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BIM + AR/VR: A review on BIM's New Technologies and its Effect in Hospital construction projects

BIM + AR/VR: مروری بر تکنولوژی‌های جدید BIM و چرایی استفاده آن در پروژه‌های ساخت بیمارستانی

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Abstract

The results of hospital design should meet the requirements of design teams as well as healthcare stakeholder, which needs the excellent cooperation of stakeholders in the design phase of the project. Although, misunderstandings that occur between healthcare stakeholders and the design teams when using 2D drawing leads re-design and rework during the phase of design. Today, one of the most significant problems in hospital construction projects is the crash detection. The problem is excessively time and cost consuming. By using building information modeling (BIM) and its new instruments, i.e., Virtual Reality (VR) and Augmented Reality (AR) every stakeholder are able to have a better understanding of the project. The merits of BIM have typically been tied to its ability to hold information structuring and exchange through the centralization of data. Its increasing acceptance and the associated ease of data acquisition has created information-intensive workplaces, which can lead to information overload and thus adversely impact workers task efficiency during construction. The benefits of the method are not only limited to the construction time but also can be used for maintenance purposes. AR and VR have been presented as a mechanism to enrich the process of information extraction from BIM to improve the effectiveness of workers' tasks. This research aims to have a review on the latest method on BIM and justify the obligation of using these methods to enhance task efficiency, cost and time.

Keywords: Building Information Modelling, BIM, Virtual Reality, VR, Augmented Reality, AR, Hospital

1. INTRODUCTION

Today, by improvements in science and technology, construction projects are becoming more complex to manage. With the progress of industrialization, the advancement of the construction industry has undergone severe change. The traditional design based on 2D drawing have been gradually not sufficient for the needs of industrial development[1]. Besides, in conventional design of buildings, the design team use 2D drawing to explain the design intent; however, it was difficult for the user to understand the concept of those 2D objects because they lack engineering knowledge[2]. One difficulty is the correlative relation between different stakeholders during or after the construction process[3]. These stakeholders mainly consist of engineers, architects, lawyer, supplier, finance, etc. in return to this correlation and for making the relation easier Building Information Modelling (BIM) as a new computer-aided tool, has been emerging. Today, BIM is one of the most common classifications for a new way of approaching the design, construction, and maintenance of a building. It was defined as "a set of interacting policies, processes, and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life cycle"[4].

The concept of BIM is a 3D model based on object-oriented techniques and a single database to assist in the design and construction of a project. The main advantage of an approach based on BIM is that it provides a virtual model of stuff, in which structural, architectural, mechanical and electrical elements are in a database[5]. Today in our country, Iran despite all the positive benefits of the BIM method, there is a great unwillingness toward the use of this method.

2. Hospital Design using BIM

BIM technology is not only limited to simple buildings but also can be extended and be used for many construction projects, such as bridges, highway, tunnels, dams, and hospitals. Moreover, BIM can also be

utilized in the repair and rehabilitation of the present valuable structures, like historical buildings[6]. The healthcare industries are one of the largest and fastest-growing industries. Hospitals, as one of the most important buildings, plays a vital role during and after a crisis in the affected area. Hospital's facilities play a crucial role throughout a crisis by providing continuity of medical care for patients and serving a large number of people seeking for medical treatments[7]. A suitable design of a hospital is fundamental for ensuring the health and the enhancement of soundness. The life cycle of a hospital can be divided into four phase of concept, design, construction, and operation.

In order to better usage of stakeholders in each phase, it is needed for every beneficiary to have specialized information and knowledge. The design of a hospital is of great importance for the success of the project, as it is essential for the satisfaction of the stakeholders and medical staff. Meanwhile, the hospital project needs all involved, like the medical staff, engineers, workers, patients, etc., have a comprehensible understanding of the plan and the utilization of each place to avoid unnecessary distraction. In this regard, digitalization of the building can be a useful tool for the strategic progress of hospital building using BIM method[8]. In fact, BIM technology can be utilized in order to assist the hospital's staff in experiencing space and presenting their feedback before the construction process.[7] The mentioned method, not only prevent excessive discussion during the construction period but also save a significant amount of expense.

2.1. The Use of VR/ AR

Although there are lots of studies dealing with BIM related applications and researches for hospitals, few studies focus on communication and simulation platform for healthcare design in virtual reality (VR) or Augmented reality (AR) environment. The major purpose of the present investigation is to enhance the knowledge of the design content for the stakeholders in every phase of a hospital project from the concept to maintenance. Meaningly, the first object is to obtain positive feedback from the medical staff prior to construction. The other one is to decrease crashes during the constructing period and finally the decrease in maintenance cost by an investigation in some case studies in a different part of the world.

