Inform, Entertain and Educate: Developing and Exploiting Virtual 3D Campus Models

Hugh McCabe, Matt Smith, George Kelly, Alan Pike, Stephen Sheridan
Institute of Technology Blanchardstown,
Blanchardstown Road North,
Dublin 15
email: firstname.lastname@itb.ie

Abstract

In this paper we describe a suite of applications centered on a 3D virtual model of the Institute of Technology Blanchardstown (ITB) campus. Our motivation for creating this model is discussed, along with the practicalities of its implementation. We then present a number of applications that utilize the model. These include: a system for remotely exploring the campus over the Internet; a physics-based driving simulation situated on the campus; and an application that uses game engine technology for rapid rendering of, and interaction with, the 3D campus model. In each case we discuss the core technologies involved in the application. We conclude by describing our overall goal for this work, which is to develop a system for health and safety training using 3D and gaming technology.

1. Introduction

Modern computer technology supports real-time interaction between users and virtual 3D worlds. Such systems can be developed for many different purposes (entertainment, training, computer aided design, architectural visualisation and so on). This paper describes an ongoing research project at ITB based around a virtual 3D model of the Institute's campus. We describe a series of applications that utilize this model. These have been developed to explore a range of technological approaches for implementing real-time interactive virtual 3D worlds, and also to explore the effectiveness of these approaches to meet a range of informational, entertainment and educational goals.

We first review existing research on educational aspects of interactive media and on the emerging field of *serious games* [12]. This work provides a context and motivation for the development of our virtual campus system. We then describe the development of the virtual campus model. The remainder of the paper deals with the sequence of applications developed, including a VRML campus exploration system, a web-enabled Shockwave campus driving simulation, and the most recent system being developed which uses an open source graphics engine with the aim of providing health and safety training for Institute staff, students and visitors.

2. Related Work

Since they were first technically possible, interactive multimedia computer systems have been developed for information purposes, including interactive encyclopaedias, CD-ROMs, information kiosks, multimedia websites, and so on. Almost as quickly, such technologies were also exploited for entertainment purposes – for example the first video game "Spacewar!" (as claimed by [7]) was developed in 1962 inspired by the science fiction writing of Doc E. E. Smith. *Interactive multimedia information publishing systems* aim to support a user's information retrieval goals, such as locating a person or room in a building at an information kiosk, or finding a diagram or explanation of a technical term. *Interactive multimedia entertainment systems* aim to support the user's personal satisfaction goals – i.e. having fun.

The use of entertaining interactive multimedia to support learning is often referred to as *edutainment*. However this term is falling out of favour with educators who are seeking to develop interactive multimedia entertainment systems to help students achieve specific learning outcomes. It usually simply denotes CD-ROMs, DVDs and computer games published by entertainment companies, who are trying to add "education" as another feature to entice people to purchase their products. In addition, whether correctly or not, the term "edutainment" has become closely associated with software systems targeted

towards young learners (under 10s or young teenagers). In the last few years the term "serious game" has begun to be widely used, although it is still a term broadly interpreted in different ways. We shall use the term "serious game" to refer to an interactive multimedia system designed to support the learning of specific skills and knowledge, and presented to the user in the form of an entertaining game.

Perhaps the most important difference between a serious game and an entertainment game is the *intention* of the system developers. Developers of a serious game have the intention that the system users will be changed by the experience – i.e. that they will learn (to some extent) a desired set of knowledge and skills. However, developers of games for entertainment do not mind whether, or how, or to what extent the system users learn while engaging in the game-playing experience. Learning is often defined in terms of a relatively permanent change in behaviour occurring as a result of experiences (for example see [5]). This definition has its roots in behaviourism (in modern times based on the extreme behaviourist views of Skinner [6]) but as a definition it nicely summarises the intention of change of the learner intended by educators, regardless of the psychological school(s) of education an educator supports.

The following definitions of "game" and "serious game" are given by [12] as follows: "Games are a voluntary activity, obviously separate from real life, creating an imaginary world … that absorbs the player's full attention … played out within a specific time and place … according to established rules"; "A serious game is a game in which education … is the primary goal, rather than entertainment". We would add to these definitions that games and serious games should be enjoyable to the players, and that from the player's point of view the enjoyment and entertainment should be sufficient as a motivation to play the game, regardless of any knowledge (or not) of educational agendas motivating the design or development of the game.

