his virtual self or character to act accordingly as required in the virtual environment.

In the PC gaming industry, an entire virtual world is developed based on 3D Game Engine technology. Also in the CAD modelling world, a similar virtual environment can be built as well. The modelling technique utilising 3D Game Engine is by far differs from the traditional CAD modelling. Although similar 3D models can be produced by both of the above i.e. 3D Game Engine and CAD but the difference in modelling technique has become a hindrance to existing seasoned CAD users to learning new game design techniques that are mainly alien to them.

Since game engines are made to handle real-time interaction, it can only carry a limited amount of geometries that can be displayed on the monitor at one moment in time. It is discovered that to export a whole 3D CAD model was proven impossible because it carries a high amount of geometries. Several approaches are taken and it is found that it is possible to export the 3D CAD model, but only in stages. The CAD geometries are firstly grouped and then exported accordingly one group at a time. Three major stages are taken to develop the VR world. The development process can be divided into 3 main categories i.e. (A) STUDY, (B) APPLICATION DEVELOPMENT and finally (C) PROTOTYPE, with each consisting of sub-tasks (See Figure 1). These main tasks and its sub-tasks is the development framework. VR developers seeking a low-cost but still maintain the high-performance and the quality aspects of VR visualisation can refer to this framework as a guideline.

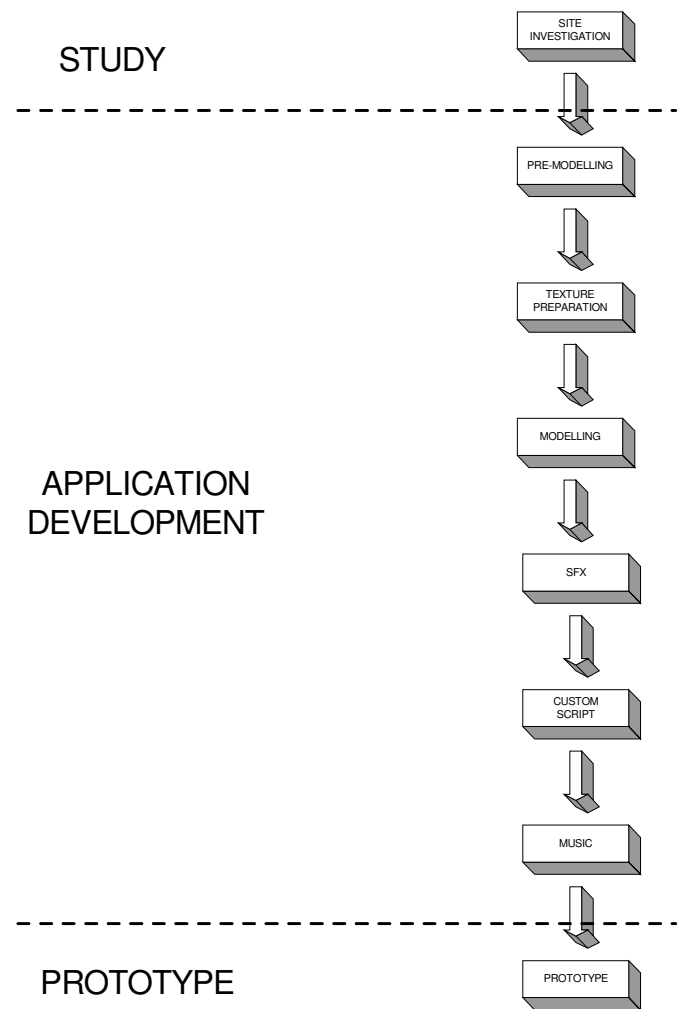


Figure 1 Overview of the development flow-chart

(A) STUDY

This category consists of one task i.e. the site / building investigation. Before this task is performed, an architect drawing is referred to get an overview of the building and site measurement (See Figure 2 for floor plan). Site investigation involves sub-tasks such as getting the image snapshots, measurement of the building, identifying the interactive elements and identifying the special effects elements to be included. The special effects elements are important since the 3D Game Engine has the ability to generate them believably in real time. Examples of the special effect elements that are available are water effect (to represent the wavering water), lens flare effect, translucent mirror effect (to make the marble floor shines and gives out reflection) and multiple sky layer effect (to enable cloud movement while stars and moon are stationary in the background) etc.

