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Adopting Game Technology for Heritage Information Modelling

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Abstract. Contemporary Building Information Modelling (BIM) has had a huge impact on the design, construction and management of modern buildings – enabling improvements across a wide range of areas, with information on item costs, materials, vendors and a whole host of other details accessible directly within a 3D model of a building. BIM principles may also offer advantages for the management of heritage sites, but using existing BIM solutions may not be straightforward. A purpose-built alternative, the Heritage Information Model (HIM), built using a current game-engine, is detailed and discussed here.

Keywords: Heritage, BIM, Architecture, Game Technology, 3D

1 Introduction

The construction industry has experienced a technological revolution with the introduction of Building Information Modelling (BIM), which has led to significant improvements in the design, development and maintenance of buildings. Meanwhile, in the heritage domain, new technologies are increasingly being used to digitally document key heritage sites in 3D. Documentation of heritage sites with 2D photos and videos has long been in use, but 3D digital models are increasingly used for accurate documentation and communication of heritage sites [1]. There has also been recent interest in the potential of adapting BIM specifically for use with Heritage sites – Heritage BIM, or HBIM [2]. This paper explores the potential for the heritage sector to successfully adopt its own form of BIM and prototypes a new platform based on commercial game technology. We note that the types and forms of data used in regular BIM differs from some of the data that could be required in a heritage context, where historical records, conservation data and ownership are generally outside of the range of information held in current BIM applications.

A brief review of BIM and HBIM is presented, along with brief insights from a series of interviews with BIM and HBIM users and developers. The development of a prototype for a Heritage Information Model (HIM), is outlined. We use a 3D data set from Provan Hall, a medieval building located in the East of Glasgow, within the prototype

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to provide context for the prototype, to demonstrate the process of developing a HIM application and model and to provide a realistic example for review.

2 Background

2.1 Building Information Modelling

The use of BIM is well established in the construction industry [3] spanning the entire life span of a building, including project planning, design, preconstruction, construction, and post-construction (operations and maintenance) phases [4]. BIM has been categorized according to the levels of information, or dimensions it provides, where 3D BIM is a model comprising a 3D visualisation with some embedded information. The 4D component of BIM is time, where BIM can represent the lifecycle of the construction of a building. Features such as cranes fencing and traffic access during construction can be simulated and planned.
The 5D component is cost, with BIM models allowing approximate construction costs to be quickly calculated through known materials pricing and estimated construction costs. 6D refers to facilities management, where model can be handed to the owner of the building and used for a variety of purposes. The model will contain all the data on the building, and operations and maintenance work required can be referenced and updated from the model [4].

Each of these dimensions of BIM models is clearly massively beneficial when constructing a new building and all should be able to be adapted to heritage models. E.g., instead of creating a development timeline the 4D could show the historical timeline, showing how an area or building has been changed over time. 5D could be applied to model the costs relating to the maintenance or conservation of a building. 6D could relate to other operational and management information, and where a site's continued operation relies on hard to repair or obtain infrastructure, this could be highly useful in practice. However, there may be distinct features of heritage buildings that mean that typical BIM packages used in construction may not be ideally suited. Indeed, where BIM is most actively used – in design and construction – is where there is typically the least need in a heritage domain.

2.2 Heritage BIM

There are a number of case studies of attempts to use BIM for Heritage. One notable example is documents a site in Batawa, Ontario, that contains a large landscape and buildings [5]. As well as typical quantitative BIM data (intelligent objects, performance data, etc.), it was noted that HBIM also looks to record other forms of data (historic photographs, oral histories, music, etc.).
A heritage reconstruction project of The Vinohrady Synagogue in Prague used BIM as a test platform [6], using ArchiCAD to model the synagogue. It was observed that areas of the building contained intricate architecture that could not be modelled in ArchiCAD, with 2D image textures placed over simpler forms to approximate the real

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architecture. The 3D modelling features of BIM applications is typically limited in comparison to that available in dedicated 3D modelling applications.
When creating the 3D model for a heritage site there may not be original plans of the building to refer to – and even if there are, these may not accurately reflect the building as-is. Alternative methods may be required to create the model – this could be acquired in many different ways, including the use of terrestrial laser scanning for a building combined with aerial LIDAR for contextual data plus photographs, onsite inspections, heritage records, etc. (c.f. [6][7]).

2.3 Object Repositories

BIM models are rarely built entirely from scratch, with most models making use of parts from a database of assets. Websites such as BIM Store (www.bimstore.co.uk) and the National BIM Library (www.nationalbimlibrary) contain a large range of models to use in projects, many of which come with a additional integrated information including manufacturer, model, manufacturer website links, and a wide range of quantitative data. Users can then easily download the models for use in their plans.

