Generalization of BIM model to visualize it through HoloLens

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1 Introduction

The improved functionalities of recent Information and Communication Technology (ICT) structures to collect and manage data and information in projects, have spawned information demanding industry conditions which, during the last decade, guided to serious advances with regard to the processes of conversion of traditional means into new formats in construction field (Chu et al., 2018). Such an advance is the Building Information Modeling (BIM) which can be considered, according to Migilinskas et al. (2013), as the expansion of Computer-Aided Design (CAD). They mention that the extensively usage of BIM in architecture, engineering and construction (AEC) industry will provide with enhanced construction industry performances through expanded cooperation among project parties, less inefficiencies and rework on alterations and improvements. Despite the advantages that BIM can offer in construction industry, the rapidness with which this technology is expanding and its potentials to gather huge amount of data, triggers worries of how people in the field can handle the quantities of information arrive to them (Chu et al., 2018). Meža et al. (2014) have stated that Augmented Reality (AR) is the technology that can boost the information elicitation from BIM, promoting the utilization and the intuitiveness of this innovative model during the design and construction phase.
Augmented Reality is the technological advance that grants digital objects and images produced by computers with the capability to absolutely overlay the real environment in real time, allowing the user to communicate with them using physical objects in a seamless way, in contrast to Virtual Reality (VR), with which the user is perfectly immersed in a virtual world (Zhou et al., 2008). Among other application AR can be utilized in the field of architecture to ease the design and communication process by projecting simulations, improving game oriented cooperation among designers, contributing to remote collaboration and minimizing the cognitive design workload (Milovanovic et al., 2017). Van Krevelen and Poelman (2010) have distinguished AR displays into three main divisions based on their position in relevance to the viewer and the physical world. Three main categories are: 1) head-worn which are displays , usually like glasses or helmets, stick to the user's head carrying video/optical Head-Mounted Display (HMD), Virtual Retinal Display (VRD), and Head-Mounted Projective Display (HMPD), 2)hand-held which consisted of hand-held video/optical see-through displays and hand-held projectors and 3) devices that have been placed statically within the space and include screen-based video see-through displays, spatial optical see-through displays and projective displays. During this project Microsoft HoloLens will be used which is a head-mounted Mixed Reality (MR), which implies that the user can interact with the projected virtual objects, device providing the functionality to create a spatial model of the surrounding

space and to identify a number of gestures to permit interaction with the users(Funk et al., 2017).

1.1 Relevance in the context of Geomatics

This thesis aims to manipulate spatial information, derived from an open source Industry Foundation Classes (IFC) file format and to visualize it through an augmented reality device. Techniques of generalization will be used to "lighten" a rather complex BIM model. Essential parts of the building will be kept depending on specific use cases by an extensive semantical and geometrical data analysis. Visualization of the produced 3D model will take place after having configured the Microsoft HoloLens by development of C# scripts. On top of that a simple and intuitive user interface will be created to achieve a smooth and direct experience for the user.

1.2 Problem statement

Nowadays, more and more companies are willing to move great sections of their design and construction procedures into computers, having as main target to replace traditional means with digital prototypes (Reiners et al., 1998). Alteration of traditional visualization means like maquettes, widely used in AEC industry, will be a great step to this direction. Agarwal (2016) has identify 8 promising AR applications in AEC covering : layout, excavation, positioning, inspection, coordination, supervision, commenting and strategizing. The present study intends to propose an approach which will facilitate the visualization of "rich" and verbose BIM models through HoloLens to give a clear perception of the building before its creation.

2 Related work

As Bazjanac and Kiviniemi (2007) declare, there are complicated and too "rich" datasets, as initially designed, which are relevant and necessary in their authentic form for certain applications, but convoluted and irrelevant to other uses. Considering the AEC industry, they mention that data transfer often requires decline or simplification in combination with translation and/or interpretation when certain applications are involved. Since, BIM models are rather complex 3D building models, visualization of them via a mixed reality device, such as HoloLens is an intricate process Given the defined processing capacity of the energy-efficient Atom processor(Furlan, 2016), limitation to the amount of detail that can be visualized through it are set. The necessity for generalization/simplification of BIM models, which by definition are complex is obvious.

2.1 Generalization/Simplification of BIM/IFC models

Benner et al. (2005) aim to extract data from an IFC model and assign it to corresponding classes of a Quasy object model. In order to achieve this, the first step is the declaration of the semantic building structure, to isolate building elements for each storey. By this, one two-dimensional geometric structure, called footprint, is generated for the elements representing the vertical structure, walls and columns and one for the horizontal elements, the floor slabs. Geometric analysis is performed, to determine the building elements touching the footprint. The identified surfaces related to the building elements are stored.
Nagel et al. (2007) propose a method to convert IFC models to CityGML Level Of Detail 1 (LOD1) by extracting the footprint of each floor and extruding it along the vertical axis. Firstly, they simplify the IFC model on the semantic level retaining only elements forming the exterior shell (Horizontal elements: Ifcslab, Vertical elements: IfcWall, IfcColumn, IfcBeam and roof elements). Next step is the production of an element-based contour polygon by depicting horizontal and vertical building elements onto the x-y surface. Finally, they bring together the element-based contour polygon using 2D Boolean operation and they resolve it to obtain the footprint for each floor.
To make a distinction between exterior and interior building parts El-Mekawy et al. (2011), as Benner et al. (2005) and Nagel et al. (2007), propose the generation of two footprints, one vertical and one horizontal. The vertical footprint derives from the projection of vertical elements like IfcWalls and IfcColumn, while the horizontal structure parts, IfcSlab and IfcBeam, form the horizontal footprint. A geometrical investigation with regard to footprints that intersect building elements of the model takes place to isolate these elements. Finally only the attached objects will be retained as exterior building elements.
Diakité et al. (2014) suggest a new method to retrieve the inner and outer topology of a complicated 3D building model from its geometry and to derive diverse Levels of Detail (LoD) from the resulting topological structure. According to them, the outer part of a 3D model can be considered as a generalization in LoD3. The assumption of a closed building model, by means of windows and doors at every opening, is made. The indoor volumes of the building and the exterior shell of it can be extracted by checking the adjacency of linear cell complex (LCC).
In order to obtain the exterior envelope of a building, Donkers et al. (2016) perform a semantic filtering and geometrical analysis. Every IfcObject, included in the IFC file, is certified whether it has a geometrical presence and if it is part of the building. To realize if an IfcObject is part of the inner structure of a model, IfcRelContainedInSpatialStructure relation is used recursively. Subsequently, the extraction of the exterior envelope, using as input the output of the previous step, takes place. To achieve the extraction, they divide the space into partitions, which is the generalization to three dimensions of a planar partition. Then depending on the adjacency of

