

Educational Virtual Reality Visualisations of Heritage Sites

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Abstract

This paper discusses the use of games engines to create virtual heritage applications. The use of 3D software for cultural or heritage applications is discussed with reference to the capabilities and potential of games engines. The contribution of students from Bournemouth University to the New Forest Heritage Mapping project through the creation of interactive virtual reality visualisations of historic landscapes is described. The creation and evaluation of three different applications representing three alternative interaction styles are discussed. The first does not indicate where information can be found, the second uses visible cues and the third implements an objective marker system.

CCS Concepts

•**Software and its engineering** → *Interactive games*; •**Human-centered computing** → *Virtual reality*;

1. Introduction

The development of serious games technologies have enabled new possibilities for archaeological research to investigate and interact with a wider range of data than ever before. Virtual reality is increasingly used to extend public engagement and raise awareness about heritage sites within virtual heritage applications [CHA16]. This paper describes the collaborative research activities that are taking place between Bournemouth University, and the New Forest National Park Authority to explore the potential of using games engines to create interactive virtual visualisations of historic landscapes and presents the initial results of research that examines alternative methods of presenting information within virtual environments. The paper first briefly reviews the literature describing the use of games technologies for cultural heritage, then describes the New Forest Heritage Mapping project and the collaboration with Bournemouth University to create visualisations past environments, and finally analyses the latest results of the evaluation of alternative methods of displaying information within the virtual environments.

2. Using games technologies for virtual heritage applications

3D software has long been used to visualise archaeological artefacts and recreations of archaeological sites. Applications range from viewing and manipulating 3D objects in isolation or in pre-rendered videos [MUS17] to visualisation software used for large data sets e.g. ArcGIS [Pro17] and QGIS [QGI17]) allow the creation of detailed landscape models from aerial photographs or Lidar ([FOR16]), which can be navigated by changing the camera angle.

The recent advances in the capabilities of computer game tech-

nology has enabled the development of sophisticated environments that can be presented in interactive virtual museums that are able to entertain and educate visitors with an engaging rich user experience, which has in turn lead to higher expectations [AML*10].

The term virtual museum has developed to encompass a wide range of activities from the use of virtual reality to enhance the experience of visitors at museums [LV04] to the use of online facilities to enable online visitors to experience the content of a museum remotely [SMP*17]. Virtual museums cannot be viewed a single entity but can be categorized in the context of a range of factors including their content, the interaction technology they use, the duration of their lifetime, the manner in which information is communicated, the level of immersivity, the distribution format and their purpose or scope [Pes14]. The V-Must web site documents the state of the art of virtual museum activity as it was in 2014 [VM14].

The use of games engines software such as Unreal Engine [UE417] and Unity [UNI17] allow 3D developers to create visualisations of past environments relatively easily using pre-existing functions that enable multiple players to walk through physically correct environments at a human scale [FK04]. Currently games engines have to optimise 3D objects in order to be able to render them in real-time which is seen as a weakness for some archaeological purposes that may require more high resolution models [OIK15]. Cerato and Pescarin [CP13] also found a differences in the requirements of subject experts and non-expert in their survey of landscapes represented in virtual museums. Nevertheless realistic environments without modern road or field systems can be created and explored without present day access limitations.

Visualisations of heritage environments made with games engines that contain a high degree of detail, such as the visualisa-

tion of Midgard [PEN12], are often still used for purely presentation purposes but there is also the potential to give the player a less detailed but more immersive and interactive experience, such as with the virtual Egyptian Temple [JH05] or the Chimu virtual museum environment [NNMP*15], among other examples, that allows players to select and interact with individual objects. Visitors are motivated to explore the information contained in the environment rather than to passively receive information, and to engage with the experience for longer periods than for traditional museum exhibits [MCB*14]. The use of serious games for museums has been found to improve the visitor experience in many reports, but the way information is presented within the environments has to be designed carefully to maximise the education benefit [PS16].

3. New Forest Heritage Mapping Project

The New Forest National Park Authority commissioned a Lidar survey in order to identify and record lost and forgotten archaeological monuments as part of the Heritage Mapping project within the Higher Level Stewardship scheme. Bournemouth University has been involved in representing the Lidar data in different ways to help the public understand what it represents [SJM16]. Staff and students have been involved the creation of virtual reality visualisations of historic landscapes in and around the forest. A number of separate environments have been created as undergraduate student projects visualising a range of historic landscapes from the Neolithic to the twentieth century. The visualisations have an on-line presence and have been presented as interactive virtual museum exhibits at public exhibitions using iPads and virtual reality headsets [FOR15].

The environments have been designed with different styles of interaction in order to examine separate aspects relating to the use of games engines for historical visualisations, from the technical issues involved in the creation of the environments to the immersive qualities of virtual reality and the educational value of the environments as serious games. Of particular interest for this paper are three environments that explored alternative methods of displaying information: Rockborne Roman Villa, the Victorian gunpowder factory at Fritham and the First World War Airfield at East Boldre.