The idea of a cloud based repository to share models and materials has also been suggested for HBIM [6]. Unlike regular BIM there will be many historical a heritage projects that will contain completely unique models. One suggested solution is to use objects that have been parameterized to allow users to make small alterations to common objects. Then the models could have more value across different projects. Additionally a database of construction materials could be stored, featuring common materials from different periods and/or locations. This could reduce the workload in creating HBIM models. Where there is limited information on a heritage site, the database could still be used to provide information on the likely materials.

2.4 Visualisation and Materials

Although BIM isn't primarily about visualization, it does involve the development of 3D models – less detailed than typical for architectural visualization but allowing users to interact with the model to virtually explore a building without constraint to pre-rendered views. Although high detail photo-realistic renderings are not as important when collaborating in the design or maintenance of a modern building, this may be of more interest for heritage models, which may be site so of significant historical interest.
The problem of accurate visualization is amplified when dealing with 4D for heritage, where a model may be represented over hundreds of years. During this time the look of the building would change drastically. Although current BIM software can accommodate simulating a change in geometry it does not consider how particular materials visually change with age.

One solution for this would be to make use of tools such as *Substance Designer*, a texturing tool originally designed for games. Within *Substance Designer*, developers can apply parameters that allow the substance to change visually at run time. This can potentially be used to visually simulate surface aging effects on a wide range of mate-

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rials. Just as [6] proposed an online database of open parameter models, an online database of open parameter materials can be developed, and some already exist – though this is primarily for use in games. One problem with these online material libraries when compared to BIM stores, however, is the lack of embedded information – as these material libraries are focused on the appearance of a surface, without care for underlying information about the actual physical materials involved. *Substance Designer* does not have the capability of using the same forms of material data held in current BIM objects.

2.5 Crowdsourcing Heritage Information

Crowdsourcing allows richer data to be collected on heritage sites, in addition to the use of established data sources [8]. However, when dealing with heritage data, there are issues with conflicting information originating from different sources, and there is a risk in allowing non-expert users the ability to directly to enter data to the model without moderation. Additionally, traditional BIM software does not feature user-interfaces that support data entry by non-expert users. In developing a new prototype, a custom interface could be developed for a specific heritage project which could be used by a wider audience including historians, local community, and other parties.

3 Requirements for Heritage Information Models

To explore further specific requirements for HBIM applications, a small set of expert interviews were conducted, with a conservation architect, a BIM software developer, BIM consultant and BIM manager (the last three employees at IES Ltd., a company specializing in energy monitoring solutions for integration with BIM).

3.1 Conservationist views on HBIM

The conservation architect interviewed specializes in traditional buildings. She stressed that current HBIM models are not tackling the problems that most conservation architects have in collecting heritage information about buildings, and this type of information come from a wide range of sources – local authorities, historic interest groups and communities, and academic research papers. To meet her requirements an HBIM model should act as a "3D database" with relevant information available from within the 3D viewer itself.

She also noted that a HBIM model should allow local community engagement by empowering people to gather and publish data pertaining to a site. For this purpose, the model or database would need to be accessible to the public as well as professionals. Having all relevant information available in one place would provide obvious benefits for production of Conservation Reports and other professional documentation.

It was noted that 3D models developed from laser scans and photographs could give an accurate level of 3D representation but typically held no information on building materials or state. She saw 3D visualizations as a separate entity than HBIM, but felt

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that a platform that combined both could be extremely useful, for example by showing how the material of a building aged over time through visual. Finally, it was also noted that BIM is not currently a useful platform to store large amounts of data in a form useful for conservationists.

3.2 BIM Developers on HBIM

The problems IES have with their current BIM software is mostly user interface related. Their key concerns are: making it easier to input the information in the correct place (without have to switch between multiple windows); encouraging users to input information and making the process less laborious; and using better visualization techniques to convey information.

It was explained that IES has looked into gaming technology to improve the visualizations created for BIM. The 3D visualization they have currently uses wireframe models and colored rooms displaying energy measurements.

Viewpoint Construction Software was mentioned as an example of BIM software for viewing and collaborating on BIM models. The software has a straight forward interface and allows users to leave notes and questions in key areas and online sessions can be created where multiple users can view the model at the same time. This software is focused in retrieving information out of a model, and does not support the design or creation of a BIM model.

3.3 Requirements Summary

The requirements for heritage focused users are very distinct from those driving modern BIM software developments. Richer forms of documentation, greater abilities to add contextual data, more support for contributions from multiple users, a possible need for moderation tools, and greater focus on visual fidelity all indicate that Heritage Information Models may not be best served by using existing BIM solutions. While conventional BIM could be extremely valuable in maintaining a heritage building that is still in use, but this this would reflect only a small part of the potential of a more bespoke solution.

