messyBIM: Augmenting a building information model with messy talk to improve a buildings' design process

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Abstract

Designing a building requires collaboration between experts such as architects, engineers, and constructors as well as with non-experts such as clients or end-users. To gather input, experts present and discuss with non-experts parts of the design of the future building in feedback sessions. With the digitalisation of the construction sector, the design process is facilitated by technologies that allow experts to work on a shared digital model. This digital model often comes in the form of a building information model, or BIM, which serves as the basis for the physical spaces that later get constructed. In feedback sessions, parts of the BIM model are presented on paper or screen and the unstructured conversations which happen during these sessions (the messy talk) are later incorporated into the design. Navigating BIM models is restricted to the specialists who closely work on and with them. In this way, BIM platforms still have a series of limitations. To begin to address this, we present messyBIM, an interactive experience that includes a virtual reality environment that allows navigation and interaction with an augmented BIM. messyBIM shows different dimensions of a BIM and opens it up to a broader, non-expert audience by recording messy talk about the building. messyBIM helps us think about the data types associated to physical spaces. We hope that those who engage with it will think with us critically about the complexities related to designing and constructing large-scale building projects.

1. Introduction

Building Information Modeling has been defined as the virtual representation of the physical and functional characteristics of a facility from inception onward. It is normally used as a

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collaboration technology for architects, structural and mechanical engineers, and construction professionals and serves as a shared information repository for collaboration throughout a facility's life cycle [1]. BIM allows professionals to incorporate and coordinate more information than with traditional 3D geometric modeling as a building is designed, constructed, and re-purposed. In the last 10 years, the adoption of BIM has grown by 43% in the UK [2], with similar trends in the Global North [3]. Architecture and engineering practices large and small use BIM in their work yet there are only a few large BIM platforms (Autodesk Revit - the industry leader [4], Nemetscheck [5], ArchiCAD [6], Vectorworks [7]) and BIM still has some limitations [8]. In 2020, some of the more famous architectural practices in the world wrote an open letter to Autodesk, the maker of Revit describing how digital design leaders wrestle with software that, at its core is twenty years old, and that the high prices of Revit do not justify the development of the software [9]. It also talks about Revit's lack of interoperability with other platforms and how customers get locked into using it due to proprietary file formats.

Additionally, when designing a new building, input from non-experts, who do not have access to the BIM model is needed. This input is currently given through feedback sessions where 2D drawings of floor plans, sections, and renderings of the current state of the building's design are presented on paper or screens. All actors involved in the design process give spoken feedback which is later incorporated into the design by the specialists who control the BIM. This process is often tedious because preparing this material from the BIM model can be time-consuming while non-experts might have trouble understanding the scale or even the meaning of the specialized drawings. However, during these sessions, unstructured conversations, or what Dossick and Neff called "messy talk" happen between actors involved, and this messy talk has been proven valuable in making the design process more effective [10, 11].

We show here that to work towards a more sustainable building industry, it is important to understand the complexities and intricacies of the data which make up a building following its life cycle. This helps to get a more holistic view of the process, understand and mitigate design decisions. messyBIM could be one such design solution.

