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Making The Transition Toward An Alternative VR

Mohd.Fairuz Shiratuddin (fairuz@vt.edu)
Walid Thabet (thabet@vt.edu)

Department of Building Construction
Virginia Tech, Blacksburg, VA 24061, USA
Tel: +1 (540) 818-4604 · Fax: +1 (540) 231-7339

Abstract

The use of 3D Game Engines to create real-world Virtual Environment (VE) applications in construction is a promising new alternative to currently available commercial VR development platforms. Although this new solution has been available for almost 2 years, it is still not well known and used as a serious VE application development tool. Recent research efforts have proven that the use of 3D Game Engine, which is also known as Game Development Kits (GDKs), is a viable solution to creating visually engaging virtual environments while still maintaining a low-cost development and execution platform. Although 3D game level designs and Game Engines can be awkward and intimidating towards seasoned VR application developers, we believe that this technology will provide a better solution in many ways as compared to what is currently available in the commercial market.

This paper will explore the major advantages that GDKs can offer over currently available commercial VR Software Development Kits (SDKs) and authoring tools. Extending from previous research, steps to be taken in order for traditional CAD and 3D modelers to incorporate their 3D creation within the game environment will be outlined. Major questions as to why GDKs are still unpopular will also be posed and discussed.

Keywords: construction, games development kit, game engine, unreal, virtual reality

INTRODUCTION

VR has been widely researched and used in many areas with various degrees of success. The traditional approach still being practiced today is through tedious programming and compiling lines of complex codes. Only until recently VR developers have came to realize that the way to propagate the use of VR in many applications is to make it easier for the users to develop their own VR applications. This is through a simpler drag-and-drop icon-based approach. Lately, several VR tools have been introduced that have such characteristics, which originated from the computer games world. These tools will be discussed in the later section of this paper.

The construction industry is known to be slow to adapt to new technologies. When CAD was firstly introduced in the early 80s, there was resistance as it was more comfortable to use traditional pen-and-paper. However, CAD gradually was proven to be an effective tool to increase productivity and accuracy of a construction design and therefore now, has been accepted as a standard. Similarly, VR has shown limitless possibilities to be able to assist the construction industry in various aspects but still a major question arises: why is VR still not widely used in construction ?

This paper focuses on a concept that is still unpopular amongst Virtual Environment (VE) developers particularly for construction purposes. The use of 3D Game Engines or Games Development Kits (GDKs) to create real-world VE applications in construction is a promising new alternative to currently available commercial VR development platforms. Although this new solution has been available for almost 2 years, it is still not well known and widely used as a serious VE application development tool.

CURRENT COMMERCIAL VE DEVELOPMENT SOFTWARE

Before we move on to the topic of 3D Game Engine and GDK, we will briefly outline some of the popular commercial VE development software in the market. There are many commercial VR software systems that can be used to create virtual worlds such as World Tool Kit (WTK) and WorldUp from Sense8, software from Division Ltd and Multigen from Paradigm. The platform on which these VR applications run ranges from desktop PCs to Silicon Graphics workstations and Onyx machines. The two widely used commercial VE content development software is from Sense8 and Paradigm.

THE GAMES DEVELOPMENT KIT (GDK)

GDK is comparatively similar to Software Development Kit (SDK) in terms of the ability for programmers to reuse the pre-made codes for a specific function thus the process of creating an application is sped up. A traditional GDK only consisted of lines of codes that were mostly written either in C or C++. In contrast, modern GDKs now include many supporting applications with more user-friendly interface (UI) that are icon-based orientated (See Figure 1).