4 Development

It was decided to develop a prototype of a Heritage Information Modelling, HIM, system distinct from current approaches. This would focus on integrating accurate 3D data, photo-realistic visualization, 4D modelling (both in information and visuals) and demonstrate how rich third party data sources might be stored within models and linked to the 3D representation. For demonstration purposes, data was used from a previous digital documentation project at Provan Hall.

The site is in Glasgow, Scotland, located to the North-East of the city center and comprises two buildings linked by a walled courtyard. The older part dates from the late medieval period, and is owned by The National Trust for Scotland, and maintained

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by the Glasgow Building Preservation Trust and Glasgow City Council (GBPT, 2013). Provan Hall is a Category A listed building.

The buildings are currently in need of works to improve the condition of the buildings, and a major renovation project is in early stages. The North Range building - medieval in origin with later renaissance alterations - dates from the 15th or 16th century. The South Range is believed to date from the 18th century, although parts may predate this (Stuff, 1970). In 2016, the site was digitally documented by students on the MSc in International Heritage Visualisation at The Glasgow School of Art. A complete external laser scan was performed, with some internal scanning, and a 3D model developed from the scan. Additionally, a large collection of photographs was collated, allowing the resultant model to be recreated photo-realistically. For the current project, some additional work was undertaken to resolve some minor issues in the 3D model and some additional optimizations made for real time rendering.

Texturing was completed using a mixture of textures from site photographs and textures from online repositories (e.g. for roof tiles). *Substance Designer* and *Painter* were also used to develop textures that could be adjusted at real time to visually demonstrate the effect of aging.

4.1 A Game Engine for HIM

The prototype was developed using Unreal Engine 4, UE4, a high-end 3D game engine which is capable of real-time photorealistic rendering and built in support for scripting. UE4 also provides a "post-processing volume", which can be built into a scene to provide a range of visual effects which can add depth and character to a heritage building, such as color correction, light bloom or a photographic vignette effect.

Different modes of interaction are supported in the prototype – with users able to examine and navigate through scenes through point-and-click, allowing users to quickly position and control a 'flying' camera, or first-person game style navigation, allowing users to virtually 'walk' around the scene, Fig. 1.

Fig. 1. A simple HIM prototype for Provan Hall

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A key goal, informed by interviews, was to make the interface as simple as possible. The Heritage Information Model uses pop-up windows with tabs for each category of information, Fig. 2. To simplify the visual presentation, there is a limit on the number of windows open at any one time to a maximum of two. External links may additionally open in a separate web browser window. The tabs are categorized based on types of data required per the conservation architect. The first is for general and broad historical information. It also provides links to related multimedia archives associated with the currently selected building part. The second tab provides conservation information. This might contain listed building status as well as all required information related to possible conservation projects – including details of consultants, contractors and project costs.

Fig. 2. User interface with first tab active.

The third tab details building and material information, with relatively simple data format compared to traditional BIM solutions. In the case of the Provan Hall, the information includes basic materials information such as building roofing materials present in the building structure. Thumbnail views and links are also provided to the material libraries where the textures used in the model are stored – an adaptation of the BIM store concept. Finally, the fourth tab is open for users to upload additional information to the model. In the current prototype this is not implemented – a final system would also need to implement a content vetting and moderation system for user content.

Each tab contains links to websites offering additional information. This is to address the idea of a central model where all information is brought together instead of a conservation architect, historian or academic having to search through multiple sources of information to find what they are looking for. The Interface has been designed to work on tablet or PC, with a simple UI featuring large buttons and minimalist UI design – this provides the additional benefit of creating a simple system for non-expert users.

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5 Discussion

To date, only a preliminary evaluation with potential end users has been conducted. This has highlighted some need for further improvements to the UI. The feedback from the conservationist focused on a need to provide more heritage documentation within the prototype. This, however was not the intended aim of the current project, where the goal was to see if additional data could be easily added to the project after delivery – rather than to provide a 'completed' example. All participants agreed that the visualization was of a very high standard and the BIM developers and users thought this was extremely impressive demonstration of the technology.

The project demonstrates that a Heritage Information Model may be a useful tool in the heritage digital documentation process. It is suggested that bespoke tools for digital documentation and information modelling may be of more value than ones based closely on existing BIM toolsets as there are many limitations in BIM software that limit its potential for heritage information modelling. This exploration highlights a promising future for Heritage Information Modelling, informed by, but distinct from Building Information Modelling.

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