solids' faces they execute a Boolean union process and the geometries contained in the exterior envelope are discarded. This happens either by retaining only the 2-manifold of the greatest volume, or by performing a topological analysis of the building elements.

2.2 Visualization through AR devices

Augmented reality (AR), as defined by Agarwal (2016), is a real time immediate or indirect view of a absolute, real-world space whose reality is augmented by artificially-generated input such as sound, video, graphics or GPS data etc. The graphics expert Ivan Sutherland was the first one who designed and constructed AR models in collaboration with his students at Harvard University and the University of Utah in the 1960s adopting a see-through technology to present the virtually designed objects (Van Krevelen and Poelman, 2010). They identified possible applications as: personal assistance and advertisement, navigation, touring, design, assembly, maintenance, combat and simulation, medical, sports broadcasting, games, collaboration, education and training. As mentioned above, AR devices may be divided into three classes based on their position in relevance to the viewer and the physical world : head-worn, hand-held, and spatial. A demonstration of successful augmented reality devices, have been released up to now, follows(Li et al., 2018):

- Google Glass includes four sensors that could be utilized for activity identification: a camera, a microphone, an inertial measurement unit (IMU), and an infrared proximity sensor looking at the users' eye, in order to discover the blinks of their eyes(Ishimaru et al., 2014). Some of the functionalities that Google Glass provides are pictures taking, video calling and web searching in combination with the feature of visualization of a virtual screen when the user stares at top right(Glauser, 2013).

- Vuzix M100 is an AR device in the form of eyeglass.It includes a computer with web access, speaker, camera, and voice and touch controls. Its functionalities are capturing and projecting pictures, taping and playing videos, recording and listening sound and web connection via the display mounted in front of the right eye of the user. Its imitations are "heavy" design, the blockage of the view of the user and narrow voice identification (Brusie et al., 2015).

- Epson Moverio BT-200 seems like an improved pair of eyeglasses. Two screens are incorporated in the body of the eyeglasses, with the display centered in the field of view and a camera looking at the front having a lamb signing when the device is on. Two removable UV protectors are included to the device. It incorporates a movement tracking infrastructure, sensors, touchpad, and Wi-Fi and Bluetooth connectivity (Wright and Keith, 2014).

- Sony SmartEyeglass provides the functionality to overlay text, symbols and images onto the physical field of view. It is a lightweight unit containing battery, speaker, microphone and touch sensor which facilitates the navigation. Furthermore, it contains a camera with 3 MP CMOS image sensor, accelerometer, gyro, electronic compass, and brightness sensor. It can connect with a smartphone over Bluetooth and WLAN (SmartEyeglass).

- Each Microsoft HoloLens has a 32-bit Intel Atom processor and Microsoft's Holographic Processing Unit, or HPU. The HPU constructs a 3D spatial model of the physical world, utilizing data produced by an inertial measurement unit (IMU), 4 spatial-mapping cameras and a depth camera The purpose of this spatial model is to maintain the capacity of the processor on manipulating data generated by the sensors, to facilitate the applications to position the holograms. Since HoloLens is, a a Windows 10 unit, can support

32-bit-processor-compatible Windows Universal Platform apps, currently available at the Windows Store (Furlan, 2016).

The combination of augmented reality with 3d Building models is a rather new field of research and not many studies have been published discussing the issue. Kopsida and Brilakis (2016) use the Kinect Fusion algorithm to rebuild the inner volumes of the environment. After having loaded the BIM file, they manually displace the model to correspond with the reconstructed model by the Kinect camera. Then, they connect the posture "calculated" by the Kinect Fusion algorithm to the BIM viewer in order the virtual projection to take place. The Kinect camera is tracked and chased by the BIM viewer camera. To not lose essential detail and incommode the tracking process, the motion of the Kinect sensors must be slow. Iterative Closest Point (ICP) algorithm is utilized to fix the adjustment of the BIM model compared to the real world. It reduces the discrepancies derive from the attempt to overlay the 3D BIM model on the produced digital model of the real space.
Fonnet et al. (2017) aim to visualize parts of a historic/heritage BIM (hBIM) to facilitate the building inspectors with the conservation of historical and cultural buildings. They suggest an approach according to which inspectors will have to approximately position the digital building without the necessity of this positioning to be extremely accurate. Using the ICP algorithm they will perform the final rectifications, comparing the planes extracted from the resulted mesh produced by the HoloLens spatial mapping with the simplified digital model.
Cardoso et al. (2017) suggest a method to project a BIM model into real world, in order to give the user the perspective of the future building. To achieve this they manipulate the BIM model through AUTODESK 3DS MAX which is a structuring and projecting software for providing virtual and augmented reality functionalities. Then, the output of the previous step is passed as input to Unity 3D in order the configuration of the 3d application to take place. Finally, the hologram is uploaded to the Microsoft HoloLens device to be projected into the real space.
One of the most important aspects for AR applications is the creation of appropriate interaction techniques that will allow end users to interact with virtual content in an intuitive way.
Considering AR interfaces Zhou et al. (2008) have identified 3 broad categories:

1. Tangible user interfaces, conception originally formed by Ishii and Ullmer (1997). Real objects are used as a mean in order the users to have the ability to manipulate digital generated information. Their main power comes from the fact that physical objects have characteristics with which the users are used to, like tangible shapes and intuitive properties, making their use easy and simple. Usually physicals elements are associated with gestures, gazes and sound interactions which guides to a multiple way of interaction with the users

2. Collaborative user interface. AR can assist both distant and co-located tasks (Silva et al., 2003). For co-located cooperation, augmented reality can be adopted to boost a common real work environment and provide an interface for three dimensional computer-supported collaborative work (CSCW) (Billinghurst and Kato, 2002). After having conducted tests with the Shared Space application, identified that this kind of interface was found straightforward and simple for extensive cooperation. In contrast to other interfaces, remains uncomplicated and depends on social protocols activities(Billinghurst and Kato, 2002).

