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A Multiuser Shared Virtual Environment for Facility Management

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Abstract

Facility management (FM) is a critical component of building sustainability because a late response to the FM needs will add unnecessary wastes. A lack of communication has been criticized as an impediment to improving the common understanding of FM requirements among the stakeholders and in turn affects the efficiency of FM. Recent developments in Virtual Reality (VR) have encouraged the utilization of interactive building visualization in the design, construction, and maintenance of different types of facilities. This study finds the interpersonal interaction in the VR environment to be a critical factor in the effective communication in FM by creating a shared immersive experience. To prove the concept, a Building Information Modelling (BIM)-based VR environment tool was developed to bring remotely located stakeholders – building occupants, facility managers, vendors and designers – together to walk through in the same virtual building. It enables real-time interactions of remote stakeholders in the same environment, with a shared immersive walkthrough experience. This tool offers an alternative communication method for sustainable FM. Unity 3D was used to create the interactive environment, and Photon Unity Networking (PUN) was used to implement the cross-platform multiuser function. A case study has shown that this alternative communication method can help stakeholders examine the same facility in remote locations and improve the efficiency of communication.

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Keywords: Facility Management, Interpersonal Communication, Virtual Reality, Game Engine

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1. Introduction

Facility management (FM) is a multidisciplinary profession to "*ensure the functionality of the built environment by integrating people, place, process, and technology*" [1]. As an indispensable activity of the building lifecycle management, FM is highly relevant to the sustainability of the built environment. Nonetheless, cumulative evidence has shown that a lack of communication is always an impediment to improving the common understanding of FM requirements among the stakeholders and in turn affects the efficiency of FM. It attributes to the commonly seen late responses to the FM needs, unnecessary wastes of time and resources, and has introduced an adversarial relationship between the end-users and FM professionals [2].

According to a National Institute of Standards and Technology (NIST) report entitled "Cost Analysis of Inadequate Interoperability in the US capital Facilities Industry" [3], the total cost impact of "*inadequate transfer of information*" across different building lifecycle phases was $15.8 B/ year, with two-thirds happening in the FM phase. The report also shows that issues pertaining to data verification and transfer have led to "*inefficient business process*" and "*losses in productivities for staff*" in FM, which was ultimately translated into unnecessary costs [3]. Similarly, in 2009, Global Job Task Analysis (GJTA) surveyed facility managers from 62 countries to identify 11 most needed competencies in FM, of which the number one was "*communication*" [1]. There is a pressing need to explore a more efficient approach of communication between project shareholders and FM professionals for the better sustainability of the built environment.

BIM-based game engines have been widely implemented in many areas in the AEC (Architecture, Engineering, and Construction) industry including architecture design review, construction safety education, and emergency evacuation [4-7]. Its powerful value in creating a low-cost, realistic game environment based on BIM models has been widely recognized. With the current advancement of Virtual Reality (VR) technologies, the integration of BIM-based game engine and VR is becoming promising in the AEC industry. VR allows construction participants to communicate in an immersive virtual environment. Unlike BIM-based game engine, the immersive virtual environment enhances participant's interaction with built environment or other users [8-10]

This study aims to test the feasibility and usability of multiuser BIM game engine based VR technologies in FM communication. Specifically, we hypothesize that a shared multiuser VR environment based on BIM game engines and cloud-based networking will significantly enhance the communication between project shareholders and FM professionals, ultimately leading to improved sustainability of the facilities. The significance of this research lies in that it presents an alternative approach to improving the common understanding of FM requirements among the stakeholders, and exploring the integration of BIM-based game engine and VR technologies into effective FM.

2. Literature review

2.1. Communication in Facility Management

Given the fact that more than two-thirds of the building lifecycle costs actually occur in the FM phase, FM defines the success of the construction business [11]. Meanwhile, as operations and maintenance (O&M) is the longest phase in the building lifecycle, its efficiency is important to the building sustainability [12]. According to Bowen and Edwards [13], the mutual information dependency dominates the entire lifecycle of a construction project; hence a lack of communication will undermine the efficiency of FM.

At present 2D drawings are still widely used to communicate FM needs. In a typical scenario, FM professionals use master MEP drawings to identify FM needs and locate facility items. Many issues could arise especially when the as-built drawings are not available. As a result, data reentry/rebuying is very common in routine and emergent FM activities. According to NIST, the wastes due to a lack of communication and data integration was estimated $0.23/SF per year for existing building portfolios, including information verification costs ($0.12/SF), delay ($0.04/SF) and O&M staff productivity loss ($0.02/SF) [3].

Recently, the AEC industry has raised a good deal of interest surrounding the use of BIM for FM. BIM is a data and knowledge repository through the life cycle of the building. This technology presents a major potential specifically in the life cycle information exchange and management. A variety of studies has been done to explore BIM-based approaches to improve the FM communication efficiency. Liu [14] and Becerik-Gerber, Ku [15] found that BIM-