2. Related work: VR + BIM

Over the last decade, a series of plug-ins for commonly used software or stand-alone applications that allow navigating through 3D models in general and for BIM, in particular, have been released [12, 13, 14, 15] facilitating the promise of virtual worlds for architectural communication [16]. Most of these applications allow users to walk through the 3D model of a BIM, yet interactions with the space are still limited. [17] describes a smaller, non-commercial project which allowed users to design a building in VR. [18] report on a case study on integrating VR with BIM to facilitate real-time creation of bill of quantities during the design phase. In [19], a comprehensive description of state of the art in integrating BIM with VR is provided concluding that VR+BIM enable better communication within the professional team and with non-experts through the possibility to consult data while walking through the building and that coupling VR with BIM improves significantly the use of BIM in design, construction, maintenance, and management. In [20], Bjørn et al. show how immersing end-users in the BIM of a hospital and simulating future activities can inform about important design miscalculations.
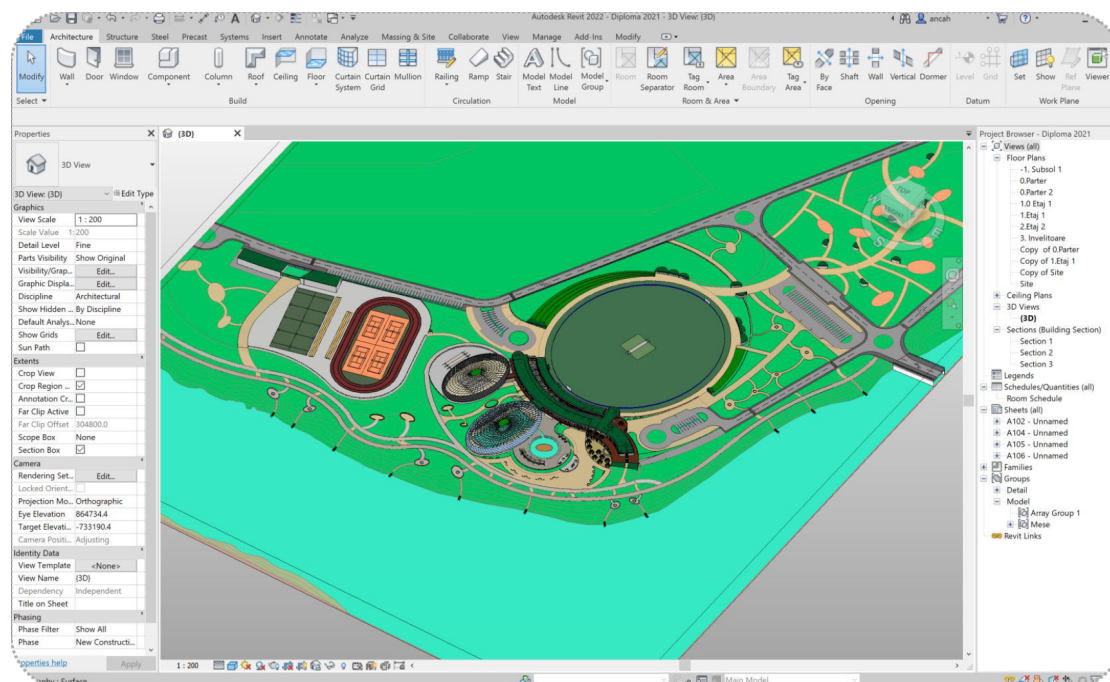
Figure 1: Image of complete BIM model for sports facility, in Revit 2022

3. Materials and methods

Inspired by the concept of "messy talk" and in continuation of prior research on integrating BIM and VR, we present messyBIM as an interactive experience that aims to (1) better visualize the extra-dimensions of a BIM by showing data types involved in a building's design, and to (2) open up the BIM model to non-experts and record the messy talk which happens in the feedback sessions between different actors involved in the design process of a building. The experience invites citizens to take part in the design process by presenting them with: (a) computer-based interactions with a BIM model through a desktop application and (b) paper-based interactions by drawing on analysis maps, site plans, floor plans, sections, and renderings. Additionally, a scaled physical model of the building will be present for investigation.