3. Hybrid AR interface. An elastic model for hybrid user interfaces naturally incorporate a dynamic number of input and output units and the interaction approaches which adopt them. The provided capabilities will remain simple and clear to provide the users with the opportunity to expand their effectiveness even more (Zhou et al., 2008).

Microsoft HoloLens is a HMD which doesn't demands the use of user's hands to interact with the holograms that it projects. It means that the interaction way will be completely different with the one that the users are used to (keyboards, mice and touchpad). In contrast to the classical means of interaction, communication with the projected holograms is taking place using gazes, gestures and voice and reaction comes in the form of sound or graphics by the projecting parts onto the real space (Fonnet et al., 2017). Since, the great majority of the users are not familiar to this way of interaction, although more instinctive, at first it will be confusing and disturbing for them. So, it is of a high importance to supply detailed instructions on how to use the provided applications. They conclude that it is better to provide an personalized interface since the familiarity of each user with the augmented reality interaction is different.

3 Research Objectives

3.1 Research questions

This thesis project aims to answer the following research question:
Which stages should be followed to generalize / simplify a rather complex BIM model to be visualized via an augmented (mixed) reality device such as HoloLens?

The objective of this thesis is to propose an approach to "lighten" a "rich" 3D model like BIM/IFC model and develop a framework to visualize this simplified version through a mixed reality device, Microsoft HoloLens, in a way that the user will interact with it intuitively. The subsequent sub-questions will be answered to achieve the final goal:

- *Should a BIM model be generalized or simplified? To what depth should it be generalized/simplified depending on the purpose of the visualization? Which method of generalization/simplification will be more efficient to provide a model without gaps and holes?*
- *Which software should be used to produce a hologram out of the generalized/simplified model? How to configure the hologram to provide essential information depending on the purpose of the visualization? How to position it in the real environment? What is the maximum workload that HoloLens can handle efficiently?*
- *How the user will interact with the hologram? Will gazes, gestures and voice be proper sources of input for every user? How to inform the users for the potential ways of interactions? What will be the most intuitive interface, if there is one, to the users interact with the holograms?*

3.2 Scope of research

The aim of this project is to visualize a "simpler" version of a BIM file through HoloLens. The initial goal is to project only the exterior envelope of a building without any indoor information in order to be feasible for the device to handle with the workload. Having accomplished this in time, a method for extraction of the indoor elements for each storey will be approached. Since, projection via HoloLens is not a straightforward process, a framework will be created to achieve the visualization of the outer part of an infrastructure without viewing geo-referenced parts of a building that don't exist. Finally, the interaction of the users with the hologram will be achieved through gestures and the development of a user interface will take place.

4 Methodology

A methodology has defined to achieve the final goal which is the visualization of a generalized/simplified model through mixed reality device, Microsoft HoloLens. The steps will be followed to answer the question and sub-questions stated above are (Figure 1):

1. generalization/simplification of the .ifc file by means of semantic filtering and geometrical analysis
2. export of the simplified .ifc model to .fbx or .obj format to be imported in Unity3D
3. manipulation of the model through Unity3D by development C# scripts to produce the hologram and an intuitive interface
4. check of the functionality of the hologram and its intuitiveness

