Heritage Building Information Modelling: Towards a New Era of Interoperability

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Abstract: H-BIM (Heritage Building Information Modelling) is an application of BIM (Building Information Modeling) in the field of documentation, preservation and managing of historic sites. The universal value of Cultural Heritage made a huge demand on applying such technology in this field, such important value needs an innovative system in data management for the documentation of Historic buildings, where a Historic building 3D model stands on heterogenous datasets and should be interoperable with different software tools in order to handover the information to several users. The interoperability is defined as the ability of two or more systems to exchange information, data and knowledge. This paper outlines the importance of interoperability in optimizing the usage of data; by reducing wasted time and effort in gathering, translating and integration of data, and how it gives a wider dissemination which allows public users to benefit from the documentation and conservation process for a deeper understanding of heritage sites; outlying and review the case of Notre Dame cathedral in Paris, and how the Heritage Information Modelling could provide a precise restoration documents form; being interoperable with game engines.

Keywords: H-BIM, Historic Buildings, Interoperability.

1 Introduction

The cultural heritage configures the collective memory of humanity and relates the past with the present. It acts a national income source; creating a growing need for optimum documentation and preservation of the heritage sites, using latest technologies. Digital documentation provides a wider dissemination through audio-visual tools, while earlier process of documentation was based on human interpretations, that has been wasting time, and giving space for human error. This paper highlights on the main problem of the lack of synchronization of data which duplicates the effort and error (Juan, et al., 2014). The Heritage building information modeling offers an innovative interoperable platform, that provides an upgraded level of data management and data utilization, resulting in a better interactive environment of the historic sites, and more advanced and accurate display of the documentation of the historic buildings. (Murphy, et al., 2017)

1.1 Methodology

This research outlines the potential of interoperability of Heritage Building Information Modelling in the visualization and dissemination of historic buildings and production of restoration documents. The paper is structured as follows; section one reviews the Heritage Building Information Modelling and how it offers a new approach for heritage preservation, while section reviews the concept of Heritage building information modelling and its related terminologies. Section three discusses the idea of interoperability and how it could provide wider dissemination. Ending with section four; reviewing the case study of Notre dame Cathedral, suggesting how to elaborate the interoperability benefits in the restoration of that remarkable historical landmark.

2 Heritage building information modeling

The heritage building information modelling is an innovative environment of managing data of historical building conservation process, in an intelligent method (Murphy a,et al., 2017). The H-BIM model is built by a library of parametric objects, that contains the semantic and geometrical information of the historical elements. This intelligent process also has the potential of being interoperable with other digital platforms involved in the building's life cycle (Simeone, et al., 2014). Parametric modelling provides instant update of elements with all involved teams in that process. The parametric library is also reusable, which saves time and effort used to be wasted in duplicated work (Murphy , et al., 2019). The H-BIM system turns to be a reusable, interoperable database that enables managing, analyzing and representing historic buildings. Researchers from different disciplines such as architecture, computational architecture, and archaeology are working on optimizing the H-BIM system by creating open H-BIM system, with automated object recognition (Murphy , et al., 2019).

3 Concept design and initial Level of Detail (LOD)

The H-BIM system required a new definition of progress, as it totally differs from conventional CAD systems. A new term of LOD referring to level of detail is introduced. It classifies the model category based on the amount of detailing that the model has; for example LOD 100 is a low detail level it may include only the masses of the building, however, LOD 400 represents a high level of detail approaching to an as built model (Murphy, 2012).

3.1 Architectural libraries

The architectural digital libraries reflect the level of detail of H-BIM model, however, the BIM library is oriented towards the modelling of modern components; however a new plug-in for BIM was introduced by Murphy for the complicated elements of historic buildings (Murphy a, et al., 2017). The coding approach offers accurate mapping onto survey from laser scanning. The detailing can be ranged from architectural pattern books, to laser scanning, and point cloud. The H-BIM system offer a deeper documentation and analysis that goes beyond the geometry, to the methods of construction and materials. Figure 1 shows the different parametric library objects built from Pattern Books, Shape Grammars in GDL (Murphy, et al., 2017).