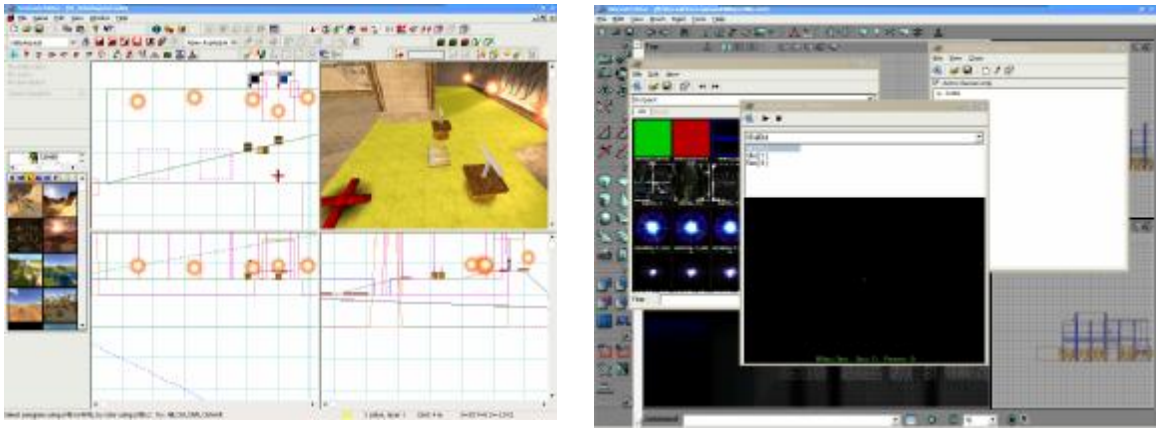

Figure-1: Examples of modern GDK

A Brief History of 3D Games and its' GDKs

In 1992, the game Wolfenstein-3D (Wolf 3D) by iD Software hit the shelf and started out a whole new genre in computer games. They are known as the First-Person-Shooter or FPS. According to Shiratuddin (2000), the generations of FPS games have begun from Wolfenstein 3D, DOOM, Quake, Quake 2, Unreal and so on until today. The latest generation is Unreal Tournament, Quake 3 Arena, Serious Sam and Tribes 2.

Having a similar concept to Walkthrough VE application, the FPS game is based on a simple notion that is the user sees the world through the eyes of the game's main character (Tabor, 1997). Today, with variety of computer games ranging from flight simulators, action, Role-Playing-Game (RPG) to real-time strategy, the FPS game genre is one of the fastest types of computer games growing on the market. This encouraging progress has led to the establishment of research and development in the gaming industry to employ the latest in computer technology, yet affordable for the general public use. Some of the technologies include support for high-performance low-cost 3D graphics card, 3D spatial audio, multi-player networked gaming either through a dedicated server or even the Internet etc. These technological supports have also led to very sophisticated design of modern GDKs and still maintain the user friendliness for the averagely end-users to creatively invent new virtual worlds.

Even though in early 3D graphic implementation such as the one present in Wolf 3D were crude and primitive as compared to current standard (See Figure 2), it has allowed the user to freely move about, see, hear and experience 3D virtual environment in real-time through the eyes of the game's main character. Partial immersive effect was introduced in which the user saw objects and characters as being small when distant but grew bigger in size when moved toward them.

Figure-2: The 3D world in Wolf 3D

Another 3D Game, Doom (also by iD Software) was released in the following year with faster and better textured 3D graphics added to the virtual environment (Crawford, 1998). New technologies such as non-orthogonal walls, light diminishing, light sourcing, variable heights floors and ceilings were achieved. Most importantly multiplayer support for up to 4 players over a local area network (LAN) was also incorporated.

In 1996, the first true 3D virtual environment was demonstrated in Quake. The Quake engine was able to use a full 3D environment and 3D characters, and increase support for up to 16 multi-players. Supporting tools and information were released to allow users to modify and introduce new levels into the game. The concept of Open Architecture was adopted where users from around the world can use the Internet as the primary communication mean, contribute their talents to design new levels, game elements, ideas and newly or improved tools. The Quake 2 engine, which was released in December 1997 incorporated features such as Silicon Graphics' OpenGL support, transparent water effect, visual effects, 16-bit textures in OpenGL mode and colored lighting.

The latest generation of 3D Game Engines and its' corresponding GDKs were released in late 1999. The two most popular games at that time were Unreal Tournament (by EpicGames) and Quake 3 (by iD Software). These two games have included many enhancements to their predecessors (See Figure 3). The two games have also included newer GDKs that are even better and easy to use to create new 3D virtual environments. The 3D engines behind the games have made new quantum leaps in computer graphics where higher polygons and far detailed 3D models can be displayed in real-time. We believe these latest additions will even further assist real-world VE developers to producing better and realistic virtual worlds.