4. Presenting information about heritage within virtual reality

4.1. Unguided exploration

A visualisation was created of Rockbourne Roman Villa that allowed the player to explore the environment unguided and learn about the site as they follow their own path. The environment was made using Unreal Engine [UE417] and allowed the player to explore the environment from first person perspective. Information is presented to the player on information boards as they walk through the environment whenever they enter a trigger area (as shown in figure 1). When the player leaves the trigger area the information board is hidden again. There were a total of 20 information boards throughout the environment but there is no indication of where the information boards can be found so the players' path will not be influenced by a pre-existing route. Therefore the amount the players learn about the site relies on their own initiative.

An experiment was conducted to assess the user experience and



Figure 1: Rockbourne Roman Villa with an information board.

Table 1: Results of the comprehension test about Rockbourne Roman Villa

Platform	Virtual	Web Site	Guide Book
Percentage of correct answers	61.90%	75.24%	77.14%
Preferred method of presentation	80%	12.50%	7.50%

test how much information was absorbed compared with two alternative methods of obtaining the same information including a web site and a guide book. There were differences in the information displayed between the presentation styles, but effort was made to display equivalent information. The information presented on the information boards in the virtual reality version was taken from the guide book. The guide book contained more in-depth information boards and was illustrated with photographs of the remains, plans and hand drawn visualisations. The web site contained five pages and presented the same text as presented on the information boards, and used a selection of illustrations taken from the guide book.

30 participants who had no prior knowledge of Rockbourne Roman Villa took part in the experiment. The participants were given one of three types of presentation and were given the goal of finding out as much information as they could about the site within five minutes before taking a comprehension test. For the virtual reality presentation participants were given control to explore the environment from the first person perspective, while participants using the web site and guide book versions had the same amount of time to explore their respective versions. The comprehension test contained seven multiple choice questions with three possible answers to choose from. Questions were specific to Rockbourne to minimise pre-existing knowledge of the participants, e.g. *what year was the villa discovered*, and *how many rooms were in occupancy at it's height*.

As shown in Table 1 the participants who used the interactive virtual reality presentation gained a reasonable understanding of the site, but on average scored over 15% lower than the participants who viewed the same information in the form of a web site or guide

book. It was noticed that the question that has had the lowest score by participants who used the virtual reality environment related to objects that were on the periphery of the map i.e. the well was in the far corner and so few participants visited that location and so few were able answer the question about the depth of the well.

Feedback from participants who explored the virtual reality presentation indicated that the lack of a structured path to follow affected their score, while participants who used the web site or guidebook complained it was tedious reading through pages of text. Table 1 also shows the results of a survey that asked 40 participants their preferred method of obtaining information about Rockbourne Roman Villa. Although the participants who interacted with the virtual reality presentation performed worse in the comprehension test, it is shown to be the most popular method of presentation. The conclusion is that the use of virtual reality for virtual heritage applications is popular but care should be taken in designing the style of interaction to allow the players to control their own exploration but there should also be some kind of guidance to ensure they do not miss all the information that is available. The next two sections describe experiments using different strategies to provide this guidance for players.

4.2. Highlighting information locations

A visualisation of Schulze Gunpowder factory what was operation at Fritham during the Nineteenth Century was created using Unity [UNI17] to present information about the site. It was designed to give more assistance to the players compared to the Rockbourne application in order to enable them to find all the available information. In the Rockbourne visualisation the information boards were hidden when inactive which meant players did not know where information could be found or how much information was available. Therefore, for the factory visualisation it was decided to leave the all information boards visible at all times so that players are able to see where information can be obtained from a long distance away. Inactive boards were coloured grey so they did not distract too much from the overall visualisation of the environment, but when player moved the mouse cursor over the sign the colour changed to yellow and players had the opportunity to display the information related to the location (as shown in figure 2). When using Rockbourne Roman Villa environment some players complained they could not read the text that was displayed on the board when it was viewed from the side or from above, therefore, in the factory environment it was decided not to write the text on the sign, but to write the information directly onto the screen. The information associated with an active board would be displayed when the player pressed the Enter key and the text remained visible until the player pressed the X key, as shown in figure 2.

In order to evaluate the environment and style of interaction two types of participant were recruited which were broadly classified as subject experts and games technology students. The subject experts (8) were more interested in the content (cultural heritage and conservation) while the games technology students (11) were more interested in the technology used to create the environment. The results that cover similar issues as discussed for the Rockbourne environment are presented below.

Three alternative methods of presenting information about the



Figure 2: Highlighted information sign with text.