3. Historic BIM (HBIM)

Historical BIM is intended as the application of BIM technology to historic buildings, which are digitally surveyed with images and laser scanners[6], [9], [10]. It should be noted that the practical application of HBIM is not limited to professionals. Particular attention is also paid to a broader user community and applications in various fields, including built environment education, interactive learning, cultural tourism, and gamification among other[10]. It also plays a pivotal role in the maintenance phase of a building (Fig. 1).

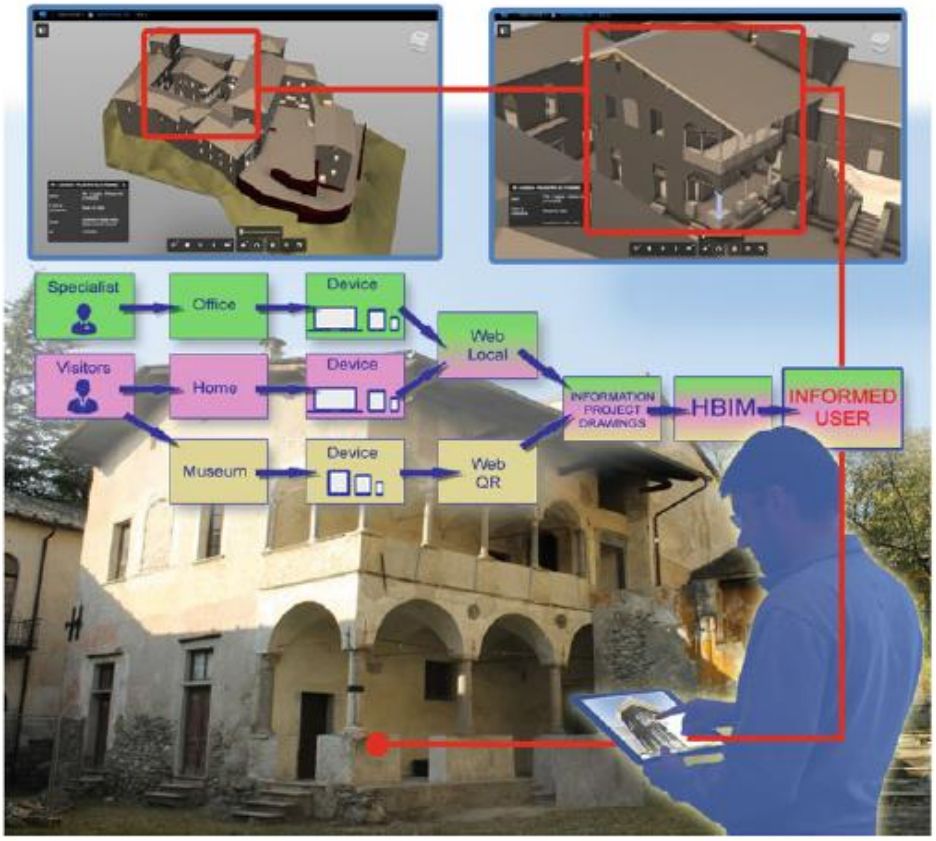

Figure 1 Possible flowcharts for different operators interested in products generated from a model based on HBIM [10]

At present, the extensive use of HBIM is in debt to its close relationship with the recent progress in the technology industry. Cloud computing allows optimized collaboration with multiple devices, including advanced tools for modeling and simulation[11], [12]. Game engines can be exploited for real-time rendering in the generation of immersive and interactive BIM environments based on VR and AR. Moreover, portable devices like mobile phones are the other wing of this technology, because they can connect specialists and casual users or technicians. This is useful in the creation of knowledge and preservation of cultural heritage. Besides, handheld portable devices like smartphones and tablets can be used for productive work or recreational purposes (fig.2).

3.1. HBIM's Instruments

As HBIM is available in 3D, there is a direct connection between digital models and advanced visualization techniques based on AR and AR. Starting from laser scanning and photogrammetric point clouds, the manual generation of 2D project boards can be avoided (or at least reduced) using BIM. The progressive modeling methods allow for the production of 3D models which traditional project boards can be automatically generated[13]. On the other hand, the level of detail that is achievable with laser scanning and photogrammetric point clouds could provide reconstruction with a large number of polygons, too many to be simultaneously visualized on mobile devices. Scalable procedures able to display only specific parts of a model become mandatory[14]. Integration with realistic visualization techniques able to provide a high level of visual fidelity is another important issue in which visibility and occlusion problems, lighting conditions, visual effects, and photorealistic textures play essential roles.