Figure-3: Images captured from Quake 3 Arena and Unreal Tournament games display many visual improvements

Advantages of using GDKs

Low-Cost Development System

An advantage of using GDKs is allowing clients to see what the end product such as buildings would look like in VE. BBC News Online (2000) reported that researchers from Cambridge's Martin Centre for Architectural and Urban Studies were using the GDK of Quake II to guide clients through yet-to-be-constructed buildings. According to director of the center, Paul Richens, the objective was to allow the clients to peruse the layout of space and design of the building and gain a better idea of how it will function. Richens also added by using Quake 2, a low cost VE with better results can be achieved. This is because their project used a £30 game, which ran on a desktop computer with £ 150 graphics card.

GDKs have numerous functions that were purposely built to support and make the game come to life. These functions are a major bonus to VE developers, as they will definitely shorten up the creation process of a virtual world. Some of the major functions are not available as standard features in VE commercial software. These functions are discussed below.

Predefined Collision Detection

Using a GDK will enhance the creation and improve the realistic experience in the VE because of the `collision detection' feature that is already preprogrammed in the GDK. This feature allows detection of collision between objects that are defined as solids or non-solids. The VE system will automatically prevent the user from walking through brick walls or other objects that are not supposed to be penetrated or walked through in real life. Therefore this feature enhances interactivity between user and the VE and improves the feeling of immersion.

Real-World Texture

Virtual environments creation can either be based on existing buildings layout or a proposed building design. Using GDKs, existing buildings can be recreated electronically using real-life textures, which can use real-world photographs as the surface materials (See Figure 4). This allows the user in the VE to experience realism and to relate to the real world as to what he/she is seeing in the VE (Mays, 1998 and Miliano, 1999). In the recreation of Virtual Reality Notre Dame (VRND) Cathedral using Unreal GDK (DeLeon, 1999) viewers to experience the cathedral and appreciate the aesthetics of its interior in a realistic way.

Figure-4: Real-world images used as textures

Built-In Audio Effect

The use of sound, music and audio effects can add realism to the exploration of a VE. Real world sounds can be incorporated in a VE e.g. the splashing to accommodate the virtual water splashing and the thundering sound accompanying virtual lightning and thunder. This feature can benefit trainings in VE e.g. the sound of machinery in an oilrig or the sound of flight engine can enhance the realistic training experience for trainees. All real-life basic audio effect e.g. footsteps, water splash, wind-gush, thunder etc are already built-in the GDK. In addition to the basic sound included, new audio effects can also be introduced into the GDK with a fairly similar concept to importing a new 3D CAD model.

Lighting Effect

Lighting effect play a major role as it provides realism to the VE. Without proper lighting conditions, the VE will be insipid and monotonous (See Figure 5 & 6). The current generation of 3D game engines supports many types of lighting effect.

Figure-5: A room with dull lighting level

Figure 6: A room with dynamic lighting

Images source: Shiratuddin, M. Fairuz & Zulkifli, A. Nasir (2001)

The Unreal engine has the most complete lighting conditions support. Unreal has Point, Dynamic, Fog, Spotlights (Search), Shimmering, Coronas and Wavering lighting effects. All the lighting effects in Unreal are all built-in into its GDK. Table 1 shows the various types of lighting present in the Quake 2 and Unreal engine.

3D Game Engine		**Quake 2**	**Unreal**
Types of lighting			
1	**Dynamic**	√	√
2	**Colored**	√	√
3	**Point**	√	√
4	**Radiosity**	√	√
5	**Spotlight (Search)**		√
6	**Coronas**		√
7	**Fog**		√
8	**Shimmering**		√
9	**Wave**		√

Table-1: The 3D game engine lighting effect support

Virtual Artificial Intelligence (AI) Character

A GDK provide standard built-in virtual characters in the form of a hostile and friendly AI computer characters (Elin, 1999 and Sweeney, 1999). In the VRND Project (DeLeon, 1999) the AI characters exist as hosts or tour guides to provide assistance and will be able to show many points of interest within the virtual structure and environment, and offer

explanations. Instead of trying to create such characters from scratch the link to the codes of these built-in virtual characters can simplify the process of adding them to any virtual environment being created. The virtual characters can include intelligence in their reactions and responses.

CAD IN GAMES DEVELOPMENT KITS (GDK)

Computers and CAD software play important roles in communicating the design intent to other project participants (e.g. clients, constructors, etc). Computers are 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 that are then built (Creative Technical Solutions, 2000). A CAD system is used to create 3D geometric models of objects, structures and assemblies (Runwal, 1998).