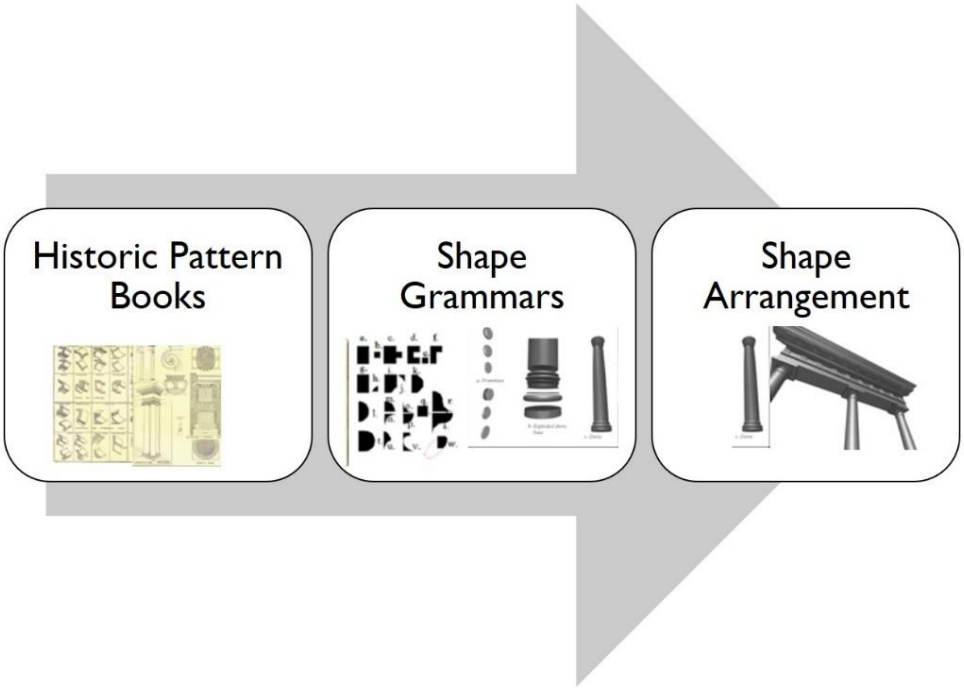


Fig.1. Parametric Library Objects built from Pattern Books, Shape Grammars in GDL (Murphy, et al., 2017)

3.2 Shape Grammars

Shape grammars applications initiated forty years ago; working on different areas of design; especially architectural design. However, it has been developed in the last ten years to integrate shape representation and computation (Eloy, et al., 2018). The shape grammars are sets of rules responsible for the composition of building elements and the relation between them within spaces. In H-BIM, the shape grammar can be based on architectural style, which configure the building's spaces. However, it gives the potential of transforming or deforming space by replacing or changing shapes (Murphy , et al., 2019). The sematic aspect of H-BIM model upgrades the model from static representation of buildings to an interactive mode; this interaction results can be traced in a multidisciplinary collaborative environment. This open system saves time, effort and cost (Murphy, et al., 2019).

3.3 Procedural Modelling

The potential in H-BIM is in creating an automated procedure; in order to generate high-quality 3D models of existing historic buildings to overcome the high cost and effort needed for the modeling and conversion of the semantic aspect of buildings (Murphy, et al., 2019). It became the focus of many researches; that gave a promising result in extracting basic architectural elements from point cloud data. However, the researchers are still working on complicated historic elements. The procedural modelling refers to the automation of the process of generation and transformation of data from one form to another. For now, the conversion is carried out manually (Albourae, et al., 2017).

4 H-BIM and Interoperability

Interoperability can be defined as the ability of two or more systems to exchange information (Santos, 2009). The upraising potential of H-BIM is opening the system to web-based files which give a wider dissemination of historical buildings documentation. The idea of interoperability became an important research field nowadays (Murphy, et al., 2019). Two of the main points in this field, are increasing the automation of the process of producing H-BIM model to eliminate human intervention, and conversion of semantic H-BIM data into web- repository to transform to an interactive, smart, and user friendly interfaces (Quattrini, et al., 2017). Figure 2 shows the architecture of the system of Archival and Storage Repository (Murphy, et al., 2019).