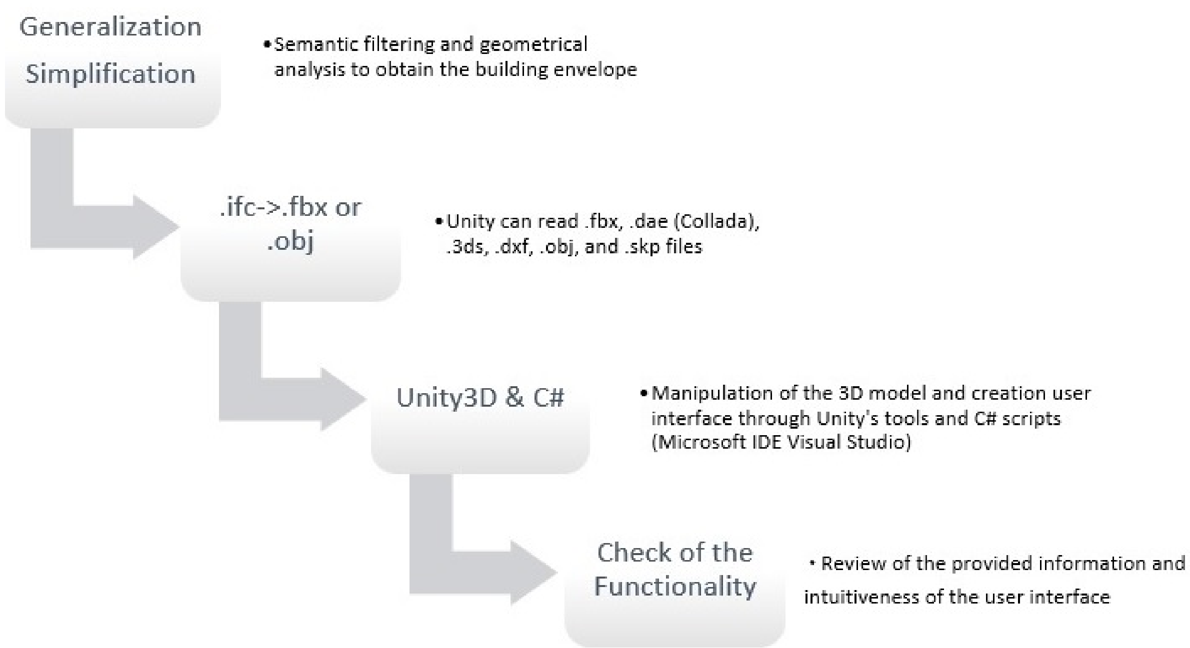

Figure 1: Flow Chart

4.1 Generalization/Simplification of the IFC model

Industry Foundation Classes (IFC) standard is the open data structure for BIM models, and the purpose of its creation is to enhance the exchange and the use of information among the stakeholders during the design and construction phase (Atazadeh and Kalantari, 2016). It follows an hierarchical spatial structure to store building information which leads to the capability of decomposition of the building model into distinctive categories such as site, building, stories, spaces and building elements inside stories (Liebich, 2009). Atazadeh and Kalantari (2016) have identified 5 essential classes to construct the building model: "IfcProject", "IfcSite", "IfcBuilding", "IfcBuildingStorey" and "IfcSpace". Figure 2 present the spatial data structure of IFC standard.

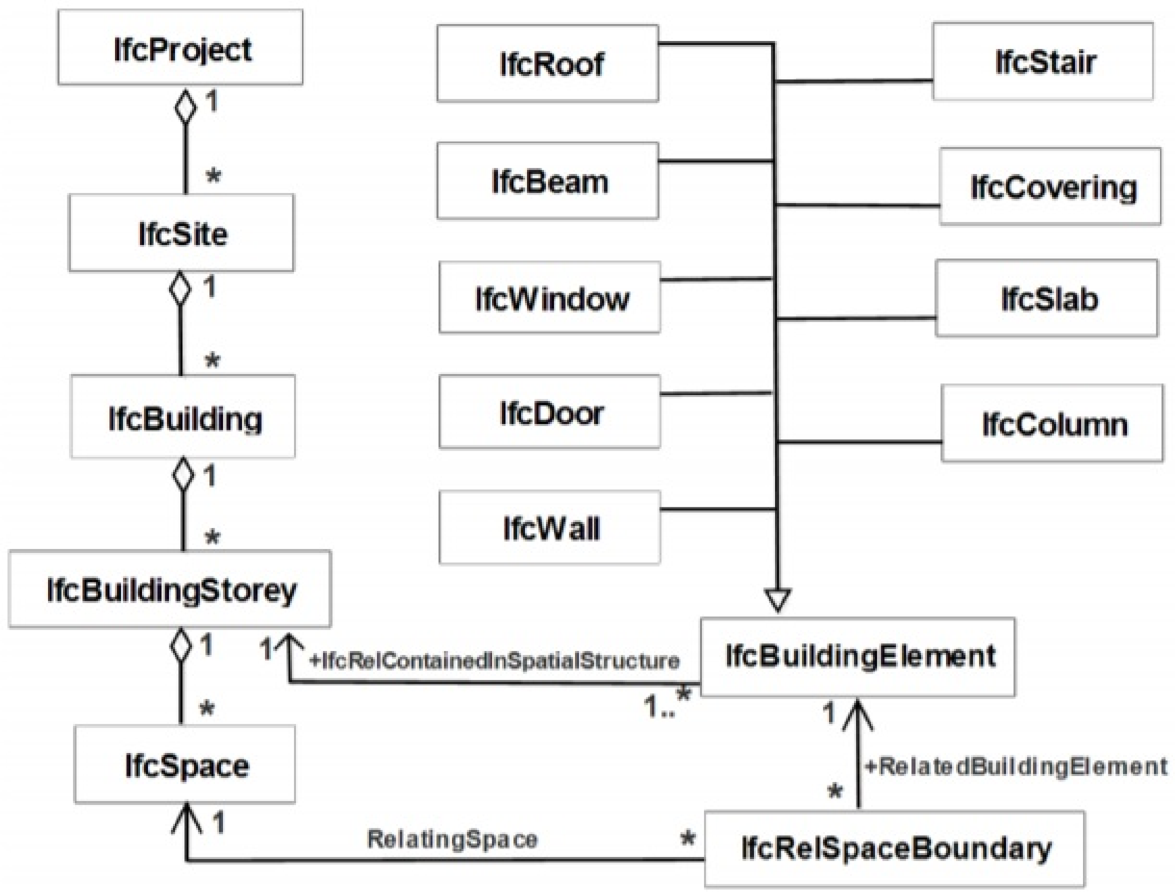

Figure 2: Industry Foundation Structure (Atazadeh and Kalantari, 2016)

For this project it was decided the IFC open file format (.ifc) to be used instead of a proprietary one since its schema is available online, there are freely available models on the web and it complies with the academic scope of this project. As it mentioned and before the HoloLens device has limited processing capacity and this limitation makes impossible the visualization of complex models. For each unique case different parts of a building are relevant to be presented. For this case the exterior envelope of the building will be visualized. This means that indoor geometries should be removed in order not to make the model too"rich" and verbose (Figure 3).