Table 2: Presentation type ranked by subject experts

Medium	Virtual Reality	Images	Text
Enjoyment	1st	2nd	3rd
Memorable	2nd	1st	3rd

factory were compared: text only, image only and virtual reality. Participants were first presented with text only descriptions, then as a series of high resolution images with no textual information and finally were asked to explore the virtual reality environment before completing a questionnaire.

As shown in table 2 the evaluation by subject experts found that virtual reality was considered the most enjoyable medium and text was the least enjoyable, however, when asked which medium they felt they would remember the most details from images were rated first, virtual reality second and text last. While virtual reality is considered the most enjoyable experience it is not able to render the same level of detail as a high resolution photograph which will potentially affect retention of knowledge. For the subject experts doubts still remain about the ability of virtual reality to show sufficient level of detail to replace other methods of presentation.

As shown in table 3 the games technology students ranked how enjoyable each style of presentation was in the same manner as the subject experts, but there was a difference in the way they ranked which medium would provide more memorable information. The games technology students were more interested in the environment and less interested in what the high resolution images showed and also placed more trust in the text than the images compared to the subject experts.

Table 3: Presentation type ranked by games technology students

Medium	Virtual Reality	Images	Text
Enjoyment	1st	2nd	3rd
Memorable	1st	3rd	2nd

The next section describes the third interaction strategy evaluated for presenting information within virtual heritage applications.

4.3. Objective Marker System

The third environment was a visualisation of the First World War airfield at East Boldre that was created using Unreal Engine [UE417]. This environment explored the use of techniques found in popular computer games including object markers and reward systems.

Object markers (as used in Halo 4 [FOR17]) are displayed as icons on the screen indicating where the player has to go in order to complete their objective and what is the distance is between the player and the objective. The objective marker system created by Devin Sherry was adapted to suit the East Boldre environment [SHE17]. Black diamond shapes were created to indicate the locations where information can be found in the environment, and so the objective was to find the information. The markers remain visible on the screen at all times that the player faces that direction, whether or not there are any obstacles in the way. When the player reaches the objective, information is displayed on the screen that remains visible until the player moves away from the location (see figure 3).

Reward systems encourage players to continue playing beyond the end goal of the game in order to achieve certain sub-goals within the game such as in the achievement and trophy systems found in X Box and Play Station games [CHF15]. The reward system that was implemented in the East Boldre environment was a list of objectives that the player had achieved that was displayed in the top left of the screen (see figure 3). As the player reaches each objective the title is added to list of Places Found. There is one objective that is not indicated by the marker system and so when all other objectives have been achieved the player has the option to continue playing to search for the missing objective in order to receive all the rewards.



Figure 3: The objective marker system with text

The use of the objective marker and reward system features were evaluated by comparing two versions of the environment, one containing these systems and one without. 15 participants were recruited to perform the evaluation that can be split into the same

Table 4: Comparison of ratings of the visualisations with or without object marker or reward systems

Medium	Without	With
How easy was it to find all points of interest? (out of 5)	3.07	4.8
Would you use the visualisation again? (out of 5)	3.13	4.73

classification of subject experts (6) and games technology students (9) as in section 4.2 above. The participants were asked to explore both versions of the environments and then rate their experience out of 5. Table 4 shows the results for the questions of *how easy it was find all points of interest* and *whether they would use the visualisation again*.

The results for each question were analysed by performing one-way ANOVA calculations to test whether there was a statistically significant difference between the way participants rated the two versions of the environment. For both questions the p value is less than 0.05 which supports the higher approval rating for the version of the environment that contains the objective marker and reward systems.

In order to assess whether the environment enhanced learning, the games technology students who had no previous knowledge of the airfield were also asked to complete a comprehension test after interacting with the environments. Four multiple choice questions related to the airfield were asked such as *how many servicemen lost their lives due to accidents during the war at East Boldre*, and *what was the shape of airstrip*. The participants achieved an average score of 77.76% correct answers, which indicates that a reasonably good understanding of the airfield was obtained using virtual reality.

5. Conclusions

This paper gave an overview of the latest results of an on-going project that is being performed by Bournemouth University in collaboration with the New Forest National Park Authority that explores the use of games engines for virtual heritage applications. Three different styles of interaction were described and the findings of the evaluation of each were discussed. The results indicate that the use of games engines to create virtual heritage applications has been successful. The environments can provide a good overall depiction of historic sites, although there are still concerns that the 3D models within virtual reality environments are not able to display sufficient detail to satisfy all the demands of subject experts. Players enjoy the interactive nature and control that is possible within the environments, but there needs to be guidance for players to ensure they do not miss important information. Possible future work for this project includes the performance of more in-depth evaluation of the environments to provide a consistent comparison of all three styles of interaction with a greater number of all types of participant. Additional styles of interaction could also be implemented and evaluated such as the use of overhead maps, arrows or lighting to draw the attention of players to areas of interest.

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