3.1. Description of project and BIM model

The interactive experience is based on an architectural project of a cricket sports club and is a conceptual project, developed in an academic context and based on the design brief of this project. The site is placed in Moara Vlăsiei, a village near Bucharest in Romania. The design specifications were developed together with the Romanian Cricket Council and municipality representatives from Moara Vlăsiei and took into consideration future building plans of the area. The site of the project was rented by the council from the municipality for 50 years. Currently, there is a cricket field on the site, and the Romanian Cricket Council intends to build a club
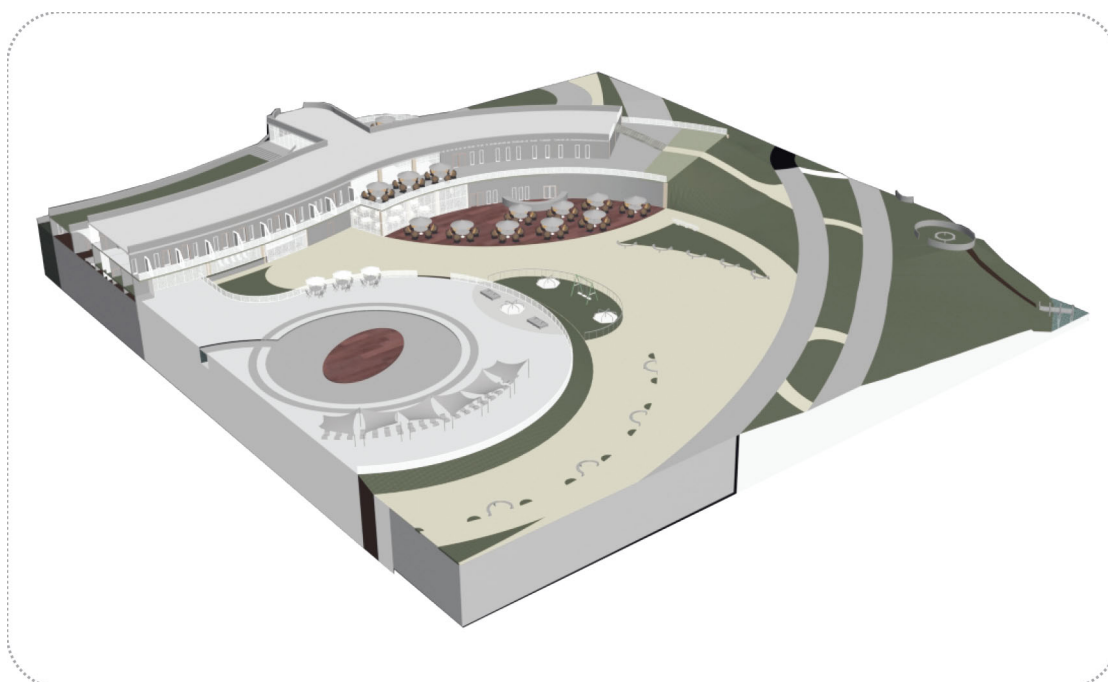
Figure 2: Section of BIM model imported in Unity 2020

and rebuild the field. The total site area is 18 hectares and is a strip of land between a forest and a river that is a protected natural site. Based on the specifications, the club includes an inside cricket pitch, an indoor swimming pool, a restaurant, offices, locker rooms, and 30 rooms for accommodation amounting to around 18.000 sqm. A BIM for the project was created using Revit Architecture [4]. Figure 1 shows the complete BIM model of the facility.

3.2. Description of Interactions for the VR experience

Due to file size limitations, only a section of the BIM was selected to be exported as a .fbx file and be part of the interactive experience. Since material properties in Revit do not import well in Unity 2020 [21], the .fbx file was taken into 3DS Max [22] where the materials were adjusted. Then, another .fbx file was exported and imported into Unity (figure 2). Furthermore, a first-person controller was added to allow the user to move around the 3D model, and mesh colliders were created for all geometry in the .fbx file so that a user would not walk or fall through floors, walls, or topography. A user can look around the scene by moving the mouse and can walk through the building using the keyboard arrows: front, back, left, and right.

Each architectural element in the scene is selectable with the left mouse button. This was done by using raytracing from the mouse position. Selecting an architectural element initializes a text box that gives information about it: its name, volume, material, when it was created, and its manufacturer. Additionally, a text input allows the user to write text (make comments) on top of the selected object. Text from previous users is visible upon selecting an architectural