Hogle [8] classifies games with educational aims into (i) simulations, (ii) microworlds and (ii) games (which we shall refer to as "serious games"). Simulations are interactive models of artefacts or processes that attempt to differ little from the real-world counterpart they simulate (although often by neccessity they are simplified versions of that which they model). Examples of simulations for educational purposes are car driving and aeroplane flying simulations for safe training of vehicle learners (for example see [13]). The goal of educational simulation developers is to assist learners by providing low cost, available, safe experiences to experiment with. Thus pilots and drivers can begin their training in simulators that allow dangerous conditions/reactions to be experienced and avoided in future. Other simulations allow students (perhaps school pupils) to gain experience of the use of devices their schools could never afford – such as radio telescopes or car assembly robots.

Microworlds are similar to simulations in that they simulate an environment or virtual world. However, they do not need to simulate a real world process or artefact, or if they do, they do not need to be true to their real-world counter part. For example the concepts of physics can be learnt in virtual laboratory microworlds [9][14].

Serious games are entertaining games in their own right, however their developers have designed them to encourage the players to learn and develop particular knowledge and skills.

Our work with the interactive 3D multimedia campus simulation demonstrates its use for all three of these categories of games – a driving simulation, a microworld allowing unguided exploration (also one with support for information retrieval) and a serious game aiming to help staff and students learn important procedures, routes and safety equipment locations to increase life saving behaviour in the event of a fire.

3. Building the 3D Model

It was decided at the outset that we were interested in building serious gaming applications that were situated within a virtual representation of the ITB campus. Therefore, the initial stage of the project involved building a detailed 3D model of the ITB campus. The general layout of the campus is shown in Figure 1.
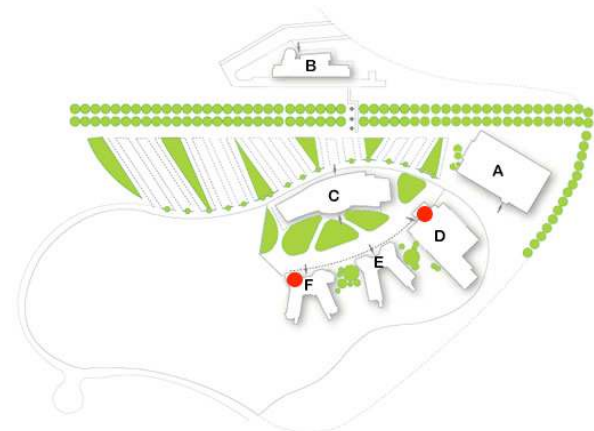

Figure 1: The ITB Campus

The model was built using the 3DS Max modeling application. 3DS Max has a number of advantages for

carrying out this type of work, including a flexible and intuitive set of modeling tools, and the capability to export the results in a variety of different formats. Creating a detailed 3D model in this manner is complex and time-consuming. The process essentially consists of two major tasks. The first task is to create the *geometry* of the model. This is a three-dimensional geometric representation of the buildings and other physical items on the campus. The geometry consists of three components:

Landscape: It is important to correctly model the ground on which the campus is located. In our case this included approach roads, pedestrian walkways, a car park, and green spaces surrounding the buildings.

Building Exteriors: There are six separate buildings on the ITB campus and the exterior of each was modeled in detail.

Building Interiors: The interior of one building, the C Block, was included in the model. This is a multi-purpose building housing the restaurant, sports hall, and student recreational facilities.

In all cases the availability of architectural plans was crucial to the feasibility of creating the model. These plans were not in an electronic format that could be imported into the modeling application, but proved extremely useful as a means of ensuring that correctly proportioned building footprints could be established. Creating the detailed geometry of each building was done using the various tools provided within the modeling application.

Figure 2: View of 3D Campus Model

After creating the geometry of the model a second important task was to carry out the *texturing*. This involved generating images of all materials present on the buildings and surroundings (for example wood textures, brick textures, grass and so on) and also images of facades of buildings and interior walls in order to capture detail not modeled geometrically. In most cases this was accomplished using a standard consumer-level digital stills camera. Figure 2 shows a view of part of the resulting model.

4. Campus Exploration System

Once the model had been created, the next stage of the project was to start developing applications which made use of it. The first application developed was a system to allow the user to explore the virtual campus interactively. Our goals for this application were that it would be:

Platform-independent: The application should be usable across a wide variety of computing platforms.

Internet-accessible: The application should be usable across the Internet so that it can form part of the ITB website.

