

An Application of Game Technology to Virtual University Campus Touring and Interior Navigation

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Many applications optimistically claim the title of virtual campus tour nowadays with a small minority deserving it. Throughout this paper various virtual campus tours are explored and analysed along with the problems of interior navigation. The technologies that support development of virtual worlds for computer games are studied and a solution to interior navigation and virtual campus tour derived from this technology is proposed.

Keywords—Interactive Virtual Campus Tour, Application of Game Technology, Interior Navigation

I. INTRODUCTION

Virtual tours supply information via multimedia, giving users the impression they are navigating locations and experiencing them in real time [1]. Successful tours provide an experience such as visiting the actual location. This is accomplished by using characteristics which realistically represent the place, giving a uniform environment which makes the virtual and real one almost indistinguishable. Characteristics such as: exact imagery or representation of objects, accurate layout, major land marks, available facilities, interactivity and the ability to freely navigate in the virtual environment.

Virtual touring can be used for more than just the novelty of visiting places remotely in a digital environment but it also can be used as a medium for promoting facilities through engaging and immersive interactive experience. For a site such as university campus, potential students and visitors in particular, often struggle with the layout of facilities and spend a lot of time lost. Satellite navigation systems have successfully assisted with this issue for many years now, alongside other technological advancements such as Google Maps (google.maps.com). These solutions however, only work in the open air environment; there is still need for a solution for interior navigation.

The advancement of game technologies have now made it possible to create realistic, highly interactive environments at an affordable and relatively quick production time. This paper investigates into the use of game engines to develop a highly interactive virtual campus tour application. There is a discussion into the approach taken and the challenges faced with this solution to the navigation and exploration of interior of buildings. Section II describes the common virtual campus tour solutions that are currently in use by most of the UK

Universities. Section III provides an overview on game technologies and the tools that support content creation. The implementation of the LJMU virtual campus tour is then described in Section IV and Section V present details and findings from the experiment which was designed to evaluate the virtual campus tour implemented using game technology. Finally, Section VI concludes and presents our future works in the area of virtual campus tour.

II. EXISTING VIRTUAL CAMPUS TOUR SOLUTIONS

The virtual campus tour is an effective way to show the public facility of a site. Many of the Universities in the UK have some form of a virtual campus tour on their website to show to their web visitors and particularly potential students both national and international the facilities at their respective campus. Based on our survey of fourteen UK Universities, the types of virtual campus tour provided in the Universities website include still image gallery, video gallery and 360° Interactive Virtual Tour.

A. Still image gallery

The still image gallery is one of the most common methods in use, providing exact imagery of various locations throughout their respective campus. Universities which feature an application such as this include: Liverpool, Liverpool Hope, Liverpool John Moores, Bath and Bangor see Fig. 1.

Image Gallery



Fig. 1. Virtual Campus Tour of Bangor University, Image Gallery

The images in these galleries do not provide any form information where the buildings are located within the campus site. The sole purpose of the images is to present positive impression of the buildings of the university campus. This kind of application discredits the meaning of virtual tour and is more acceptable for used in a promotional pamphlet.

B. Video gallery

Video galleries are effectively the evolution of image galleries, usually presented in a similar manner, but with much richer content. Videos provide continuous imagery, improving from still images and allowing for some attempt at a mental composition of a floor plan. The inclusion of sound also supplies an idea at the ambience of an area giving some detail as to the real location.

Videos as a solution to virtual touring however, do little more than images. Video-based virtual tour still provides very linear content and gives the user very little control over what they view. They also have a habit of being accompanied by a presenter, who has an uncontrollable urge to block 50% of the screen and make any viewing of the surroundings near impossible. These individuals seem to thrive at being exceedingly monotonous and make what should be a good experience a daunting task. The UK Universities featuring video galleries include Dundee, Nottingham, Portsmouth and Kingston see Fig. 2.