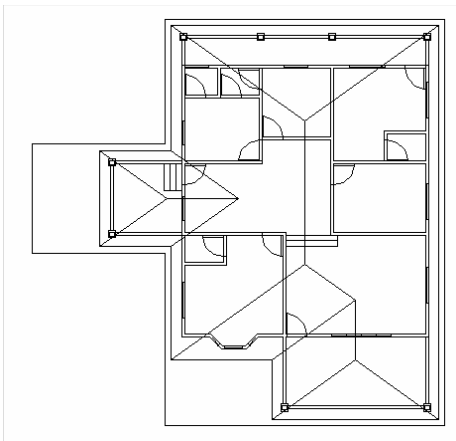


Figure 2: 2D floor plan

(B) APPLICATION DEVELOPMENT

Terminology

Before development is started, some of the basic terminologies used in game development system have to be fully understood. Some of the common terms used are:

- Object** : everything that is added to the level
- Brush** : a geometric shape and it is the basic building blocks of the level
- Active Brush** : also known as the Red Brush or Building Brush
- Actor** : any non-brush object added to the level e.g. PlayerStarts, monsters, lights, inventory items, weapons, triggers etc
- Icon** : an image used to represent an item.

Modelling Concept

It is also important to understand how it works as the approach chosen is nevertheless the opposite of traditional CAD modelling. CAD software started off with a huge `EMPTY` area. Thus if one is to build a structure, one will have to `ADD` to that world. In contrast, 3D Game level modelling started off with a huge SOLID block. This solid block does not have any empty or blank space in it. Hence if a room is to be created in that virtual world, then the room is actually being `SUBTRACT` from the solid block.

Elements of the Engine

Surrounding the 3D Game Engine are 6 main game elements (See Figure 3) [10]. They are (a) 3D Models / Levels, (b) Textures, (c) AI Characters, (d) Audio, (e)

Real Time Computer Special-Effects and (f) Behavioral Scripts¹.

These elements surrounding the 3D Game Engine are removed and replaced by the Walkthrough-VR application elements. To represent a realistic and believable virtual environment, high quality textures and material maps are used. Using a high-resolution digital camera, real pictures are captured, later edited and processed to create the required texture format supported by the game engine. Samples of the texture maps used are shown in Figure 4.

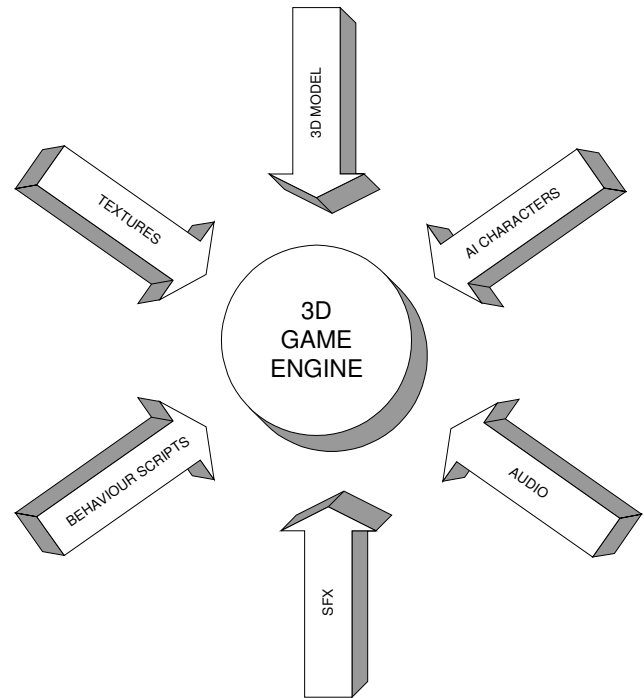


Figure 3 The 6 main components surrounding the 3D Game Engine



Figure 4 Real texture maps

¹ E.g. when user is within a close proximity of a door, the door opens, user can interact with light and fan switches etc. AI characters may have scripts attached to it.

