BIM CAPACITIES IMPROVED WITH VR TECHNOLOGY IN THE BUILDING PROJECT

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ABSTRACT

The potential of Building Information Modelling (BIM) methodology to support a transformation of the processes of design and construction has been evident in the construction industry. A current topic that requires attention is the integration of BIM with Virtual Reality (VR) where the user visualizes a virtual world through interactive devices or a total immersion. By adding VR, the BIM solution can address retrieving and presenting information and increasing efficiency on communication and problem solving in an interactive and collaborative project. BIM + VR allow two main capacities: walkthrough and consulting data, and currently BIM tools allow links to VR plugins in order to achieve both capacities. The objective of the study is to report the improvement of BIM uses with the addition of interactive capacities allowed by VR technology.

KEYWORDS

BIM Methodology, VR Technology, VR+BIM Applications

1. INTRODUCTION

Building Information Modelling (BIM) methodology enables project stakeholders to create information-rich virtual models that help better visualize building projects. There is currently a shift in the AEC (Architecture, Engineering and Construction) industry to embrace BIM as a tool that can assist in integrating the fragmented industry by eliminating inefficiencies and redundancies, improving collaboration and communication, and enhancing overall productivity (Campbell, 2007). BIM is defined as the process of creating building information, stored in a centralized virtual model that can be managed allowing exchanging and sharing building data in an interoperable and reusable way (Azhar et al., 2008). BIM concerns the process of development of a computer generated model representing all disciplines of a building design, and its use in several tasks as design simulation, construction planning or facilities management. The resulting product, a Building Information Model, is a data-rich, intelligent and parametric digital representation of the building project. So, as a first perspective, the result of BIM methodology can be considered as a virtual representation of a building, an object-oriented three-dimensional (3D) model, but is also a repository of project data (Eadie, et al., 2013). The BIM data-model can be easily accessed, facilitating interoperability and exchange of project data with related software applications.

An actual BIM subject that requires research, practical application and software adaptation, is the integration of BIM with Virtual Reality (VR) technology. Current VR devices allow the user to visualize a virtual world and to interact with the virtual space and its components. The main objective, that has been reported, concerns the use of VR system combined with plugins in order to support BIM multiuse throughout the building lifecycle. As so, the VR environment integrates information systems and immersive environments. For that, VR requires devices for interaction with the virtual environment of the building and the construction space. The current target, concerning integrating VR and BIM, is the study of how to use or adapt those VR devices and how to establish links for the presentation of information contained in a BIM model. This is bringing BIM data into a VR environment. Visualizing virtual worlds and interacting with it, is essentially a VR aspect, and creating and manipulating design data, is the essence of BIM, so the link of these two strong capacities should be known and explored. Following this perspective, commercial software houses have been developing advanced BIM + VR products. The use of BIM technology on construction

projects has the potential to improve the process by allowing all team members to collaborate in an accurate and efficient way. Unlimited extension of the use of BIM information combines BIM-based software with other advanced technologies (Chen and Luo, 2014). These advanced technologies link the digital to the physical entities and research has already been conducted to investigate the combination of BIM and other technologies. The present reflection involves the link of BIM to VR.

Concerning BIM training, the school has an important role in the education of young entrants in the industry and to equip them with BIM skills, including the additional knowledge about VR+BIM. Regarding current digital 3D modelling technologies, added to design information and provided in mobile equipment, students and professionals can use advanced capabilities of interaction like VR technology, improving the use BIM methodology. The objective of this text is to report some of the most important enhances of BIM uses, when interactive capacity allowed by VR technology is added. A research concerning technologic advances in VR software, as a complement to improve BIM environment's management, was made.