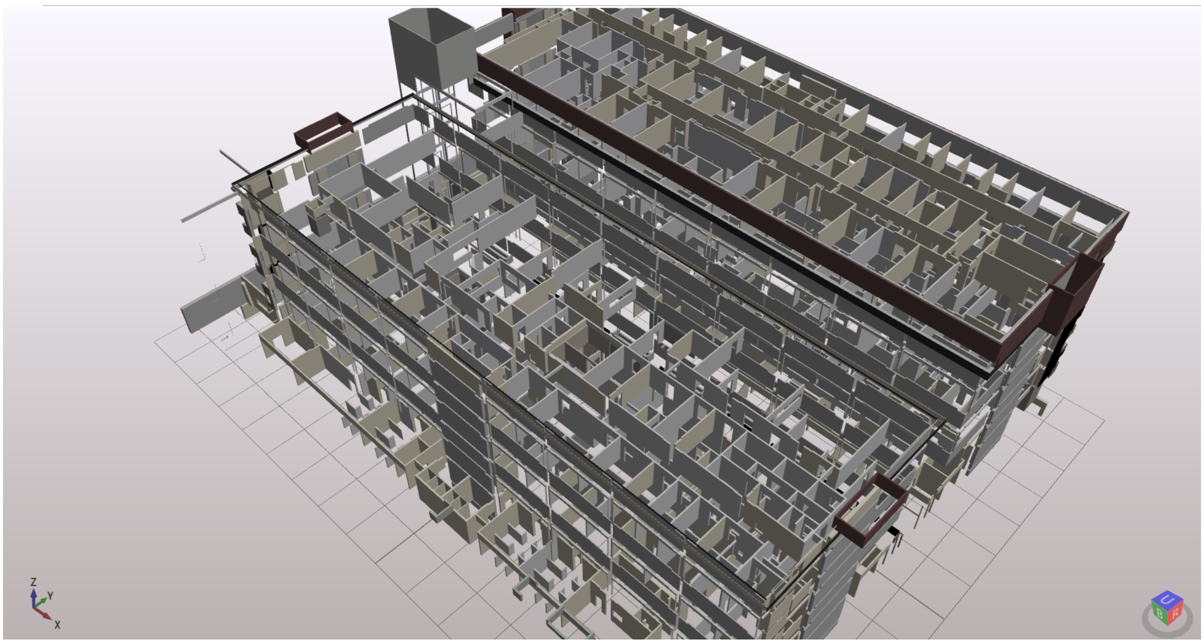

Figure 3: Complex and verbose IFC model

A generalization/simplification process will take place to remove parts of the buildings that are not essential for this project. In order to achieve this, at first the filtering method as described by Donkers et al. (2016) will take place. Many entities in the IFC structure either represent non static objects or are entities without geometry at all. Each IfcObject is tested to realize if it has a geometry and whether it is part of the inner building, using the IfcRelContainedInSpatialStructure relation recursively (Figure 4).

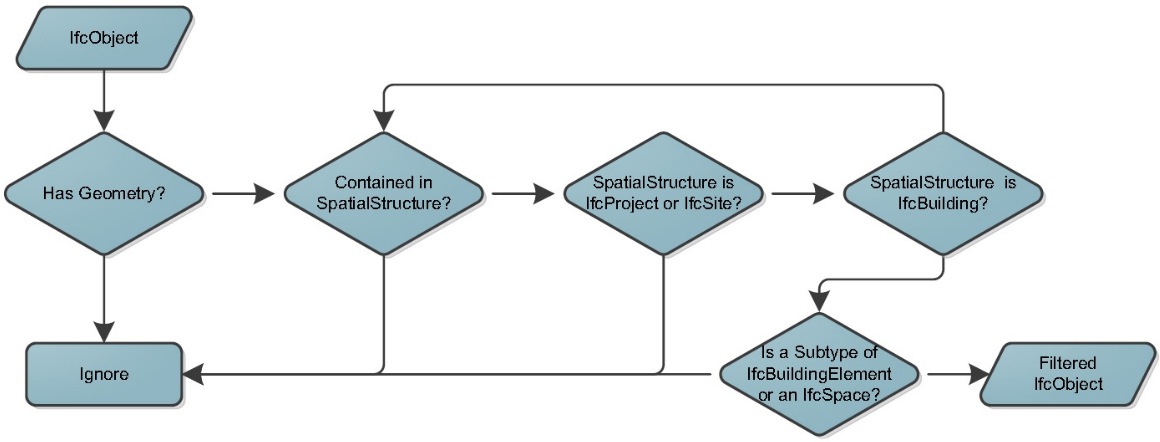

Figure 4: Filtering of IfcObjects (Donkers et al., 2016)

The semantic filtering procedure will preserve all important building elements related to each building storey. Since each storey is composed by different building elements, they will be treated separately. Each horizontal and vertical building element for each storey of the model will be depicted onto x-y plane, to create a corresponding ”footprint”. To extract the exterior footprint for each floor, the produced projection, with all horizontal and vertical elements, will be merged and resolved using two dimension Boolean operations (Nagel et al., 2007) and (Benner et al., 2005)(Figure 5). IfcOpenShell, free and open-source library,will be used to read and geometrically manipulate the IFC file (`http://ifcopenshell.org`).