Interactive: It should allow the user to navigate around the 3D campus model in an intuitive manner.

Informative: The application should provide relevant information to the user so that as they are using it, they will be gaining useful information about the ITB campus.

The key factor in choosing a technology with which to build this application was the necessity to ensure its accessibility over the Internet. Various technologies exist for delivering 3D content within a web browser (see [3] for a discussion of the merits and demerits of various techniques). The technology chosen was the Virtual Reality Modeling Language (VRML) [4]. A number of factors made this an obvious choice. Subject to downloading a small plug-in, which is freely available, VRML content is accessible within any browser on any computing platform, and accessible across the Internet. Navigating around, and interacting with VRML worlds, is simple and intuitive and the VRML plug-in automatically provides sophisticated navigational controls. VRML also provides flexible methods of attaching informational content. The VRML can be embedded within standard web pages and links can be added between VRML and HTML pages. Finally, converting existing 3DS Max models into VRML content is a relatively straightforward process.

The application is embedded within a set of web pages through which the user initially interacts with it. A screenshot of the application is shown in Figure 3. It consists of a number of significant modules:

Walkthrough module*:* This places the user at a fixed initial position within the 3D campus model and then allows her to walk around the campus using standard VRML navigational controls.

Flythrough module*:* This places the user at a fixed initial position in the air above the campus and allows her to use VRML navigational controls to fly around the model and hence gain a birds-eye perspective.

Map module: This presents the user with a static overhead view of the campus in which all of the buildings are visible. Clicking on a building will bring up information about the purpose of the building and also load up the *walkthrough* module with the initial starting point situated in front of that building.

Information Module: This is a set of HTML pages providing information about the ITB campus. It is linked to the VRML model in the sense that many of the hyperlinks within it will bring the user to the relevant parts of the 3D model.

Figure 3. The VRML Campus Exploration System

5. Driving Simulation

A key goal of this work is to develop applications using the 3D campus model that are geared towards engaging the interest of both existing students and potential new students. While the VRML campus exploration system fulfilled its stated goals, it relies on a slightly outmoded form of technology that does not reflect the cutting edge of current work in computer graphics or game technology. One consequence of this is that the quality of the graphics, and indeed the

overall experience, is far inferior to that commonly experienced by students familiar with either PC or console games. Another shortcoming of the system is that the form of interaction employed, walking or flying around the campus, is not likely to excite the interest of students who are used to far more sophisticated and dynamic ways of interacting with 3D virtual worlds.

These considerations motivated the development of a second application more specifically geared towards this audience. Our goals for this application can be summarized as follows:

Compelling interactivity: A form of interactivity more in line with that commonly experienced in modern computer games.

High quality graphics: A graphical experience comparable to that delivered in computer games.

New technology: The employment of current and innovative graphics and gaming technologies.

In order to fulfill the first goal it was decided to implement a *driving simulation*. The idea here is to allow the user to drive a car around the virtual campus, thus providing a more engaging and dynamic experience. Modern computer games implement extremely realistic driving experiences by using *physics simulation* [15][16]. The idea is that as well as having visual properties associated with them, objects within the virtual world also have physical properties, such as mass and volume. This allows the physics simulator to calculate the velocity and acceleration of these objects by taking into account global forces such as gravity, and also more localized forces produced as a result of collisions and user interaction. Applying this principle to cars results in vehicles whose movements and interactions with their environments are extremely realistic.

Figure 4 shows a screenshot of the driving simulation application. It was created using custom software designed by CanDo Interactive [1]. This software takes as input a 3DS Max world, with certain modifications made, and generates a Shockwave application that contains a fully physically simulated car. The software also allows the developer to add other functionality by editing the 3DS Max files.

The basic application allows the user to drive the car rapidly around the campus. All physical interactions are handled realistically so the car can collide with objects, knock them over and so on. The physical simulation also ensures that the driving experience is realistic and convincing, as braking, acceleration and the effects of friction are all included.

Additional functionality was added to the application in order to provide a more game-like experience. This takes the form of a challenge whereby the player has to locate and pick up a number of objects that are scattered around the campus. They are picked up by simply driving over them and if they are all picked up an exit sign is revealed in the car park. If the player manages to pick up all the objects and reach the exit before a specified time limit is reached, then he wins the game.

