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# Smart Adaptation of BIM for Virtual Reality, Depending on Building Project Actors' Needs: The Nursery Case

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## ABSTRACT

Nowadays, virtual reality (VR) is widely used in the AEC (architecture, engineering and construction) industry. One crucial issue is how to reuse Building Information Modeling (BIM) models in VR applications. This paper presents an approach for a smart adaptation of BIM models for using in VR scene, by following the needs expressed by building projects actors. The main adaptation consists in filtering BIM data to keep the necessary ones for VR, according to the user objectives. Moreover, VR system should be chosen by taking into account the purpose of usage of the VR model. This approach is applied to a study case of a nursery building project.

**Keywords:** BIM, virtual reality, model adaptation, user needs.

**Index Terms:** I.2.1 [Human-centered computing]: Interaction design—Interaction design process and methods; J.6.4 [Computing methodologies]: Computer graphics—Graphics systems and interfaces

## 1 INTRODUCTION

The aim of this research is to provide a new methodology for the usage of Building Information Modeling (BIM) in virtual reality (VR) system, based on the needs of the building project actors (professionals and end users). A smart adaptation of BIM model takes into account these expressed needs. For this purpose, we focus on preparing adapted VR models by filtering the required data, which will be appropriate for the users. In addition, we use the user needs to choose the right VR system (e.g. immersive room, head-mounted display etc.). As a reminder, BIM can be defined as all the methods and processes used during the building life cycle (design, construction and usage), joining all the information in one 3D model, providing great possibilities of collaboration among all the participants of AEC (architecture, engineering and construction) projects. Also, according to Saleh et al. [4]'s study, user evaluations have shown that 3D computer visual materials are better than traditional visual materials to support user's participation in architectural design process. That is why BIM and VR are combined for innovations in architecture.

## 2 RELATED WORK

In the scientific literature, a crucial BIM advantage is its capacity to provide collaboration between all the project actors, facilitating the share of information. But one limitation is its static aspect, as Heidari et al. explained [2], facing to a hypothetic smart-BIM and dynamic with free-interactions. They propose a prototype between

an ordinary BIM and a smart one, which provides a virtual environment with predefined interactions on some scene objects: here is the "game aspect" that VR interactions entail. Yan et al. [6] propose a BIM-Game prototype, for interoperability between game engines and BIM. It consists on transferring geometric and non-geometric data in both ways (BIM to VR, VR to BIM) through a crossover module. They implicate the users in the design using the VR interactions, applying their Design-Play process, where Design is a phase for the building definition in BIM and Play another to make decisions collaboratively.

For implicating the end users in the first design phases, Bullinger et al. [1] propose to combine participatory design, where the user takes decisions which help for prototyping and user centered design, where the user is evaluated when testing immersive prototypes, to improve them. Prerequisites are defined with the users thanks to geometric volume layout simulations. Then detailed models are created (based on simulations and data from the first phase, not BIM) and presented through a projection based 3D stereoscopic large-scale displays for a review between end users and professionals. Wu et al. [5] choose another approach: a BIM-based educational gaming prototype where user profiles are stored: each user participates and data are collected to improve the game. To conclude, Heydariana et al. [3] use a similar approach using less BIM information and more data simulation, studying user choices and experimenting it through a realistic game engine that allows to make decisions on lights.

To resume, all provide methodologies that give interactions to end users only, where VR models are adapted from BIM for only one specific kind of actors. Moreover, all use a VR system but they did not choose it based on user needs to get the most adapted one. In our research, we propose a method and tools to adapt BIM model to VR, which take into account the diversity of actors (professional, end users). We also propose a method for choosing the VR system determined by the influence of the user needs on it.

## 3 METHODOLOGY

Therefore, we propose the following approach (fig. 1). First, we will have to know the users of the VR system(s), their job, their role and the VR usage purpose. Knowing that, we could filter the data we want to use from BIM and create a focus on the VR model on what we want to show and what interactions we want to provide thanks to the VR (in terms of content). Furthermore we could also choose the correct VR system (in terms of devices) for this usage (VR headset, CAVE, large computer screen etc.).

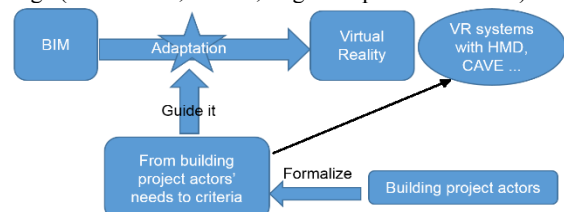


Figure 1: Methodology schema.