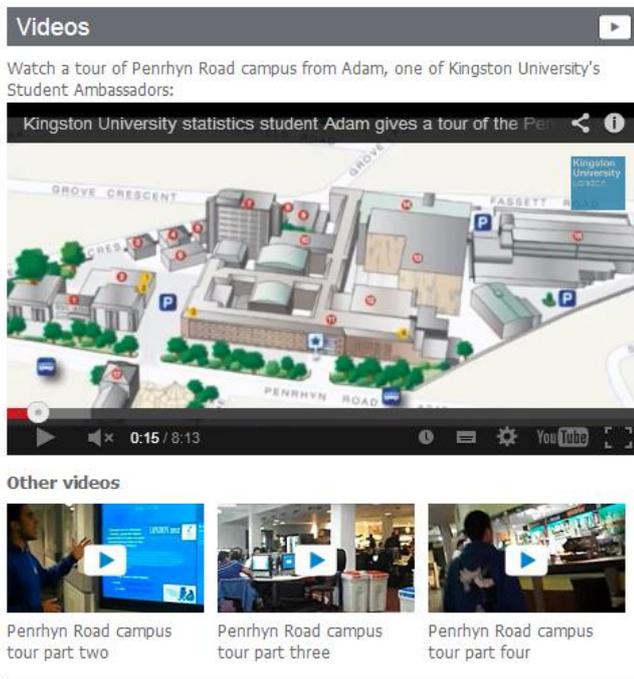


Fig. 2. Kingston University, Video Gallery

C. 360° Interactive Virtual Tour

The 360° interactive virtual tours are one of the few solutions which provide a “real” tour experience. There are two variants of this virtual tour solution: panoramic and 360°. Panoramic tours give the user the ability to view a room across the horizontal axis, scrolling left and right to view a continuous image around a location. Whereas, the 360° tours allow the user to move at any angle and have full control over what is

viewed. Similar to that of a real world tour; allowing the user to choose what they view.

In comparison to the image gallery and video gallery, the 360° tour provides the better experience by far, allowing users to interact with the environment opposed to observing it. The method however, is still not a perfect solution. Users are able to view locations from various angles but they are always viewing it from a fixed location. In addition, they are also limited on what they can view and do not indicate how areas are linked due the excessive blind spots these tours provide. The UK Universities which feature this type of tour include Sussex, Hertfordshire, Heriot Watt, Oxford and Newcastle see Fig. 3.

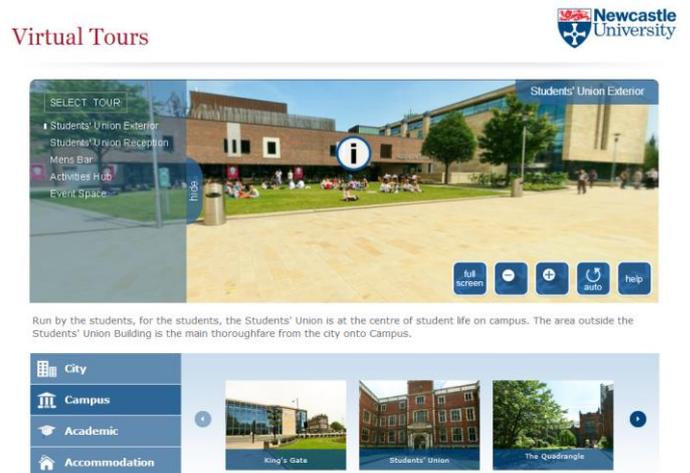


Fig. 3. Newcastle University, 360° Interactive Virtual Tour

Aforesaid this virtual tour does its jobs but it still limits the user from freely exploring the campus. The next section, explores using game technology for the creation of a true virtual campus tour, with no fixed positions and area restrictions. We believe a virtual campus tour developed using game technology can provide more immersive experience and give more freedom of interactions to explore the environment with the aims to plan the route and to locate facility inside a building.

III. GAMES TECHNOLOGY AND DIGITAL CONTENT CREATION

The modern 3D video games provide more than just an objective, enemy and set of rules. Games today, provide highly realistic physics along with fully immersive environments. The same technologies can also be used to create immersive interactive virtual campus tour that allows users to freely explore the interior of a building modeled after the physical artifact.

In this section, we identify the key game technologies to an interactive 3D virtual tour solution and describe the tools that are used to develop the 3D assets and compose the scene for the virtual campus tour.