Shiratuddin and Zulkifli (2001) found that a usable real-world Walkthrough-VR application utilizing a GDK and CAD model could be produced. The merging of both technologies enables the creation and sharing of a common database between them. Starting with static 2D or 3D CAD model and then utilizing GDK, a 3-dimentional virtual environment is built for a far more realistic real-time visualization and evaluation purposes.

An entire 3D model can either be developed in the GDK or using a CAD software. However, the difference in modeling techniques has become a hindrance to existing seasoned CAD users due to the fact that they have to learn new design techniques that are mainly alien to them. However, Shiratuddin and Zulkifli (2001) have proven that it is possible to export an existing 3D CAD model, but it can only be done in stages. The CAD geometries are firstly grouped and then exported, one group at a time. Exporting the entire 3D CAD model was impossible due to the high amount of geometries it carried.

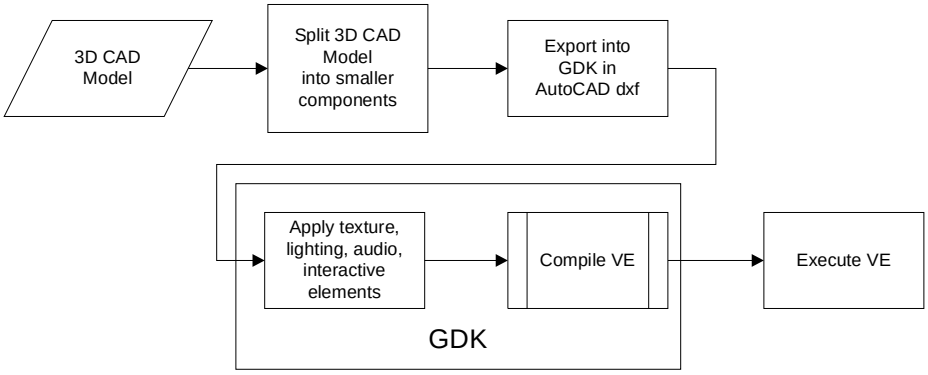

Figure-7: The overall process of using a 3D CAD model and a GDK

Shiratuddin and Zulkifli utilized the Unreal GDK. Figure 7 shows the process of importing a 3D CAD model in a GDK for the purpose of building a VE. Firstly the 3D CAD model was split into smaller components. The logical and appropriate way to do

this was to split components that have the same properties e.g. windows, pillars, doors, walls etc. These components were then grouped together and saved in the AutoCAD dxf file format since Unreal GDK has support for it. Once imported in the GDK, textures, lightings, audio and interactive elements were applied to the newly created VE. Finally the VE was compiled and executed. The VE was entirely developed and run on an entry level Intel Pentium III PC.

SUCCESSFUL REAL-WORLD PROJECTS

Since 1998, companies and researchers throughout the world have undertaken some major successful projects. The projects utilized 3D Game Engine and its' GDK to create highly realistic, believable and fascinating virtual worlds. Table 2 lists out some of the major VE projects that utilized a mixture of 3D CAD and GDK.

Year	VE Project	GDK	Developer	Description/Comments
1998	Virtual Florida Everglades National Park	**Unreal**	Project leader: Victor DeLeon	A project to educate the public and also promote ecological awareness
1998	Notre Dame Cathedral of France	**Unreal**	Digitalo Studio	Funded by UNESCO. Demo can downloaded at http://www.vrndproject.com.
1999	Long Island Technology Center	**Unreal**	Perillith Industrielle for Rudin Management	Demo can be downloaded at http://www.unrealty.net.
1999	Heartland Business Center	**Unreal**	Perillith Industrielle	An office complex in New York.
1999	HypoVereinsBank	**Unreal**	Perillith Industrielle for Turbo D3	Virtual bank in Germany. Demo can be downloaded at http://www.unrealty.net
2000	Virtual Graz of Austria	**Unreal**	Bongfish	Graz is the second largest city in Austria. Funded by UNESCO.
2000	Virtual International Space Station – VISS	**Unreal**	NASA Langley Research Center Spacecraft & Sensors Branch	An International Virtual Space Station. Demo can be downloaded at http://www.unrealty.net
2000	Cambridge University and Microsoft Science and Technology site in West Cambridge	**Quake 2**	Martin Centre for Architectural and Urban Studies, Cambridge University	Part of a project on using electronic communication between buildings' architects and their eventual users
2000	CAVE Quake 3	**Quake 3**	Visualization and Virtual Environments Group, NCSA	A CAVE system based on the Quake 3 Arena engine. Web-site at: http://www.visbox.com/cq3a/.