CAD Modelling

Solid modelling technique is used to create the 3D CAD model. For simpler components, they are extruded (extended along the z-axis) based on 2D profiles (the x & y-axis) to produce their counterpart 3D components. Boolean operations such as union and subtract are also used. On the other hand, complex 3D structures use a combination of extrusion, union and subtract operations. To avoid crashes the 3D geometries are grouped and then exported one group at a time into the 3D Game Engine development environment.

Lightings

Lighting plays important role to creating a realistic virtual environment. Without the right light settings, the environment will not be convincing. In order for the virtual environment to be seen and perceived clearly, there must be a difference in brightness between the foreground and background. Darkness that represents shadows not only can assist in defining space, but through contrast, it expands the sense of scale and emphasises the sculptural quality of any object being illuminated (Refer to Figure 5 & 6). All the required lighting conditions are present in the game engine.



Figure 5: A room with dull lighting level.



Figure 6: A room with dynamic lighting.

Audio

All computer games have music. The 3D Game Engine can import from an external source, a different number of digital music format (See Table 1). Soothing sentimental background music is added to the level to enhance the enjoyment and virtual experience of the user.

Interactivity

The 3D Game Engine supports quite a number of other interactive components such as lift, light ON and OFF, moving objects, banners etc therefore one interactive element is added in the prototype level i.e. doors will automatically open if the user is within close proximity.

(C) PROTOTYPE

In analysing the prototype system requirements, several factors are considered. The factors are:

Users Requirement

It must allow users to participate in the 3-dimensional virtual environment. This enables them to freely walk through and around the environment at their own pace to gain a higher level of understanding of the environment. They must be able to realistically experience how the environment appears and make selections and changes without any constraint.

Music Format Extension	Music Format Type
MOD	Amiga Modules
STM	ScreamTracker 3
S3M	ScreamTracker 2
XM	Fastracker
IT	Impulse Tracker
FAR	Farandale
669	ComposD
MP3	MPEG Layer-3

Table 1: Supported import digital audio format

Hardware Requirement

The hardware in use for the development system is an IBM-PC computer running under Windows 98, 128 MB RAM and a 4Mb AGP graphic card. The navigation device is a normal two-button mouse.

Software Requirement

AutoCad Release 14 is used to model the house. The generated CAD file is saved as a .DXF file format then imported into the 3D Game Engine development system. Finally with all the required elements in placed, the prototype is completed. The recommended PC specifications as stated by the game engine developer are as shown below.

PC system	: Pentium-200 MMX or equivalent
RAM	: 32 MB
CD-ROM speed	: 4X
Video Mode	: SVGA with 2MB of video memory
Hard Drive	: 450 MB
3D Accelerator Board	: Yes

Conclusion

It is now an acknowledged experience that synthetic worlds generated wholly in the computers can stimulate our senses [11] therefore a Walkthrough-VR experience is as almost as real as the physical experience. From the successfully developed prototype, it can be seen that utilising the above technique the virtual experience is enhanced in terms of real-time realistic representation and good visual quality. It has also proven that a good VR application can be developed only using a low-cost desktop computer system with minimal PC software and hardware requirement.

The designing concept is able to enhance real-time visualisation applications. The virtual environment constructed provides the indefinite architectural possibilities and gives the users (client and designer) the contentment they need to virtually experience it [8]. In the case of utilising the 3D Game Engine coupled with a CAD model, the time to render and re-render geometries with full texture and lighting support will only take minutes [7] instead of hours or days like the one present in CAD and 3D modelling software packages.

The ability to integrate CAD and 3D Game Engine to developing a low-cost but still maintains the high-performance VR application is beneficial especially for those directly involved in construction industry e.g. architects and interior designers to replace conventional techniques of design representation.

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