A. Game Engine and its components that support Development of Virtual Campus Tour

Game engines provide the core technologies that aid developers to produce a variety of games rapidly. These components are used to handle task such as handling user input

from human interface device and Graphical User Interface (GUI), simulating motion and artificial behavior, simulating physicality in virtual environment, updating internal states of game object and rendering visuals on the screen [2].

For the development of a virtual campus tour solution, the following game engine components are crucial to the operation of the interactive virtual tour:

- **Renderer** is responsible for displaying both 2D and 3D assets on the screen. It performs all the necessary computations to generate imagery that represents the virtual campus.
- **Game Physics** allow for the application of real world restrictions to the virtual world such as the inability to fly and travel through walls. This adds realism to the interactive experience when navigating and interacting with solid objects within the virtual campus.
- **Lighting** helps to illuminate and add more depth to the 3D objects within the virtual environment. It also helps to set the mood of the environment.
- **Audio** can help to set the mood of the virtual environment and thus providing an additional level of immersion.
- **Graphical User Interfaces (GUI) and Head Up Displays (HUD)** provides the necessary visual elements to display information and present graphical-based input options to users.
- **Inputs** enable human interface devices such as keyboard and mouse to relay user's action which can then be mapped to actions that allows user to explore the virtual environment.
- **Scripting** allows developers to access game engine functionality and program the mechanics and interaction of the virtual campus tour without the need to alter any of the game engine implementation.

Game engines are now more accessible to the hands of developers. Most of the modern game engines come with the aforementioned component and the more advanced game engine such as Unreal Engine, CryEngine and EgoEngine are packed with grander features and sophisticated tools that enable creation of high quality game software [2]. Game engines can vary in features, support and price for the license. Since most of the virtual campus tour is often developed as an online marketing tool, it is important that in-house developers of the virtual campus tour decide on an affordable game technology platform which can still provide the required functionalities.

B. Game Level Editor

In the production of computer games, game designer often rely on tools to help them author the virtual environment using assets that are produced using digital content creation tools [4]. The game level editor provides a friendly user-interface that help users author and visualize the virtual environment. Many features within the game engine can be turned on and off via the User Interface (UI) within the game level editor. This simplifies the workflow and reduces the time producing virtual campus tour. Examples of game level editor include Unreal

Engine (<https://www.unrealengine.com/>) and Unity (<https://unity3d.com/>).

C. Digital Content Creation Tools

Digital content creation (DCC) tools are used to produce all the assets such as the 2D graphics, 3D models and audio for the purpose of virtual world scene composition. For 2D graphics, tools such as Adobe Photoshop is used to create graphics for GUI and textures that will be used for the 3D models. The creation of 3D assets will require the use of 3D modeling tools such as 3D Studio Max and Maya. These tools also provide the facility to create key-framed 3D animation which can be ported to game engine. Alternatively, 3D assets can be produced using digital sculpting tool such as Mudbox and ZBrush which provides more fluid manipulation of vertices to ease the creation of form and textures for organic-shaped models [3].

These tools are generally used by digital artists to create 2D or 3D artifacts for use in the creation of virtual world. Creation of assets needs to conform to the requirements of the game engine to ensure assets are rendered correctly and do not cause run-time performance issue. In the next section, we describe the process we undertake to implement the Liverpool John Moores University (LJMU) virtual campus tour.

IV. IMPLEMENTATION OF A VIRTUAL CAMPUS TOUR USING GAME TECHNOLOGIES

Our review in Section II has identified the weaknesses of existing virtual campus tour solutions used by most UK University to promote in-campus facilities. We believe a virtual campus tour build using game technology can overcome the identified weaknesses and provides opportunities to incorporate interesting activities that further introduces services and facilities made available to students and visitors.

A. Scope and Requirements of Virtual Campus Tour

The current LJMU operates in three different campuses in the city of Liverpool. In this project, we have limited the scope of the virtual campus tour cover only include the 7th Floor of the James Parson's Building at the city campus which has open study area, computer labs, research labs and staff offices for the School of Computing and Mathematical Sciences.

Based on our assumption, the intended audiences of the virtual group are users between the aged of 18-50 years old. Users could be students, parents of student, or adult visitors on business visit to the University. These users seek spatial information that can help them plan their visit or provide them information about facilities offered potential students.