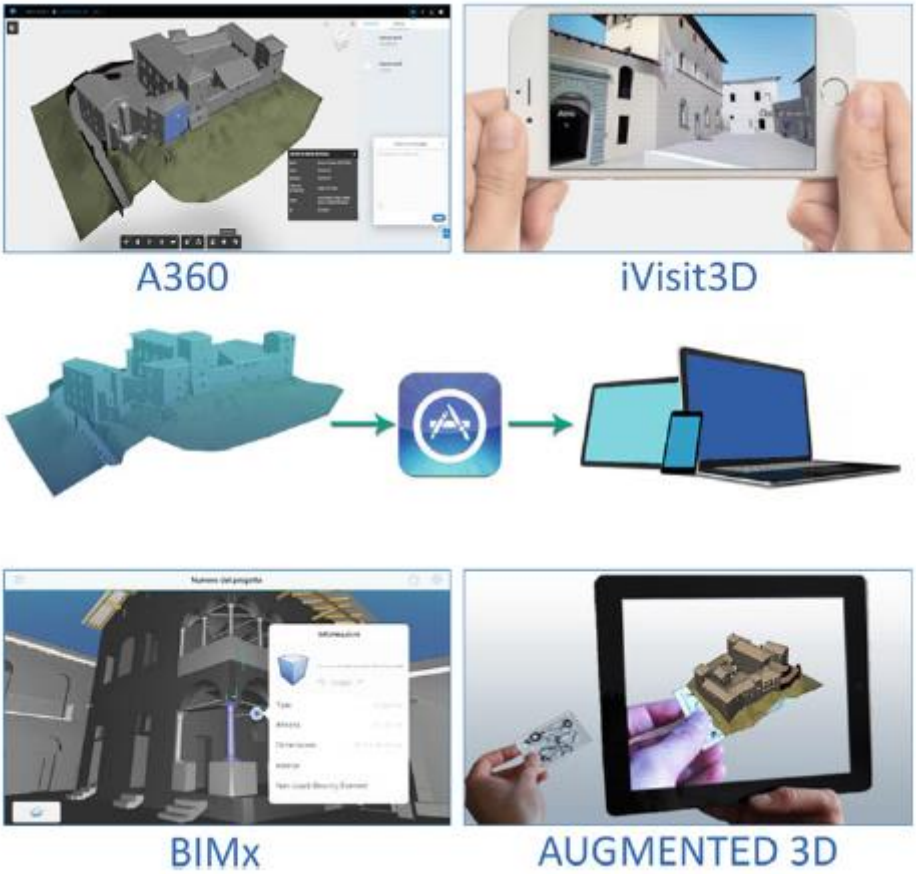

Figure 2 Apps allow the use of HBIM in mobile devices[10]

In the present work, some VR and AR applications designed to be run on mobile devices will be described. Examples of mobile applications integrating BIM technology were proposed in [15], where a virtual panoramic environment was developed to show the construction progress. A mixed reality tool to support professionals in the architect, engineering, and construction industries were developed in[16], whereas AR and BIM were integrated to detect construction defects. Nowadays, several BIM application is available for download in mobile devices. Some examples are Buzzsaw, Graphisoft, Autodesk 36, Structural Synchronizer, BIM 360 Glue, etc. The main idea for using such devices is to move the use of BIM from the office to the construction site, providing a new environment for an engineer, architecture, customers, and builders. Besides, It should be mentioned that these days those apps which has the ability to integrating cloud technology for connecting multiple users are in the center of attention. In these apps, a centralized version of the model can be remotely accessed by different professional operators, who can review, inspect, and edit project files without expensive hardware and software. Real-time communication can be carried out between multiple specialists through chat and e-mail notifications. An example of these apps is Autodesk 360 (A360). fig.3 demonstrate a mobile application with an associated cloud bases services that can handle projects generated in Autodesk Revit.