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Notice that the application of our methodology also depends on the nature of the project, its current state and the actors' aims. These elements have influence on the required BIM data and the VR system choice. Knowing that, we can deduce criteria that guide us for the BIM adaptation. For example, in the following case: a building transformation, in built phase, requiring project reviews between the architect and the end users to check the built advancement, would lead us to: end users are the targeted people and the focus extracting information from BIM is on all relevant elements for the building realism. The emphasis would be on the maneuverability of the virtual walkthrough, about lights and materials. These criteria would guide the adaptation, to answer to the following needs: the major one is to give a realistic immersion that allows to provide communication about the project between the actors and other ones could be to show the actual state of the construction work and to supply interactions on editable elements.

Then users have to try the model and evaluations are required. Our goal is to ask them how they feel using it and to compare it to a BIM or a not adapted VR model (with all BIM elements). We propose to use questionnaires; for the previous case, questions could be: how do you rate the maneuverability of the model (navigating, interacting)? And comparing it to a BIM or a not adapted VR model? Was it immersive? Did you feel to be present in the environment? And comparing to BIM? Notice that for this last point we can add an objective measure about the application fluidity, which influence on the immersion quality: the frame rate.

## 4 STUDY CASE

### 4.1 Context

This study case is a nursery construction project, a transformation of an old covered market. A division of the council dedicated to the urbanism is responsible of planning and reviewing this kind of projects so we decide to meet the architect in charge.

### 4.2 Concrete Realization

The BIM of the nursery is an Autodesk Revit 2017 ® model. The first step is to export it as an FBX file and to open it in Autodesk 3ds Max ®. But then the FBX file is composed of a large amount of elements with no hierarchy. So we order and rename them to prepare the VR model separating interior and exterior objects. We also delete the ones that are never visible in a visit. For this case, we just decide to delete the elements under the roof. In 3ds Max, we use ProOptimizer, an integrated tool, which allows to reduce the number of polygons for one object until 70%, due to the high quantity of polygons for this model (2 billion). Notice that materials have been lost when converting the file. We choose for this case to recreate the materials next to the FBX file, but future research could include reflection about BIM materials transfer.

Next, the FBX file is imported to Unity ® to build the VR model with the user interactions. About the metaphor of virtual walkthrough, we choose for this case a teleportation between defined checkpoints, with the render of moving when going to a new one. It allows to navigate easily, in particular outside; however for the indoor visit, other options may be tried in future research because indoor environments often offer more navigation ways so user choices may be more eclectic (check-points could be not sufficient). Moreover, to overcome the doors issue (open, close) the walkthrough has been separated between an indoor and an outdoor visit. The user has to choose before starting, in a helicopter view: it may help, giving an overview, similar to a 2D map but in VR with the visible checkpoints (he can quit the roof).

After that, work has been done for the scene realism (fig. 2) (which include materials work already done), without affecting the fluidity of the VR model, with main efforts on the lights and

the visibility of the objects. In this study case, we apply a binary choice: when walking outdoor, indoor objects are hidden, to consume less resources and when walking indoor, everything is loaded: in one future work we could show only the rooms close to the current one. About lights, as the building project is on built phase, major modifications are not possible. But at least users want to check the exposure depending on the sun, the interior lights and the walls/windows materials. For this issue we had to get back the building orientation from Revit to Unity. Then we use the Revit solar cycle simulation to get the positions of the sun path, depending on the date of the year. In Unity, we simulate three different solar cycles (equinox, summer and winter solstice). So we allow end users to check the building exposure in the VR system and to ensure quality to the user experience, users can stop at any moment the solar cycle and stay with the current exposure.



Figure 2: Nursery in VR.

About interior lights, windows, walls and floor materials, they are not definitive even in built phase, so in a future version we would give the possibility to the users to edit them. They could see and try the possible changes, based on the current project advancement and architectural rules (load-bearing walls etc.).

## 5 CONCLUSION AND PERSPECTIVES

This study case allows us to test the first part of our methodology, by adapting a BIM model thanks to building project actors' needs, in this case the end user needs. This VR prototype has to be tested by the architect and in a project review meeting, to evaluate and improve it thanks to the user feedback. Notice that we

Then some researches have to be done on BIM data transfer, VR system choices and particularly on the smart data filtering, which could be linked to the planned virtual walkthrough. Finally, we would search about how to improve the preparation ways for creating these models, trying to automatize or simplify processes.

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