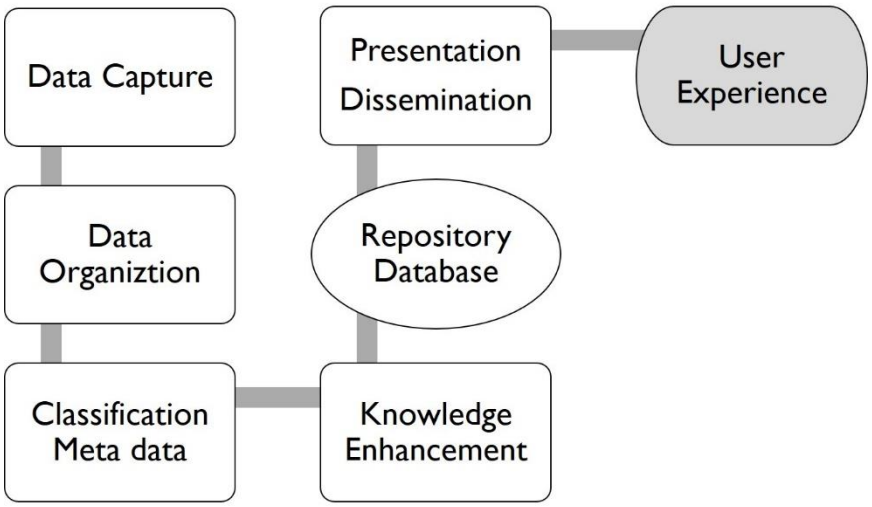


Fig. 2. The architecture of the system of Archival and Storage Repository (Murphy, et al., 2019).

4.1 Towards wider dissemination through H-BIM and Game Engine integration

Architectural visualization is one of the main outputs of H-BIM. However, it is most likely limited only to specialists (Murphy, et al., 2019). Unlike Game engine platforms, which are more user centric, the integration of both Heritage building information Modelling and Game Engines is the upcoming upgrade of the user experience of heritage sites (Albourae, et al., 2017). The game engines offer Virtual Reality (VR) which is a simulated environment that enables users to experience heritage sites without visiting them. While the Augmented Reality (AR) as a system allows the integration between reality and computer model aligned together by geographic information system (GIS). This great potential can store and visualize geographic data, in order to experience heritage sites in an interactive way, or virtually reconstruct a specific time in history, that helps public users in understanding heritage more in-depth (Albourae, et al., 2017), in order to provide a user centric experience to be used as a learning tool in pedagogical approaches (Wua, et al., 2015). The game engines are also used for combing visuals and audio in Virtual Reality, which riches the experience of spaces (Postma, et al., 2016). Figure 3 shows how Interoperability tests for data visualization in AR and virtual reality (VR) (Osello, et al., 2018).

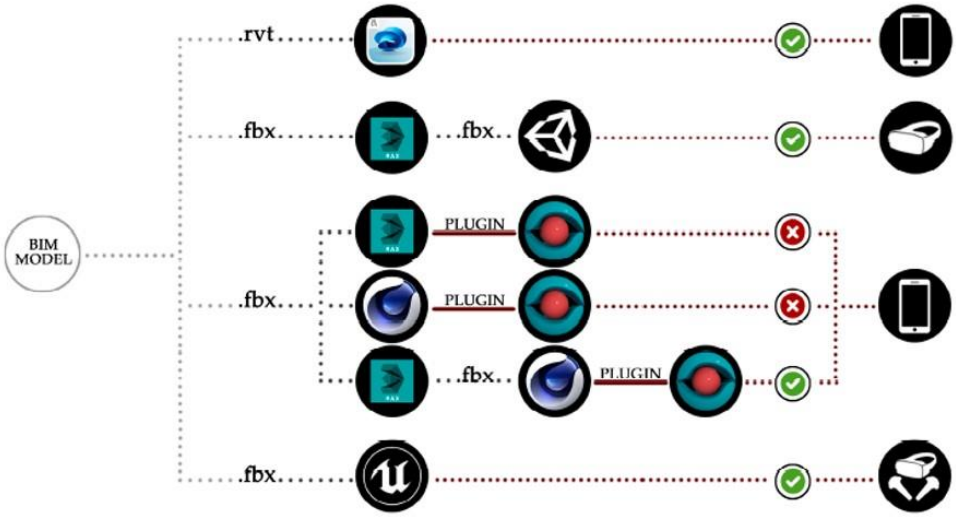


Fig. 3. Interoperability tests for data visualization in AR and virtual reality (VR) (Osello, et al., 2018).