Figure 3: Moving a slider will show past, present and future images of the site
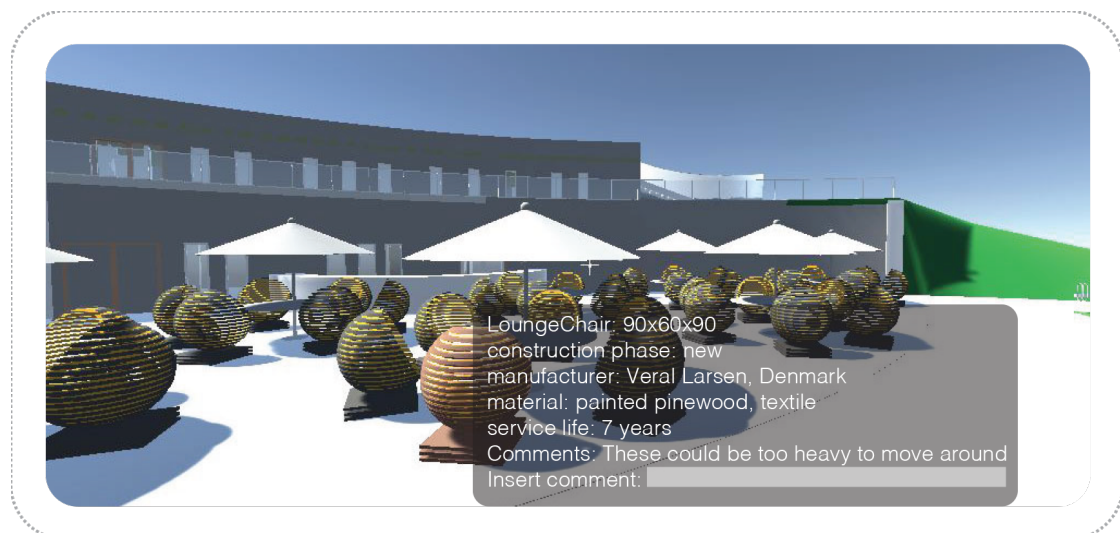

Figure 4: Selecting objects shows BIM data associated with them and allows the user to insert a comment on top of them.

element (figure 4), and these comments are saved upon exiting the application.

Finally, a slider allows the user to "move through time": the slider goes from 1990 until 2050 and different scenes present the site of the project at different moments in time. If the timeline slider is positioned in the past, historical images of the site are presented, while if the slider is placed in the future - the BIM of the new building is shown. This is done by making different scenes in Unity and switching through scenes as the slider moves (figure 3).

4. Discussion

When talking about BIM, several additional dimensions are often discussed [19, 23], each including different information about the design process. For example, 4D often refers to time, 6D, or 7D to sustainability estimates. While visualizing the 3D of a BIM is straightforward, the other dimensions are harder to visualize in current platforms and collaborative technologies for construction. With the VR application of messyBIM, we visualize the time dimension (4D) by allowing the user to modify a slider that shows the site at different moments - past, present, and future. By making all architectural elements in the environment clickable, and showing information about them, different 6D or 7D data dimensions are made visible. While messyBIM is a work in progress, the goal was to create a tool that will help the design process of the building in the critical early stages of decision-making, which have been shown to have the highest impact on a building's sustainability [23, 24, 25]. The interactive experience will invite non-experts to interact with architectural design data including both computer-based interactions (recorded through the VR application), a scaled physical model, and paper-based interactions with data describing the same building. The intention is to analyze how citizens engage with these different data types, how they express opinions about the project, and what their input is and use this to further develop messyBIM.

Across the construction sector, architecture and engineering professionals started building software tools to complement what is still missing in existing BIM commercial software [26, 27, 28, 29, 30] and messyBIM fits under this area as well. We experienced Revit's interoperability problems while making the application (simply exporting a section of the building from Revit and keeping all BIM information is currently not possible), as [18, 31] also report. Finding ways to seamlessly import BIM data into game engines, or to develop for VR in BIM platforms could be a useful direction for future research. Digital tools that complement commercial software are often developed by construction professionals who have domain-specific knowledge on what their tools should do but little knowledge on designing scalable, robust digital tools. Further efforts in research and practice are needed to facilitate seamless communication between the different actors that come together in designing a building (architects, engineers, investors, end-users, HCI researchers, and practitioners) as facilitating this communication might lead to a more sustainable building industry [32].

5. Conclusion

In this paper, we presented messyBIM, an interactive experience based on a building information model of an architectural project. The interactive experience includes both computer-based interactions, through a VR desktop application, physical and paper-based interactions. The VR application is built on top of a BIM and a user can walk around the building and surrounding landscape, select architectural elements, see information and write feedback. The user can also navigate "through time" by interacting with a slider that shows the site at different moments (the past and present show images of the site and the future shows the BIM). messyBIM is a suggestion of how BIM platforms could be augmented to allow experts and non-experts to interact with the multiple dimensions of data attributed to the design of a physical space.

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