Our aim is to create an accurate representation of the 7th Floor of James Parson Building in the virtual campus environment that would give positive impression and help users to visualise the environment through the use of the virtual campus tour solution. In order to achieve this aim, the layout of the site must have close resemblance to the physical world, the scale and aesthetic of the 3D objects need to be realistic and clearly recognisable, and the virtual tour need to include all necessary objects such as chairs, desks and computers to populate the scene.

The virtual campus tour needs to be user friendly and addresses the technical ability of the intended audiences. Since some of the intended audience may not be technology-savvy,

the virtual campus tour will consist of two modes; (1) an interactive mode that allows technology-savvy user to navigate the environment using the conventional first-person pc game control (WSAD or arrows) keys and mouse to navigate around the virtual environment, and (2) a less interactive virtual tour that presents an automated walkthrough of the virtual environment for the less tech-savvy users. The virtual campus tour will also provide users with the ability to be positioned directly to a specific “spawn location” of choice without the need to traverse through the connected spaces before getting to a location. This provides another degree of freedom of navigation where users can have direct access to the location within the virtual world and explore the area that interests them the most. The environment will also be populated with digital billboards that present additional information about the facility upon interaction. Finally, this virtual campus tour must be deployable to web and made and made accessible to the intended audience.

B. Choice of Technologies

There are two different clusters of technologies to decide on for the development of the virtual campus tour; (1) technology for producing the assets and (2) the game technology that runs the virtual campus tour.

In this project, we have chosen to model the 3D assets are modeled using Autodesk 3Ds Max and textures are created using Adobe Photoshop. Both of these tools provide the necessary functionalities to create 3D assets to compose the 3D virtual environment.

Amongst the game technologies identified in section III.A, the Unity Game Engine (www.unity.com) is the choice in this project for two obvious reasons. The Unity game engine provides a very user friendly environment to develop 3D game and it has well documented online supports to aid developers. In addition, it allows games to be published to multiple platforms including the web where audiences can run interactive real-time 3D within the web browser using the Unity Web Player plugin.

C. The Development Phases of Virtual Campus Tour

The development of the virtual campus tour can be broken down into three phases – planning, asset production and development (see Fig. 4).

Once the scope of the virtual world was finalized, the physical site was visited and reference photos were taken using a smartphone camera. These visual references were used to help decompose the site into smaller manageable sections. Assets within each section were identified and images for each of the assets were captured for reference purposes during the production phase.

At the start of the asset production phase, a common unit of modeling was agreed upon. Since it is not possible to acquire exact measurements of the site and there is no blueprint to refer to, a dummy cube of the size of an average person was used as volume guide for production of assets. Low-polygon modelling approach was used to ensure where models are modelled with the lowest possible polygon count to minimise lag time when operating virtual campus in real-time. The approach requires modeler to model the mesh of 3D asset using lowest amount of polygon before object looks deformed and unrecognizable. An

example of an asset photographed and modelled can be seen in Fig. 5. For the composition of scene (7th floor of James Parson Building), 3D assets required include walls, flooring, ceiling, recycle bins, blinds, different versions of chairs and desks, doors, keyboard and mouse, computer monitors, printers, projectors, radiators, tower, television and water fountain were modelled using 3Ds Max modelling software. Realistic texture was created by sourcing similar texture from the web while some textures are created by editing image captured. These 3D models are then exported to the FilmBox (.fbx) format which can be recognised by Unity game engine.