5 Notre Dame Cathedral Case study

Notre Dame cathedral is a famous and remarkable heritage landmark, located in Paris, France. The construction started in1163, and wasn't completed until 1345, it was built by gothic French architectural style. Notre Dame means 'Our Lady' in English, which refers to Virgin Mary, the cathedral witnessed most of the epic French history, and contains revered relics as well (BBC news, 2019) (Notre Dame cathedral paris, 2019. The Cathedral roof was damaged by fire in April 2019); as shown in figure 4, and restoration action plans of the cathedral, became now a main issue in France, and a part of the international heritage concern. The common process of restoration from available documents and manuscripts doesn't provide an accurate restoration document. H-BIM presents another approach based on the interoperability, in integeration with game engines; the cathedral was digitally build in a game called Assassin's Creed Unity in 2014, and was modelled over a period of 14 months by Obisoft (BBC news, 2019); as shown in figure 5.

Fig. 4. Notre Dame Cathedral fire (BBC news, 2019).

Fig. 5. The Assassin's Creed Unity model (BBC news, 2019).

There is another digital representation of the cathedral the Ubisoft's, and yet is not the only one. Another digital representation one was made by the Vassar College historian Andrew Tallon, it was based on more than 50 locations laser scanning that contains more than a billion data points (BBC news, 2019). The game engines are used in combining visuals and audio as mentioned before; there is also another model of the cathedral generated on a 3D MAX visualization platform and exported to Blender game engine. It was combined by an acoustical software creating computational acoustic model to study auralization in virtual reality performance; as shown in figure 6 (Postma, et al., 2016).

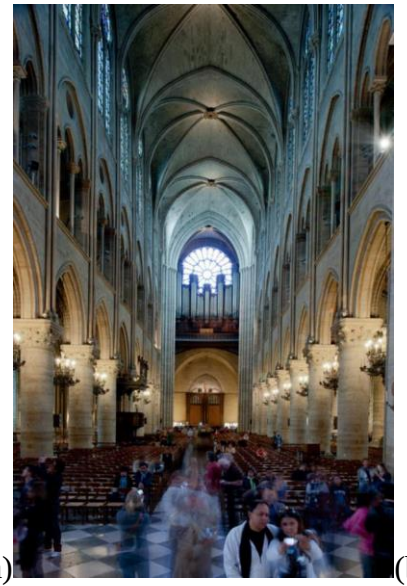
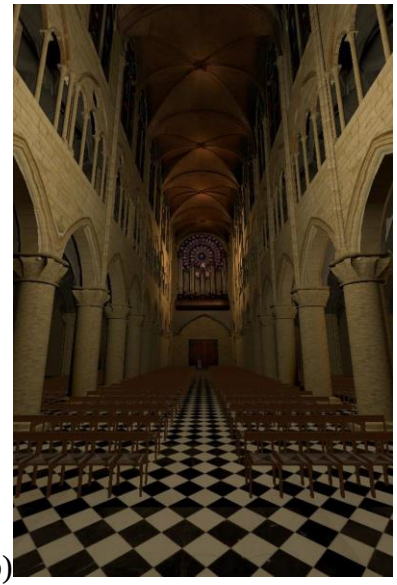
(a)  (b) 

Fig. 6. (a): Picture of the Notre-Dame de Paris cathedral from the altar towards the organ. (b): Similar view in the Blender VR model (Postma, et al., 2016).

The relation between Heritage building Information Modelling and Game Engine is a two-way data transferring channel (Edwards, et al., 2015); as shown in figure 7. Here stands the benefit from the interoperability of H-BIM, integrated with game engine in providing a wider interactive dissemination, with a user-friendly approach; the process could be reversed to create an accurate restoration documents from game engine models.