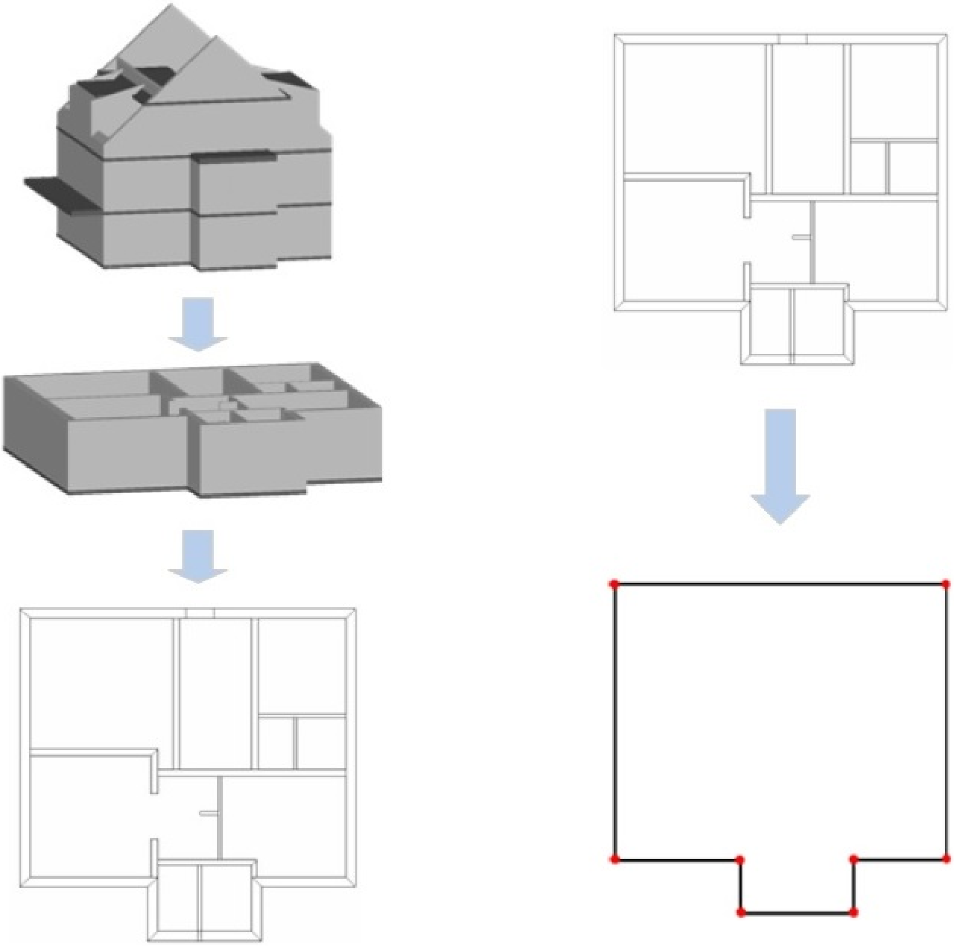

Figure 5: Simplification steps(Nagel et al., 2007)

4.2 Conversion of .ifc to .obj

The ”lighter” model produced by the previous process should be converted to a file format that Unity3D can support. Unity3D is a software framework initially designed for video games development that provides tools and function for real-time rendering, input devices manipulation, collision detection, sound and scene management (Kalarat, 2017). Microsoft co-operated with the Unity3D game engine to create a SDK to support and facilitate the creation of applications in the Unity environment(Toler, 2017). Unity can read .fbx, .dae (Collada), .3ds, .dxf, .obj, and .skp files (Unity3D, 2018).

For this project the simplified .ifc model will be transformed into .obj file format. An .obj file includes 3D objects that may have 3D coordinates, texture maps, polygonal faces and other information, and considered as basic 3D image format supported by a great variety 3D image software(noa, 2018b). Programs that open .obj files are NewTek Lightwave 3D, Adobe Photoshop CC 2017, Autodesk Maya 2018, Autodesk 3ds Max 2018, DAZ 3D DAZ Studio 4, IMSI TurboCAD Pro 2017, Blender, MeshLab, MAXON Cinema 4D, Smith Micro Poser 11, Autodesk AutoCAD with OBJ Import plugin etc (noa, 2018b).

Autodesk Revit will be used to for the conversion of .ifc file format to .obj. Revit software is clearly created for Building Information Modeling (BIM), to boost design and construction experts transporting ideas from concept to reality with a organized and rational model-based method (Autodesk, 2018b). It supports both the insertion of .ifc files and the export of .obj by using OBJ Exporter For Autodesk Revit (Autodesk, 2018a). Autodesk gives students, teachers, and educational institutions free of charge access to its design software, applications and learning resources(Autodesk, 2018b).

4.3 Holograms manipulation

The first step is to configure the unity environment for our project. Certain actions should take place in order to achieve a environment ready to manipulate the imported .obj file and scan the space to locate the model to the real environment.
The project which will be created to manipulate the hologram should have 3D setting selected. The original empty scene should be changed to do holographic development. Having selected the Windows Store icon, 16 bit depth buffers, virtual-reality supported should be selected, InternetCLientServer, PrivateNetworkClientServer, Microphone and SpatialPerception should be enabled. Furthermore, in the inspector panel the "Levels" tab of the "Default" row should be changed to Fastest in order to get better performance for the application. The main camera and the Directional Light object in the Hierarchy panel will be reconfigured. A cursor will be added to the scene to help the users visualize their gazes (noa, 2018a).
The Mixed Reality Academy is a Microsoft's web page which contain a number of detailed and well-organized tutorials to use and configure the HoloLens (in combination with Unity3D) (link). Spatial mapping is capability to retrieve triangle meshes that represent the surfaces in the world around a HoloLens device, for placement, occlusion, room analysis and more(noa, 2018c). Except for Mixed Reality Academy, Microsoft has gathered a lot of C# scripts that facilitate the HoloLens development under a GitHub repository called MixedRealityToolkit-Unity(link). These scripts will be used and further developed to transform the real word objects into digital through the spatial mapping feature. Spatial mapping data will be analyzed to find planes and these planes will be used for the placement of holograms. Determination if a hologram will fit on a surface will take place and proper feedback will be given to the users whether the hologram can fit or not. A potential occlusion of the hologram by the spatial mapping mesh will be taken into account. Finally, C# script will be developed for the creation of an intuitive interface that will make the use of the application easy and understandable for everyone.

4.4 Functionality of the application

Given the fact that the present thesis project is taking place in combination with SWECO, a 14,500 employees leading engineering and architecture consultancy company, a demonstration of the model to experienced people of the company will be performed. Their opinion considering the ease and functionality of the application will be used as feedback. Relevance of the model with regard to the facilitation of the projects being held right now will be used as an indication for further research. The simplicity and intuitiveness of the user interface will be examined and reconsidered according to their comments.

5 Time planning

5.1 Tasks

The Task List and the Gantt chart below (Figures 6, 7) are clear indications of the sequence of the tasks, combined with time intervals, that will be followed to achieve the completion of the project. This schedule shows an approximation of the objectives that will be reached during the year. Presentations dates will be more accurately specified in communication with my supervisors.