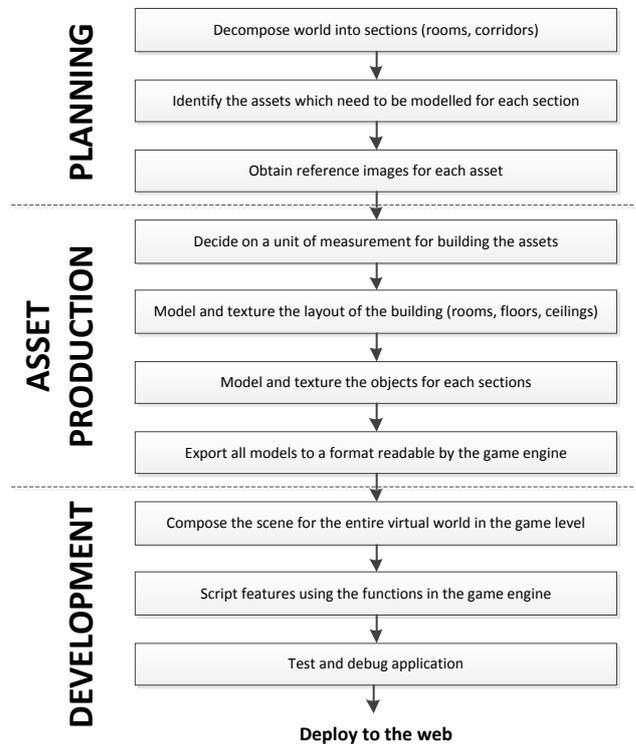


Fig. 4. The development stages of virtual campus tour



Fig. 5. Asset photograph, wireframe and model respectively

The individual assets and all models are placed into position by referring to the reference images obtained to compose the virtual environment. Once the virtual environment has been composed, the menu, collide-able billboard, pop-up head-up display (HUD), mini-map, scripted camera animation and spawn map are scripted using Unity’s game engine component. Each of the features is tested thoroughly before deploying to the web as a streaming application.

The interior navigation of the virtual campus tour is configured to provide user the first person camera view and controls. User controls the angle of the camera using the mouse control and WSAD (or arrow key) to navigate in the virtual world. The mini-map shown in Fig. 6 and Fig. 7 provides the current location information to user to aid them with navigation in the virtual environment.



Fig. 6. Screenshot of Spawning Menu

The spawn map provides the option for user to select the spawn points in the virtual campus tour. The first person camera is reposition to the user’s selected location allowing the user to explore the area that interests him (See Fig. 6). There are five spawning points implemented in this virtual campus tour (spawn points in blue from right to left of the map); (1) lobby, (2) open study area, (3) Computer Lab 722, (4) Computer Lab 724 and (5) Computer Lab 726 on the 7th Floor of James Parsons Building.

The collide-able billboards shown in Fig. 7 expand on collision. These provide information about each area and room to users whilst they are exploring the area.



Fig. 7. Information pops up when user collide with billboard

For the non-technology savvy users, the automated tour provides a linear virtual touring experience. This is achieved through definition of the paths the camera must follow in each area. This mode of virtual campus tour is less interactive and users are limited to select previous or next area to view and pause the camera movement (see Fig. 8).



Fig. 8. Automated mode in the Virtual Tour.

V. EVALUATION OF THE LJMU VIRTUAL CAMPUS TOUR

An experiment was conducted to evaluate the effectiveness of the interactive virtual campus tour. Triangulation was applied to enhance the confidence of the findings [5]. In this experiment, questionnaire, observation and interview methods were used to gather feedbacks from users and to cross validate findings.

A. Experiment setup

The experiment designed to mimic the environment and hardware that a typical user would use to go online and use the virtual campus tour. The experiment was carried out in several different locations (specialist computer lab, general computer lab, participant’s home) which have multimedia PCs with internet connection in different times and different day.

The participants that take part in this experiment can either be someone who is familiar with the site and someone who have not been to the site. This demographic can provide valuable insights on the accuracy of model and usefulness the virtual campus tour.

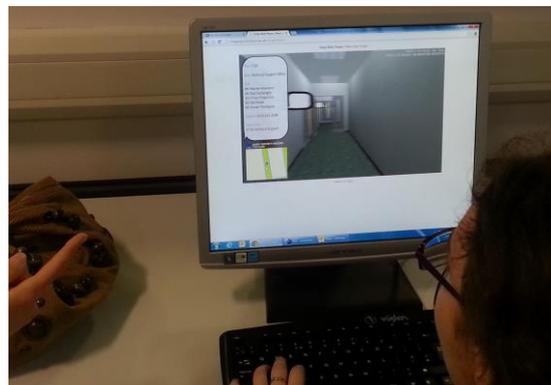


Fig. 9. Participant in taking part in the experiment.