Figure 4: Driving simulation

The driving simulation system has been demonstrated to numerous students at ITB promotional events such as open days and has proved extremely successful and popular. It provides a compelling and entertaining experience that promotes a positive and exciting image of the Institute but it also can be used to as an informational device. This can be done, for example, by informing the player of the location of the objects to be picked up in advance. For example, he can be told that one object is "in front of the library" and another is "by the door of the canteen" and so on. This means that to complete the challenge successfully, the player needs to familiarize himself with the basic layout of the campus.

6. Game Engine Application

The previous application fulfills the stated goals of compelling interactivity and use of new technology but the graphics are still relatively primitive compared to the level of realism present in modern computer games. Similar shortcomings are also evident in the VRML navigation system. In both cases this is a result of the development platform being used. Neither are designed for high-quality graphics but rather for low-bandwidth transmission, as both platforms are geared towards delivering 3D graphics over the Internet. Another shortcoming of both applications is that the level of functionality that can be incorporated is relatively limited. In the case of VRML, the basic functionality provided is navigational controls. Additional interactivity can be added by attaching dynamic behaviors to objects in the VRML world, but there is still a limited range of possibilities. In the case of the software used to create the driving simulation, we are similarly restricted to the functionality provided by the designers.

It was clear that neither approach would be suitable as a basis for creating a sophisticated and flexible software program for serious gaming applications. For this reason work is currently ongoing on the use of *game engines* [2] as a means of developing applications to render and interact with the campus model. A game engine is a software system that implements all of the basic functionality of a modern 3D computer game. This will typically include the ability to rapidly render 3D models and worlds, the ability to deal with keyboard and mouse events in order to provide interactivity, and also components to handle networking, audio, physics and so on. The use of such engines simplifies the process of developing games, as all of the low-level functionality is already present, thus allowing the developers to concentrate on design and content issues.

Figure 5: Campus model rendered in game engine

Figure 5 above illustrates the campus model rendered by a client developed with the OGRE [10] open source engine. A games engine is being developed around this graphical client to support users playing of a goal-oriented serious game. The use of a pre-existing engine to do this has distinct advantages. Firstly, the quality of the graphics is extremely good in these systems as they can directly access the 3D rendering hardware of the PC. Secondly, they can be

used to program any sort of interactivity or functionality we want. At present our application can be used to render and navigate rapidly around the ITB virtual campus. Our current work involves developing this into a serious game that is aimed at improving the player's health and safety knowledge of the following for the ITB campus:

Fire Escape Routes*:* routes for fire escape from each floor of each building

Fire Assembly Points: location of fire assembly points after exit from each building

Equipment Location: location of fire fighting and first aid equipment in each building

The game itself will involve many of the features of "first person shooters" such as Quake and Doom. Examples of the types of features that can be incorporated include:

- spawning at a random location in the virtual world when joining a game and after dying

- score increments based on interaction with other computer controlled characters (although in this game they will be on fire or injured and the aim is to aid them with fire and first aid equipment)

- score increments related to speed of solving tasks (such as reaching a destination such as a fire assembly point)

- individual "health" points that can be increased by picking up first aid equipment

Possibilities also exist for competitive interaction with other human players. For example, players may be able to compete by taking turns to make the world more difficult. This could be done by removing nearby equipment from the campus, by locking or blocking nearby exits, or by forcing the other player to navigate an unfamiliar route.

As can be seen from the preceding, the aim of this serious game is to provide as many of the enjoyable, challenging and familiar aspects of first player shooter games to users as possible, but in such a way as to encourage (or even require) that the well-defined educational goals be met as an integral part of a successful game-playing experience.

7. Conclusions and Future Work

Although a more complex approach, the development of a multi-user game engine based around a sophisticated graphical rendering system, has opened up possibilities for both improved quality and speed of graphical rendering, and a more sophisticated interactive experience. We are confident that our latest virtual campus system will yield an effective educational and entertainment user experience based on the quality of existing game systems such as the OGRE graphics engine (e.g. see [10] and the gallery at [11]), our current prototype, and the focused educational goals for the serious game we are developing,

In parallel with the development of the serious game system, we are engaging with the Institute's heath and safety representatives to undertake experiments to evaluate staff and student knowledge of fire procedures, routes and equipment locations. The experiments will involve pre-tests for all participating staff and students. The participants will then be split into three groups (a) a control group who will be given no additional training; (b) one group who will be given typical seminar and handout training by an Institute health and safety officer; and (c) a third group who will be asked to play the serious game for a similar period of time as the seminar. Our intention is to then carry out an evaluation and testing process in order to determine the effectiveness of training in this manner.

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