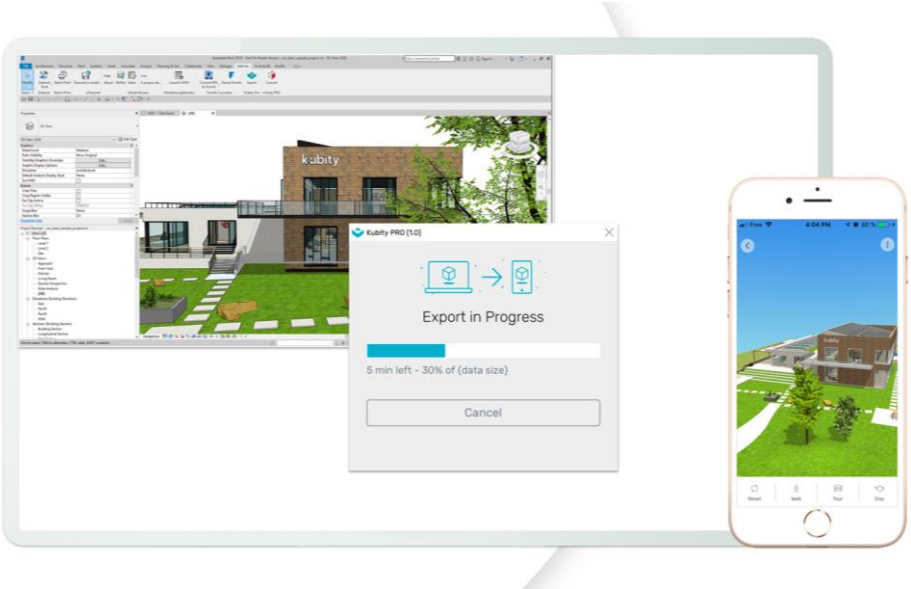

Figure 3 BIM of a proposed model in A360

4. Case Studies

Here the result of two of the previous studies will be presented here. The first project is using VR technologies for healthcare design and the second is a comprehensive investigation of 35 construction projects and its results.

4.1 Case study of a cancer Hospital[7]

In this study, VR technologies were developed for healthcare design and demonstrate its effectiveness in practice. This systems by modeling a design project of a cancer center in Taiwan let both the design team (i.e., nurses, doctors, etc.) and the design team (i.e., architecture and engineers) have a great cooperation by following methods:

1. The walk through module: The user can experience the BIM-VR environment via walk through the module, and refer to the result and content of the design in the BIM-VR environment.
2. The sign simulation module: The user can use the system to find the optimizing way for a different kind of patient, medical staff and worker. The user can discuss and plan the paths; the user can pre-walkthrough the tracks to separate the stream of people, who has a diffident goal.
3. The building panorama module: The function provides the design team and medical staff to have a 360° view and experience within the model of the healthcare environment. Usually, it is easy to get lost in the VR environment.
4. The walking path simulation module: The module is developed to simulate work in a particular direction or rooms with the proposed sign design in the DVBCS system. With the assistance of simulations, all the work path, working distance, and working time can be recorded and analyzed in the DVBCS system.
5. The questionnaires feedback module: To acquire the feedback from medical staff, the system is designed to let the medical staff entry their feedback through questionnaires feedback module after they access the space design of the hospital.

Fig 4. also shows the V.R system used in the case study

Figure 4 Discussion using V.R system in the hospital project of Taiwan

The combined results from case study demonstrate that the used system in this case study, employing game engine and VR technologies, is an effective visual communication system for healthcare design. The system can provide better visual communication and understanding for healthcare stakeholders and medical staff compared with 2D drawing usage and 1:50 Mock-up model usage based on the case study feedback results. The advantages of the system lie not only in improving the communication efficiency for design teams and medical staffs stakeholders, but also in facilitating visual interactions, enhancing VR/BIM-based design simulation results, and easier decision-making process while communicating in the semi-immersed VR environment. The experience result shows that using the proposed DVBCS system would assist design teams and healthcare stakeholders impressively in systematically handling healthcare design work using BIM, game engine and VR technologies in future healthcare design.

4.2. A case study On 35 constructing projects

Table 1 shows data for using BIM in a case study by [3] consisting of 35 cases. It shows that the Cost success criterion was most often seen as receiving a positive effect from the use of BIM. Cost reduction or control benefits were mentioned on 29 occasions, covering

21 (60%) of the case studies. Data obtained from the case studies suggest that BIM is an effective tool in improving certain key aspects of the delivery of construction projects.

Table 1 The success criteria ranking of BIM use

	Positive benefit		
Success criterion	Total instances	Total number of projects	% of total projects
Cost reduction or control	29	21	60.00%
Time reduction or control	17	12	34.29%
Communication improvement	15	13	37.14%
Coordination improvement	14	12	34.29%
Quality increase or control	13	12	34.29%
Negative risk reduction	8	6	17.14%
Scope clarification	3	3	8.57%
Organization improvement	2	2	5.71%
Software issues	0	0	0.00%

[3].