The participants were randomly approached and were asked to voluntarily take part in this experiment. An email was set out to the participant which provides the instructions and links to (1) the pre-experiment questionnaire that gathers participant’s background information, (2) the LJMU virtual campus tour web app¹ and (3) the post-experiment questionnaires that

¹ The LJMU virtual campus tour web app can be accessed from <http://cmpproj.cms.livjm.ac.uk/virtualtour/>

collects feedbacks pertaining to the usefulness of virtual campus and their experiences.

For those participants who have agreed to take part in the experiment on the day it was conducted was observed and some were interviewed informally on a one-to-one basis. During the observation, participant's behavior and interactions with the virtual world were documented. Duration of the observation varies between 5 to 10 minutes depending on participant's ability to navigate around the virtual world and interest. Some of the participants choose to do the experiment and completed the questionnaires in their free time unobserved.

B. Findings and Analysis

The observed experiment was conducted in within 3 hours on a specific day, but the online questionnaire only closes five days later. Throughout the experiment a total of 59 participants took part. Out of the 59 participants, 76% (45) were aged 18 to 24 years; the average student age and all potential end users (25 to 35:10% (5)). The split between male and female participants were 73% (43) male and 27% (16) female.

It is evidently clear that navigating in an unfamiliar location can be difficult. Many of our respondents rely on technology to plan their journey on the day of travel or ahead of time. In our survey, 74% (43) used satellite navigation system and 98% (58) frequently planning on their journey in advanced using Google Maps. Navigating inside a building can be equally (or even more challenging) even though the space is more confined and this is supported by our findings that 95% (56) of the respondents have been lost inside a building before. This supports our initial hypothesis that an interactive virtual campus tour could help visitors plan their visit to a building ahead of time.

In this experiment, all of the respondents were asked to use the LJMU virtual campus tour and 85% (47) of the respondents confirm the likeness of the virtual campus to the real one. 91% (51) responded that they feel they would have benefitted from such an application before attending the University, while another 5% (3) which have not visited the building found the virtual campus tour useful. In the questionnaire, respondents were asked to locate a room within the virtual tour. 88% (49) manage to locate it and through our observation some participants did make use of the virtual campus tour to answer that particular question.

Our findings also shows that an interactive virtual campus tour developed as a full 3D virtual world can change how people navigate and explore a site. 66% (31) of the respondents acknowledged that they did discovered facilities they were not aware existed while exploring the virtual campus. This is encouraging considering 76% (45) of the participants in this experiment regularly visit the physical site of which the virtual campus is being modeled and 9% (5) have never visited the physical site. This would suggest that virtual exploration could help a person discover more information about a location because it does not require them to physically explore every corner of the site and there is no distraction present within the virtual environment. This would also suggest that most of the respondents are familiar with this scheme of exploration and in our survey 76% (45) say that they "play video games". This

also has a correlation with the ease of navigating within the virtual campus tour as 73% (41) of the participants state that it is very easy to navigate around the virtual campus tour because they are very familiar with the controls setup used in the virtual campus tour.

The outcome of the experiment is positive and all (100%, 59) of the respondent have expressed that they would use the virtual campus tour again. They have also express that it they would like to see the scope of the virtual campus tour expanded to entire campus. In addition, all the respondents would also like to see other building such as arenas, museum and galleries to offer similar virtual tour experience to our virtual campus tour. This is showing a trend that people are becoming more tech savvy and the technology to support rapid production of interactive 3D virtual world is now readily available to developers.

VI. CONCLUSIONS AND FUTURE WORKS

In this paper, we have surveyed the existing virtual campus tour approaches used by UK Universities to promote campus facilities. We believe that existing virtual campus tour can be made more interactive and provide users greater degree of freedom explore the virtual campus. Our virtual campus tour takes advantage of game technology provides users full 3D immerse environment to freely explore the facilities in the virtual world from their web browser and help them plan their visits to the physical campus. Our findings show that the virtual campus tour can to help showcase facilities of the modeled site (even to users who are familiar with the physical location), provide additional location related information and help users to plan their navigation inside a building. The future of this project truly has infinite avenues it could take. Furthering our research in this area, we plan to expand the virtual world to include more sites at the LJMU campus, incorporate elements of serious-play to make exploration fun and engaging, and integrating route planning facilities within the application.

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