Preserving the forgotten Heritage of the Silk Road through the use of Image-Based Historical Building Information Modelling (HBIM) and Immersive Technologies

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Introduction

Heritage sites along the Silk Road represent a vast cultural legacy often under threat from neglect, lack of resources, and limited accessibility (UNOSSC, 2019). Traditional preservation methods can be costly and time-consuming and may not fully capture the intricate details or historical context of these sites. The use of Image-Based Historical Building Information Modelling (HBIM) and Immersive Technologies offers a cost-effective and accessible solution for documenting and creating immersive virtual representations (Zhang, 2022; Alshawabkeh, Baik and Miky, 2021). This paper adopts a case study approach, focusing on Bayt Wakil in Aleppo, Syria, a typical wealthy Aleppine courtyard mansion from the Ottoman era. This architectural gem, known for its grandeur and historical significance, offers a glimpse into the opulence of that period. Bayt Wakil showcases remarkable craftsmanship and architectural elements, featuring a structure built with load-bearing masonry and incorporating elements such as arches, columns, domes, and vaults. Following the devastating earthquake that hit Syria and Turkey in February 2023, another section of the outer wall collapsed, blocking an alley with debris (Demir and Çilingiroğlu, 2024). The Directorate of Antiquities in Aleppo has ordered the stones to be moved inside the property without any reconstruction or repair work (Silk Cities, 2023). The focus of this research is to assess the viability of HBIM and Immersive Technologies to establish an accurate condition assessment to help raise awareness, promote appreciation, and support preservation efforts.

The Silk Road, a historic network of trade routes, facilitated the exchange of goods, ideas, and cultural practices across Asia, Europe, and Africa for over two millennia. This network significantly influenced the development of civilisations along its path, including the architectural heritage that stands today as a testament to this rich history. Bayt Wakil, situated in the historic Al-Jdayde quarter of Aleppo, is a prime example of such heritage (Silk Cities, 2023). The mansion's intricate wooden panelling, known as the Aleppo Room, features biblical scenes and is currently housed in the Museum of Islamic Art in Berlin. This highlights the global significance of the mansion's artistic and cultural value. The application of HBIM in this context involves creating detailed 3D models that capture the architectural and historical details of Bayt Wakil. These models serve as a digital archive, aiding in the preservation and restoration processes. Immersive technologies, such as virtual reality (VR) and augmented reality (AR), further enhance this by providing interactive and engaging ways for the public and researchers to explore the site. This approach not only aids in the physical preservation of the site but also in educating and engaging a global audience, thereby fostering a deeper appreciation for the cultural heritage of the Silk Road.

Methods and Materials

The research methodology includes a comprehensive literature review of relevant studies on HBIM, image-based modelling techniques, VR/AR applications in cultural heritage, and case studies specifically within the Silk Road context. The case study strategy focuses on Bayt Wakil, combining systematic literature review, qualitative content analysis, and inductive reasoning to provide an in-depth understanding of the site. The mixed-methods design blends both qualitative and quantitative techniques for a more holistic analysis. The objectives of this research are to conduct a critical analysis of existing image-based virtual reconstruction processes for heritage sites, develop a comprehensive HBIM framework for Bayt Wakil, create an interactive virtual representation of the heritage site, explore the potential of data visualisation tools based on AR and VR to enhance and optimise conservation practices and evaluate the effectiveness of AR/VR technologies in facilitating a faster and more efficient recovery process in emergencies involving historical buildings.

The integration of HBIM and Immersive Technologies presents a transformative approach to heritage preservation (Jong Jin Park et al., 2024). By focusing on Bayt Wakil, this research aims to demonstrate the potential of these technologies in safeguarding and promoting the rich cultural legacy of the Silk Road. The ultimate goal is to create a sustainable model for heritage preservation that can be applied to other sites along the Silk Road and beyond, ensuring that these cultural treasures are not forgotten but celebrated and preserved for future generations. The exploration of digital and virtual heritage, HBIM, and Augmented Reality (AR) highlights the transformative potential of these technologies in the preservation and promotion of cultural heritage. Digital heritage encompasses a wide range of activities and initiatives aimed at preserving and promoting cultural artefacts and traditions in digital formats (Alshawabkeh, Baik and Miky, 2021). The preservation of digital heritage involves a combination of technical, organisational, and procedural aspects. United Nations Educational, Scientific and Cultural Organization (UNESCO) has played a significant role in highlighting the importance of digital heritage through initiatives like the Charter on the Preservation of Digital Heritage document (UNESCO, 2003). This charter, closely linked to the Memory of the World Programme, emphasises the preservation and promotion of cultural heritage through digitisation projects and guidelines.

Conclusions and Discussions

The use of advanced technologies such as 3D imaging sensors has gained traction in the preservation of cultural heritage, particularly in museums and archaeological fields . Additionally, the publication of guidelines like the "Guidelines for the Preservation of Digital Heritage" by UNESCO has spurred global interest in fabricating digital cultural heritage. Methods for 3D digitisation specific to cultural heritage have been reviewed, indicating the ongoing efforts to adapt technological advancements for heritage recording. Digital interpretation frameworks have been proposed to enhance the understanding and presentation of digital heritage. Initiatives in various countries have focused on preserving cultural heritage through digital means, recognising it as a vital component of cultural development (Piaia et al., 2020). The interdisciplinary nature of digital cultural heritage preservation requires collaborative efforts, reliable IT infrastructures, and adequate funding (Preuss, 2016). Challenges and opportunities in cultural heritage digitisation have been identified, emphasising the need to address obstacles while leveraging the potential benefits of digitisation. Overall, the integration of

digital and virtual heritage, HBIM, and AR represents a multidisciplinary approach to cultural heritage preservation. These technologies not only improve documentation and conservation practices but also offer new ways to engage the public and foster a deeper appreciation for cultural heritage. Continued research and development in these fields are essential to address the specific challenges of heritage preservation and to fully leverage the benefits of digital technologies.

Keywords: Historical Building Information Modelling (HBIM), Documentation, Virtual Representation, Digital Technologies, Cultural Heritage, Preservation.

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