5. CONCLUSIONS

Mobile devices play a fundamental role in promoting interactions between people and digital cultural heritage in different ways: connecting people and heritage, creating knowledge, and preserving cultural heritage. Particular attention must be paid to interoperability requirements, standards, and protocols for the efficient use of digital reconstructions in both BIM packages and VR/AR applications. Standardized procedures and formats are needed for the reliable exchange of digital information, starting at the first phases of work (data acquisition) to the delivery of outputs in various formats, which can be used with multiple devices through cloud-based services.

Of the success criteria created for the analysis of the case studies, Cost was the one most positively influenced by the implementation of BIM followed by Time, Communication, Coordination Improvement, and Quality. The negative benefits or challenges of implementing BIM implementation are relatively fewer, and most of them are focused on software or hardware issues. These challenges seem to relate to the management of change associated with the adoption of BIM and could be addressed with such initiatives as better training for all employees involved and stakeholder engagement activities to allow key actors to get used to a new way of working.

12. REFERENCES

[1] Y. Wang, “Research on the Assembly Building Integrated Construction System Based on BIM,” vol. 32, pp. 543–551, 2017.

[2] R. C. Okada, A. E. Simons, and A. Sattineni, “Owner-requested Changes in the Design and Construction of Government Healthcare Facilities,” *Procedia Eng.*, vol. 196, pp. 592–606, 2017.

[3] D. Bryde, M. Broquetas, and J. M. Volm, “The project benefits of building information modelling (BIM),” *Int. J. Proj. Manag.*, vol. 31, no. 7, pp. 971–980, 2013.

[4] B. Succar, “Building information modelling framework: A research and delivery foundation for industry stakeholders,” *Autom. Constr.*, vol. 18, no. 3, pp. 357–375, 2009.

[5] H. Son, F. Bosché, and C. Kim, “As-built data acquisition and its use in production monitoring and automated layout of civil infrastructure: A survey,” *Adv. Eng. Informatics*, vol. 29, no. 2, pp. 172–183, 2015.

[6] M. Murphy, E. McGovern, and S. Pavia, “Historic Building Information Modelling--Adding intelligence to laser and image based surveys of European classical architecture,” *ISPRS J. Photogramm. Remote Sens.*, vol. 76, pp. 89–102, 2013.

[7] Y. C. Lin, Y. P. Chen, H. W. Yien, C. Y. Huang, and Y. C. Su, “Integrated BIM, game engine and VR technologies for healthcare design: A case study in cancer hospital,” *Adv. Eng. Informatics*, vol. 36, no. August 2017, pp. 130–145, 2018.

[8] P. J. Hareide, S. Bjørberg, M. Støre-Valen, A. Haddadi, and J. Lohne, “Strategies for optimization of value in hospital buildings,” *Procedia-Social Behav. Sci.*, vol. 226, pp. 423–430, 2016.

[9] Y. Arayici, “Towards building information modelling for existing structures,” *Struct. Surv.*, vol. 26, no. 3, pp. 210–222, 2008.

[10] C. Rejón Altable, C. Martínez Pastor, and A. Vírseda Antoranz, *Mixed Reality and Gamification for Cultural Heritage*, vol. 32, no. 4. Springer, 2017.

[11] L. Barazzetti, F. Banfi, R. Brumana, D. Oreni, M. Previtali, F. Roncoroni, G. Gusmeroli, and G. Schiantarelli, "BIM from laser clouds and finite element analysis: combining structural analysis and geometric complexity," *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.*, vol. 40, pp. 345–350, 2015.

[12] M. Murphy and others, "Structural simulations and conservation analysis-historic building information model (HBIM)," Dublin Institute of Technology, 2015.

[13] V. P\uatr\uaucean, I. Armeni, M. Nahangi, J. Yeung, I. Brilakis, and C. Haas, "State of research in automatic as-built modelling," *Adv. Eng. Informatics*, vol. 29, no. 2, pp. 162–171, 2015.

[14] F. Fassi, C. Achille, and L. Fregonese, "Surveying and modelling the main spire of Milan Cathedral using multiple data sources," *Photogramm. Rec.*, vol. 26, no. 136, pp. 462–487, 2011.

[15] L. M. Waugh, B. Rausch, T. Engram, and F. Aziz, "Inuvik Super School VR Documentation: Mid-Project Status," in *Cold Regions Engineering 2012: Sustainable Infrastructure Development in a Changing Cold Environment*, 2012, pp. 221–230.

[16] P. S. Dunston and X. Wang, "An iterative methodology for mapping mixed reality technologies to AEC operations," *J. Inf. Technol. Constr.*, vol. 16, no. 30, pp. 509–528, 2011.