START	END	TASK
15-Oct	08-Nov	Exploration of Graduation Topics
09-Nov	13-Nov	P1 presentation preparation
14-Nov		**P1**
15-Nov	07-Jan	Literature Review
15-Nov	07-Jan	Graduation Plan Reporting
20-Dec	07-Jan	Identification of useful Tools
08-Jan	14-Jan	P2 presentation preparation
15-Jan		**P2**
16-Jan	04-Mar	Implementation of the generalization/simplification process
16-Jan	04-Mar	Configuration of the Hologram
05-Mar	11-Mar	P3 presentation preparation
12-Mar	16-Mar	**P3**
19-Mar	30-Mar	Configuration of the Hologram
19-Mar	06-Apr	User Interface Development
09-Apr	29-Apr	Thesis Reporting
30-Apr	06-May	P4 presentation preparation
07-May	11-May	**P4**
14-May	01-Jun	Finalize Thesis
28-May	10-Jun	P5 presentation preparation
11-Jun	15-Jun	**P5**

Figure 6: Task list

5.2 Meetings

This project is cooperation of TU Delft and SWECO. Weekly, meetings will be held with the main supervisor, Stelios Vitalis, in TU Delft and regular meetings will take place with the second mentor, Ken Arroyo Ohori. Furthermore, assistance and guidance will be given by Henri Veldhuis and Marco Grimaudo, SWECO's supervisors, on a weekly basis.

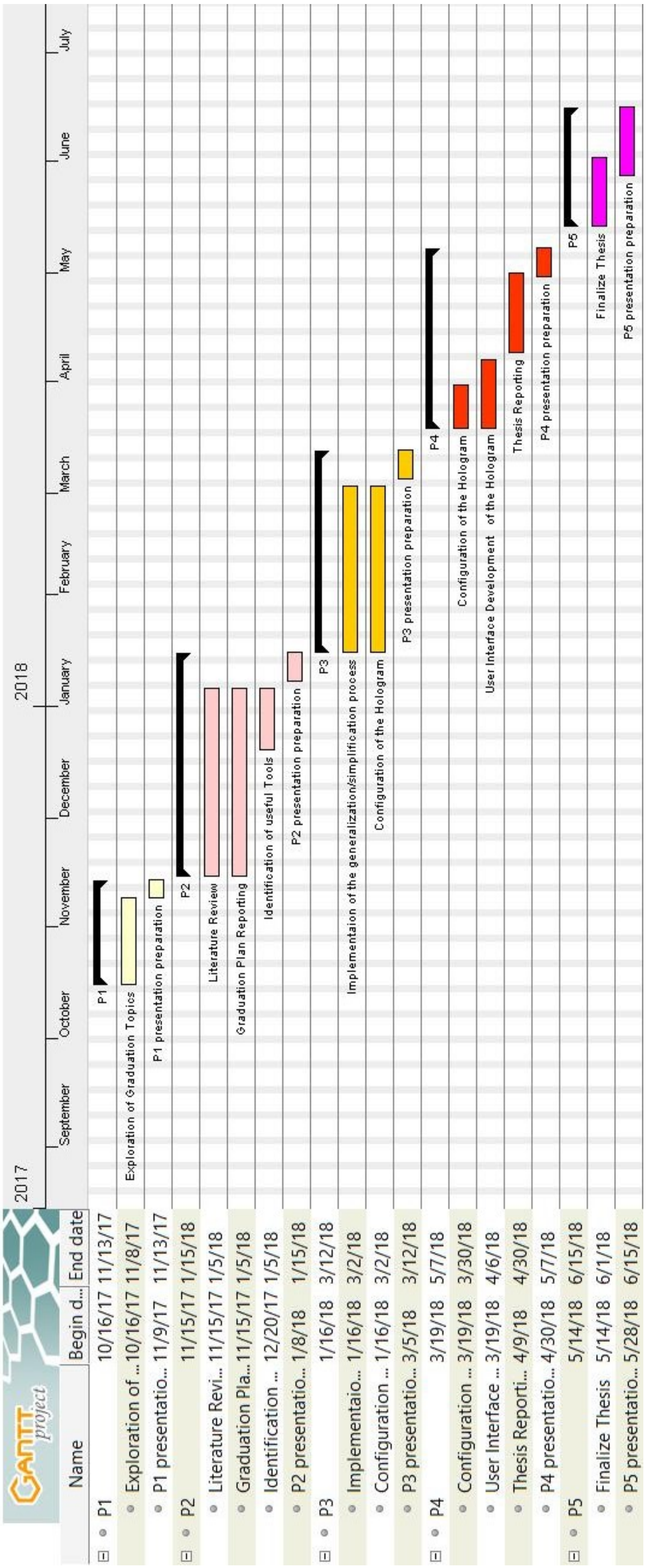

Figure 7: Gantt Chart

6 Tools and datasets used

6.1 Tools

For the completion of this thesis a number of tools will be used in different steps of the project. These tools will be used for conversion of file formats, visualization of the model, configuration of the hologram, development of scripts for generalization, manipulation and user interface creation.

- **Autodek Revit**, building information modeling software, will be used for the conversion of file formats in two phases. Firstly, the given data model is in .rvz, a proprietary file format owned by Autodesk. This file will be transformed to .ifc using Revit. Secondly, after the completion of the generalization/simplification process, the produced model will be inserted in Revit once again to be transformed in .obj file format in order the Unity3D game engine to support it (link).

- The **xBIM Xplorer** is a free, open-source IFC viewer. It will be used for the visualization of the model during the generalization/simplification procedure (link).

- **Python** is open-source and freely usable programming language that will be used for the generalization/simplification step (link). **IfcOpenShell-python** is a python module based on IfcOpenShell that convert the implicit geometry in ifc files into explicit geometry and it will be used for the manipulation of .ifc file (link).

- **Visual Studio IDE** will be used for the development of **C#** scripts (link) . Microsoft Visual Studio Tools for Unity provides powerful tools for code editing, debugging and productivity features while writing C# scripts (noa, 2018e). **C#** is an object-oriented language developed by Microsoft and it will used to develop scripts for hologram manipulation and user interface creation (link). Microsoft has created a web page called **The Mixed Reality Academy** which provide a number of useful tutorials. (link). Furthermore, **MixedRealityToolkit-Unity** GitHub repository contains a huge number of a C# scripts to scan the environment and load spatial mapping data to unity, find planes, move and place holograms and use the occlusion feature(link).