Table-2: Major VE projects utilizing GDKs

CURRENT SHORTCOMINGS AND SOLUTIONS

High Licensing Fees

Licensing issues can be a hindrance to serious VR developers. To license the Unreal engine can cost approximately USD 350,000 and the Quake 3 Arena engine approximately USD 500,000. They are currently reported as the best game engines but may not be cost effective for small size construction projects.

However, there exist engines that are affordable to users e.g. V12 engine (Sullivan, 2001). It has been developed by GarageGames.com, which consists of components such as the scripting engine, mesh engine, mission editor, terrain engine, particle engine, interior/building engine etc (V12 FAQ, 2001). With such features, VE developers can easily create virtual worlds with more concentration on the design, creativity and not the underlying codes.

Another company that is highly involved in making 3D game engines affordable to the mass public is Morfit, Inc. They are currently licensing their latest software technologies that include NorthDragon 3D WebMaker v.1.5, Morfit 3D Developer Studio v.5.0 for: Microsoft Visual C++, Borland Builder, Borland Delphi, and Microsoft Visual Basic for only USD 49 for non-commercial and USD 399 commercial purposes.

No Official Manuals

Most GDKs released to the public do not come with official manuals from the developers. It can be a daunting task to learn how to use these GDKs without a proper user guide. Due to the popularity of the game itself, immense online support from gamers throughout the world share their experiences in creating new game levels or virtual worlds based on these games. Therefore there are many online resources such as unofficial user's guide, manual, tips and tricks etc are widely available on the Internet. Sweeney (2000), one of the main programmers of Unreal states, "As the online community learns more about building levels, we will see complete online worlds spanning hundreds or even thousands of levels interwoven by teleporters". Therefore, it is the online communities that are currently the only main source for free support to knowing and exploring more about the game, the game engine, and the GDK.

Lack of Awareness and Acceptance

In February 2000, a report on VR Awareness Campaign of UK businesses for the Department of Trade and Industry (DTI) of the UK (Cydata Limited, 2000), clearly showed that the country's construction industry was one of the top 5 key sectors that can benefit from VR. Others were Automotive, Aerospace/Defense, Oil/Gas, major Engineering Contractors and etc. 82% of construction industry respondents reported increase of awareness after the campaign. The sector was the 2nd after the Telecommunications sector.

The report also concluded that the general reasons for inactivity of VR in UK businesses were:

Reasons given:	%
No need/ not relevant	**20**
Lack of information	**18**
Lack of applications	**18**
Cost	**17**
Standards/Compatibility problems	**8**
Technology problems	**2**
Other (e.g. company too small; not ready; other priorities; no perceived benefit)	**44**

Table-3: Reasons for inactivity
Source: Cydata Limited (2000)

Based on Table-3 above, more awareness campaigns regarding the benefits of VE applications are needed. The acceptance what is currently the best solution to developing a better VE application lies in the gaming industry is also required.

CONCLUSION

We strongly believe that game engines and design concept will accelerate the adoption of real-time VE applications by construction industry including architectural walkthroughs, 4D planning, virtual pre-construction planning processes and many more. The VEs constructed using GDKs will also provide infinite architectural possibilities and will give users e.g. client and designer the contentment they need to virtually experience it (Patel, 1994).

In the case of utilizing the GDK coupled with a 3D CAD model, the time to render and re-render geometries with full real-life textures and lighting support will take a minimal amount of time (Millano, 1999) instead of hours or days like the one present in commercial CAD, 3D modeling and rendering software packages. The ability to integrate CAD and 3D Game Engine to developing a low-cost that still maintain high-performance VE application is beneficial especially for those directly involve in construction industry e.g. architects and interior designers to replace conventional techniques of design representation.

The gaming technology is designed with a one main goal i.e. to run on almost any entry-level hardware, affordable and easy to use. Hence utilizing 3D game engine and GDK can result in lower cost of developing a VE application. This technology will greatly improve the real-time visualization technique needed in a VE application, especially in resulting higher frame-rates and higher quality resolution images, it greatly enhances the users' experience in the virtual environment portrayed.

The challenges outlined above are diminishing and overcome as newer technologies are invented.

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