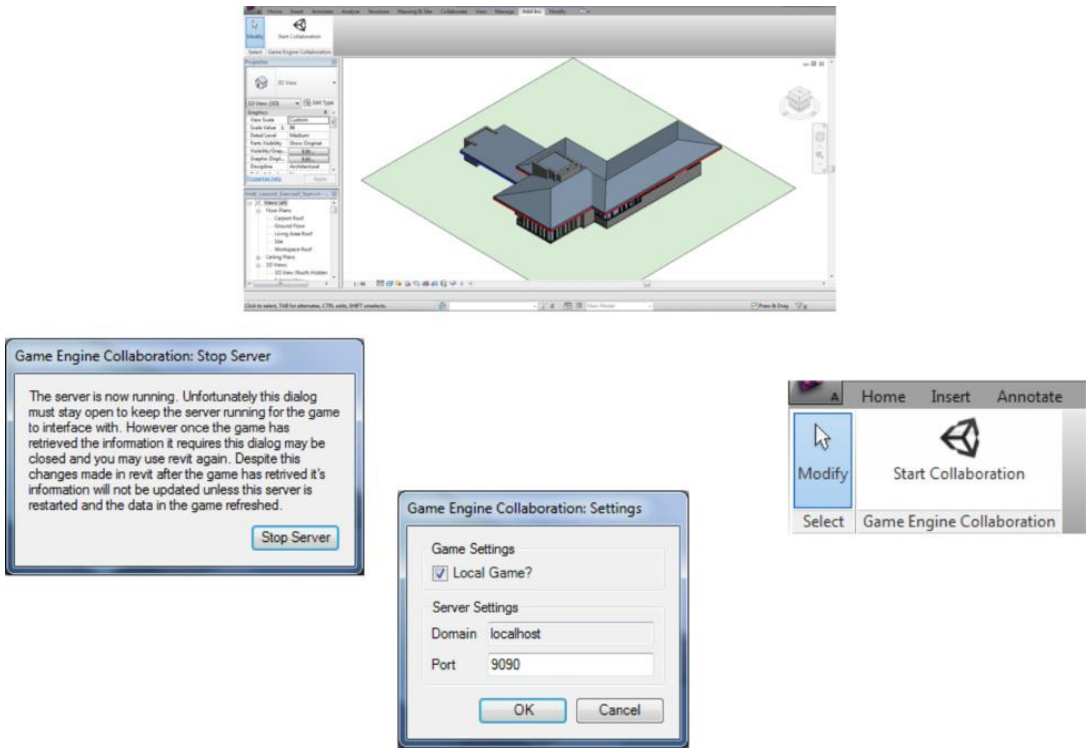


Fig. 7. Starting the server to create the link from the game to Revit (Edwards, et al., 2015).

6 Conclusion

The Heritage Building Information Modelling has the capability of being interoperable with different Platforms, which saves effort, time and provides wider dissemination through the integration of Game Engines platforms, through a common data repository that acts as two-way transfer channel. As a result of wider dissemination, a better user experience and a deeper understand of cultural heritage is now available for public users. Figure 8 shows a concluded summery of the potential of H-BIM, in which it reverses the conservation process of historic buildings to produce restoration documents from game engine platforms.

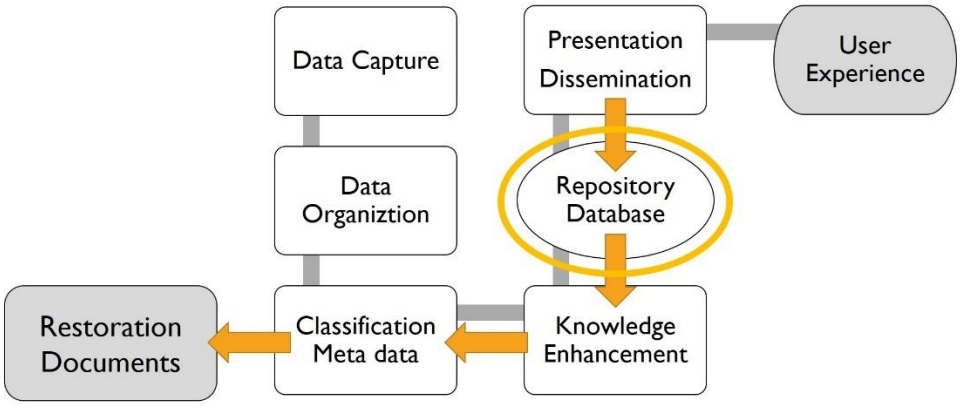


Fig. 8. The potential of H-BIM to reverse the conservation process of historic buildings to produce restoration documents from game engine platforms.

The Notre dame cathedral as a case study proves that Interoperability of HBIM system is an added value in the conservation of cultural heritage, which in this case could have been lost totally or partially; but with the new conception of H-BIM; the process of conservation could be reversed to start from the game engine platform to extract the restoration documents for the roof of the cathedral in an easy and accurate process. H-BIM is the new Era of Interoperability of heritage conservation.

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