- **Unity3D** is game engine providing mixed reality and HoloLens support. It holds a wide tools, packages, and resources that make it simple for a developer to create mixed reality applications (noa, 2018d). In its official page simple tutorials are provided to facilitate the configuration procedure(link).

6.2 Dataset

The dataset which is about to be generalized/simplified was given by SWECO. It is the building information model of Amsterdam's Hospital (AMC). As it mentioned above, it is in a proprietary format, Autodesk Revit. Revit was used to export it in the industry foundation classes format (.ifc). Since it is rather complicated, it is not possible to be visualized through HoloLens (Figure 8). A generalization/ simplification process will be applied to it in order to eliminate the irrelevant indoor geometries (Figure 9).

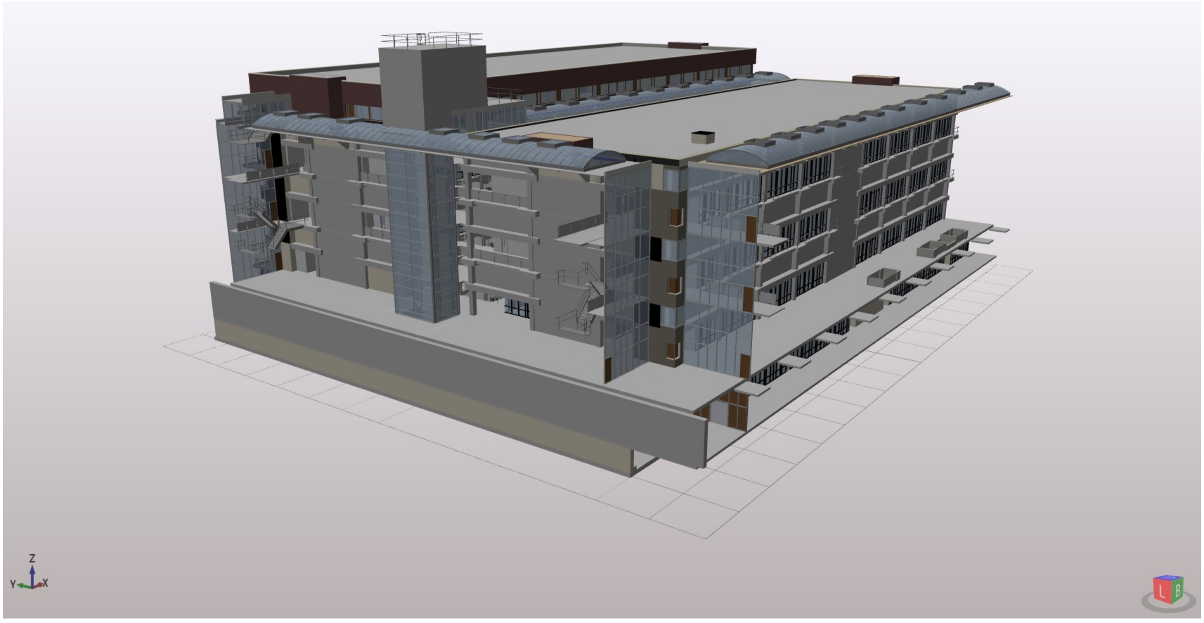

Figure 8: AMC visualized by xBIM Xplorer

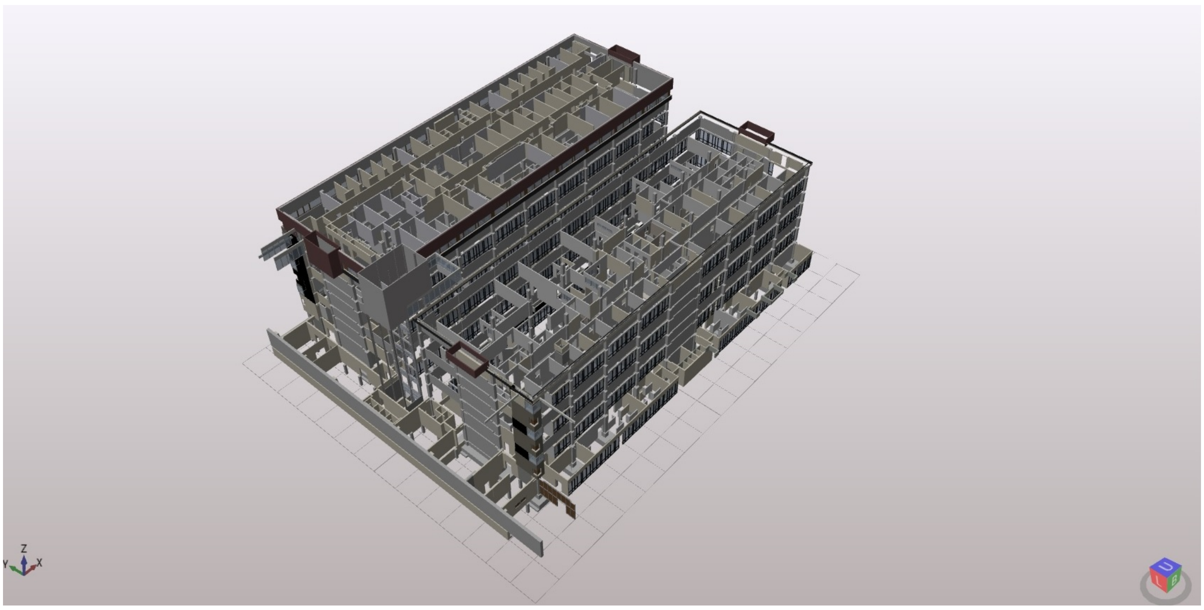

Figure 9: Indoor geometries of AMC

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