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Literature Review of Augmented Reality Application in the Architecture, Engineering, and Construction Industry With Relation to Building Information

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INTRODUCTION

Productivity rate in construction industry shows a general pattern of decline in comparison to other industries. This issue influences on performance and efficiency of construction projects by adding unnecessary costs, time, materials, and manpower waste Alwi, Hampson et al. (2002). In dealing with this issue, it is necessary to apply proactive approaches rather than reactive ones through using new method and processes in the construction industry. During the last decade, Information and communication technologies (ICT) have been advanced significantly where the application of these technologies could improve the construction industry efficiency to some level (Park & Kim 2012). However, in order to fulfill this task in a larger scale, new methods and processes are required to develop and analyzed. This paper presents a conceptual framework to enhance construction industry efficiency via a comprehensive and proactive mechanism of Augmented Reality (AR) and Building Information Modeling (BIM) linkage. To fulfill this objective, the study begins with an extensive and critical review on AR and BIM separately in order to investigate the efficiency of each technique in the construction industry. Then the study proposes a conceptual framework of AR and BIM combination by investigating this collaboration in the enhancement of construction industry procedure.

BACKGROUND

Augmented Reality (AR) provides the means for intuitive knowledge presentation by enhancing the perceiver's situational awareness and cognitive perception of the real world. Through AR approach, virtual objects can be registered in relation to real objects where these objects can be seen in the same position and orientation of other real objects of the scene, as perceived by the user (Wang et al. 2004). In addition the real objects can be tracked and their 3D shape can be reconstructed from pictures (Azuma 1997).

AR has introduced as a technology which allows the user to see, hear, touch, smell and taste things that others cannot (Van Krevelen and Poelman 2010). It is a technology to perceive elements and objects within real world experience in a complete computational environment. It applies creatures and structures that could be used in daily activities unconsciously through interaction with others such as enabling mechanics to see instructions for repairing an unknown piece of equipment, surgeons to see ultrasound scans of organs while performing surgery on them, fire fighters to see building layouts to avoid invisible hazards and people to read reviews for each restaurant on their way (Feiner 2002). (Wang and Dunston 2007) describes AR as a tool allowing users to work with real world environment while visually re-

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ceiving displays of additional computer-generated information about the item by superimposition of additional information onto the real world scene. This approach enhances the user's perception of the real environment by showing information that cannot sensed unaided.

It is expected that in the near future, an increase in the use of AR applications will occur due to the advancement of hardware and software. (McKibben and Furlonger 2009) predict that by the end of 2014 approximately 30% of workers will use some form of AR capability and after a long period of technological development and refinement, the implementation of AR applications for the general public will reach its peak. In addition, the commercial market shows a same trend by promising examples such as Project Glass as an R&D program by Google (Goldman 2012) to develop an AR head-mounted display (HMD) for enabling users to experience a truly immersive digital life. ABI Research (Hyers 2006) predicts that by the end of 2014 the revenue from the AR mobile market will reach $350 M and Juniper Research (Holden 2005) predicts that the market for AR services will reach $732 M at the same time. It is widely believed that AR technologies are maturing and that within the coming years they will be broadly adopted by industry.

Estimations show that at least 5% of total building construction costs are due to occurrence of problems in the early design process, causing insufficiency, inconsistency and omission of design-related information towards construction phase (Hwang, Thomas et al. 2009). Construction worksite layout planning relies mainly on 2D paper media where the worksite planners sketch the future layout adjacent to their real environment. This traditional approach is ineffective and prone to error because only experienced and well-trained planners are able to generate the effective layout design with paper sketch (Wang and Dunston 2007). In the architecture, engineering and construction industry (AEC), gaps between planned solutions and practical implementations, poor communications between project participants and inefficient scheduling are the main issues for the lack of sufficient information/communication technology (ICT) support and innovative business procedures (Chi, Kang et al. 2013). (Froese 2005) has categorized trends in construction ICT into three categories. The first category is stand-alone tools to assist specific work tasks such as CAD, structural analysis and estimating programs. The second category includes communication and online information sharing tools through worldwide web document management system. Finally the third category includes the potential for integrating first and second category as a cohesive model through Building Information Modeling (BIM) (Froese 2010) where project teams come together to produce comprehensive and virtual prototypes of all aspects of the construction project as the central activity.

With the progress of ICT use in the AEC industry, higher quality visualization platforms are necessary for the efficient use of shared information among involved teams. Available research studies show the attempts of construction activities simulation with feedback generation through visualizing construction information for easier understanding and data share among project participants (Kang, Anderson et al. 2007). However, this approach only enables the visualization of activities in the virtual environment without enough resemblance to the actual tasks in the real world. (Froese 2005) introduces AR approach for the generation of digital project information prior to construction with transfer onto construction site in a fully digital way where this process facilitates the comparison of the actual situation with the planned final appearance to identify the concerned items.

Building Information Modeling (BIM)

(Penttilä 2006) defines BIM as a set of interacting policies, processes and technologies that generates a methodology to manage the essential building design and project data into digital format throughout the building's life cycle. BIM creates an