2. VR AND BIM CAPACITIES

Virtual Reality (VR) technology leads to a better communication for key players across the building sector, based on a greater design visualization, contributing to a better understanding of the project (Jiao et al., 2013). The knowledge about the different type of data that can be associated to the set of parameters that identifies each parametric object, base of the BIM modelling process, is of great importance when the team members wants to analyse problems and to discuss alternative solutions. Interacting with the BIM model, in order to visualize the geometry of the elements and to consult the parametric data, is an improvement in the development of a collaborative project. For instance, a VR tour can be applied over a BIM model in order to check, from a facility management perspective, the maintenance schedule (7D/BIM model), or from a project team view, the constructability review (4D/BIM model), supporting decisions making. VR technology can improve BIM methodology, as it allows interaction with 3D/BIM models in two essential ways:

- **Walkthrough** is the most popular as the user can view the 3D model in a virtual environment in real time from multiple perspectives of the building, from inside or outside;
- **Consulting data** concerns the possibility to retrieve information centralized in a BIM model, namely, data associated with parameters that compose the parametric objects used in the modelling process.

2.1 Walkthrough

VR technology allows the user to observe artificial world, by walking through outside and inside and see everything around, and also reach out touching objects in real time. The immersive VR spaces are created using a combination of computer graphics, wireless tracking technology, headsets, high-definition projectors, polarized glass and more, all working together to create interactive and real-life experiences (VRS, 2017). The world of 3D virtual design and engineering is a fast growing field and the current perspective is the use of VR applied over the BIM model improving the construction nD activity. VR technology has seen developments in recent years and has been applied in architectural, engineering and construction fields. Currently architects, engineers and other construction specialists are already exploring the length and breadth of the joint RV+BIM technology in a walkthrough base:

- **Oculus Rift** is a real-time viewer application with interactive capacities, developed by the Oculus Company, and can be implemented as a plug-in in Revit (Rift, 2017). The device provides stereoscopic 3D view and includes a gyroscope, an accelerometer and a magnetometer to determine the orientation of the user's head in the real world. In the case of the Rift the stereoscopic 3D view is implemented by means of split-screen rendering, where the left half of the screen corresponds to the left eye, and vice versa (Figure 1);

Figure 1. Left and right half of the screen corresponds to each eye [20] (Rift, 2017) and touchable holograms

- The use of **hologram projections** in the construction activity, enables the end user to experience different textures or choose from a variety of in-built texture formats the required aspect for the project (Cherian, 2016) (Figure 1). The Revit model can be manipulated using hologram projections supporting a building collaborative design;
- With the **Enscape** Revit plugin, the user is able to quickly explore different design options in projects and so it has become a standard application in projects worldwide (Enscape3D, 2017). A walkthrough using Enscape for real-time visualization and rendering enables the project team to accurately communicate with engineering design, clients and stakeholders, improving the collaborative design. The ability to walkthrough inside BIM models and to regenerate design changes without leaving Revit is of a great importance and time saver (Figure 2);

Figure 2. Walkthrough capacity using Enscape Revit plugin and an igloo BIM cave

- **CAVE** (Cave Automatic Virtual Environment) platforms have been developed for immersive VR experience as they track user's head and control stick usually with 6 degrees of freedom, to navigate inside the virtual environment and interact with the contents of a 3D model including a 3D (BIM model (Nikolic, 2017). A CAVE takes normally the form of a cube-like space in which images are displayed by a series of projectors, but an Igloo BIM cave was recently developed (Figure 2).

2.2 Consulting Data

Once the model is inside the VR environment, things like materials, lighting, furniture and other small details that make the VR experience feel real, are added. This is the concept of walkthrough, but BIM contains data and it is convenient to explore BIM-data while walking inside a virtual model. VR can play an important role at all stages of the design-to-construction process, from evaluating design options and showcasing proposals, to designing out errors and ironing out construction and serviceability issues before breaking ground on site. Fully interactive VR software has extremely high performance demands, during a tour, but additional technology capacities concerning model-data retrieving is required when bringing BIM data into a VR environment.

The model is centrally hosted and access to project data is permissions-based, and it can be accessed by project teams anywhere. So, when collaborative projects are discussed between firms, they consult BIM data in models hosted on clouds. In addition, the capacity of consulting BIM data can be improved with VR devices applied directly over the BIM model. Several plugins or BIM viewer allows consulting data from the 3D/BIM model and now there is a new class of mobile apps available that let project teams experience building plans in 3D:

- Autodesk 360 allows the integration of the team in collaborative projects, as every modification in a BIM model is displayed in a handy timeline for everyone to see (Autodesk360, 2017). Along with showing the 3D model, Autodesk 360 display every sheet embedded in the uploaded Revit model (Figure 3). So all data can be consulted, analysed and changed, refining the project in a collaborative environment;

Figure 3. Using Autodesk 360 in a collaborative project and Enscape plugin of Revit to access data

An accessible high end visualization and virtual reality of a BIM model is obtain using the VR plugin of Revit, the **Enscape** (Enscape3D, 2017). It was previously mentioned just the walkthrough capacity, but Enscape also allows, together with Revit, to consult data. Inside Revit is possible to access the plugin Enscape and the user can observe both models in Revit and in Enscape (Figure 3). In Revit the user can consult the rich-data incorporated in the 3D/BIM model and in Enscape, can interact in a virtual space. So, all changes in Revit are immediately available to evaluate in Enscape.

- Combining BIM and VR, based in linking Revit with **Covise**, VR software (Covise, 2017), projects as well as data can be visualized in VR and reviewed 1:1 scale even in team meetings. Compared to various existing approaches, the new approach is to have bidirectional data exchange between the systems and as so, changes in Revit are directly reflected in Covise software and vice versa, continuously updating the model and its underlying database (Figure 4).

Figure 4. Interacting with Covise software and system coordination and constructability review using Web3D.

- Some progress has been made on VR techniques but only recently the link to BIM methodology has being made. A VR system should be combined with in-use applications to support multi-disciplinary users throughout construction lifecycle. Jiao et al. (2013) presents a pilot cloud framework regarding an environment utilizing **web3D**. It can be applied in several BIM uses supporting the AEC industry, namely, in system coordination and constructability review tasks (Figure 4). So technical solutions to key issues such as authoring, publishing, and composition are designed. The proposed environment is seamlessly integrated into in-use information systems and therefore enjoys greater usability.

The BIM includes semantics into the construction process (e.g., structure, air conditioning/ventilation, mechanical, electrical, plumbing, etc.) and data for simulation (materials/structure resistance, energy consumption, thermal calculations, lighting, acoustic simulations, etc.). These issues must be addressed throughout the construction project but mainly, at the beginning during the design phase to fulfil the customer's requirements, during the maintenance phase to control the building. Any BIM tool allows the consult of BIM data and so it support management and maintenance within a collaborative team.

VR+BIM enable architects and designers to better communicate design within the team members and with the client. The advantage to using VR is in the communication of ideas, concepts and the vision for the

building. This enables all the parties to more quickly reach a full appreciation of the building plan and the distinct discipline projects. The BIM + VR topic require dissemination; application in real cases and pointed out, in reports, achievements and limitation; following the technologic advances that supports the BIM use and the visualization of data, in real time while the interacting with the model made possible by VR technology. BIM + VR provide an opportunity to analyze and explore BIM models within virtual environments.

In construction activity the use of VR capacities brings interesting potentials. Presenting BIM models of projects in VR environment redefines communication and collaboration in the field and in the office. BIM technology and VR have the ability to innovate the building industry. At a first perspective, many feel the benefits of using a BIM model with VR are only for improving the 3D model for visual aids, but taking a second perception at a BIM model it reveals diverse reasons to adopt BIM with VR. Collaboration in VR can be the future of VR BIM.

3. CONCLUSIONS

Introducing VR interactive capabilities into 3D/BIM models in the construction process is a main way to test virtually and correct a construction project before the realization, as the walkthrough is available as well the visualization of data linked to each parametric object, improving the necessity collaboration within the design team. So, BIM/VR applications can contribute to reduce costs due to the construction of a real mock-up, and to avoid mistakes on site that generates material wastes. Software houses have been demanding the integration of BIM with VR plugins in order to support the development of nD/BIM tasks. The fundamental base of BIM+VR concerns the collaboration as a first step, but the possibility of consult data while walking through the building, improves significantly the use of BIM in design, construction, maintenance and management.

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