Generating a Simplistic 3D Model for Mobile Platform Applications

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Abstract: The number of buildings is increasing day by day. The next logical footstep is tackling challenges regarding scarcity of resources and sustainability, as well as shifting focus on existing building structures to renovate and retrofit. Many existing old and heritage buildings lack documentation, such as building models, despite their necessity. Technological advances allow us to use virtual reality, augmented reality, and mixed reality on mobile platforms in various aspects of the construction industry. For these purposes, having a BIM model or high detail 3D model is not always necessary, as a simpler model can serve the purpose within many mobile platforms. This paper streamlines a framework for generating a lightweight 3D model for mobile platforms. In doing so, we use an existing structure's site survey data for the foundation data, followed by mobile VR implementation. This research conducted a pilot study on an existing building. The study provides a process of swiftly generating a lightweight 3D model of a building with relative accuracy and cost savings.

Key words: VR, modeling, mobile platform, visualization

1. INTRODUCTION

There was a time when building designs were visualized by creating two-dimensional architectural and technical drawings. Then, with the advancement of technology, CAD (Computer-Aided Design) tools arrived, which paved the way for the creation of interactive 3D visualizations [1]. BIM (Building Information Modeling) currently widens 3D building models by adding multidimensions to its arsenal. Dimensions such as time (scheduling), quantities, cost, sustainability, and risk analyses are added, which allows for emphasis on 3D visualization and collaboration during the design phase [2].

Scarcity of resources, challenges in sustainability, and stricter authorization of recycling motivate the AEC (Architectural, Engineering, Construction) community to manage existing resources efficiently. Due to long building life cycles, maintenance, and deconstruction management, especially in industrialized countries, the construction sector is increasingly shifting towards building modification and retrofitting existing buildings [3]. For many benefits during

design, planning, and construction, the growth of BIM in the construction sector is ever-growing. However, BIM implementation in existing buildings faces many challenges, among which as-built documentation and incomplete building information are predominant [4][5]. Missing or obsolete building information results in many possible drawbacks, such as ineffective project management, potential time loss, and cost increase in facility management [3]. As these structures lack proper documentation creating a typical BIM from scratch can be not only daunting, but costly in terms of money and resources.

Digital technologies have automated the measurement and data collection processes. Some of the digital technologies include the use of a laser to determine range and geometry, digital photo modeling geometry and texture, and modern software platform to compute and model virtual building environments [6]. Laser scanning provides a high level of accuracy and detail to compute parametric models of complex objects [7].

Past research created 3D models of building roofs and facades by utilizing 3D terrestrial laser scanning (TLS) data for building renovation purposes [8]. This laser scanning-based method is advanced but requires considerable time and effort to produce a digitized model. [8], [9]. In recent years, point cloud software development has seen its fair share of improvement. However, 3D laser scanning is an effective tool for precise and detailed model development; however, it could suffer a major drawback with efficiency for a lightweight 3D model for mobile platform implementations. Efficiency is compromised with various aspects including measurements in occlusion, ambient light, required expertise and computational demands in processing [10].

Computer-generated environments in the advancement of construction technology are gaining popularity. Technologies like VR (Virtual Reality) can help to assess job site conditions visually and create an immersive environment for the user [11]. After the availability of the first mature wearable VR/AR devices (i.e., Google Glass, Forte VFX1), it is now inevitable that mobile VR/AR devices take center stage. To enhance the way information is accessed and presented, more and more tangible VR/AR solutions exist to match client requirements and objectives, as graphically, the gap between real-world and digital representation is narrowing [12]. Many researchers have been studying the application of VR in various areas of the construction industry. From progress monitoring of construction processes, planning and layout of the site, evaluating the scenarios of construction, to simulating the erection sequences, usage of this technology is booming quickly. Areas like maintenance and inspection, construction safety training education, fire safety, and hazard identification are also utilizing VR technology to its potential [12]–[15].

2. OBJECTIVE

This paper presents an approach to swiftly create a 3D model of an existing building with no readily available documentation, such as the floor plan and measurements. As a validation of the process, we implemented the framework in an actual case study to generate a lightweight 3D building model for the mobile platform that can be connected to visualization tools like VR.

3. USED TOOLS

This section of the paper provides an overview of the application technique that is used to acquire geometric information about a building. A total station is an accurate instrument that records single points of geometric information. Depending on the required accuracy of a model of interest, other measuring devices, such as distance meters can be used. Also, information regarding the software applications that were used to accomplish the work is described.

3.1. Measurement

The total station is a surveying instrument that consists of a theodolite with a built-in distance meter. It can be used to measure distance and angles at the same time. Modern-day electric total stations have electric angle scanning and optoelectronic distance meters (EDM). Digital data from observations taken from the total station can be adjusted and transformed to local XYZ coordinates by using an internal microprocessor. Data from the device are sorted with programmed functions which automatically detect various errors, such as atmospheric corrections, grid, and geodetic corrections. Data observation from a typical total station can be saved to the device itself, and saved observations or points can be downloaded to an external device [16].

3.2. CAD and 3D model software

Two of the leading software used in this study are Autodesk Civil 3D and SketchUp. Autodesk Civil 3D is a civil engineering application built upon the CAD (Computer-Aided Design) program AutoCAD [17]. SketchUp is a very popular 3D modeling computer program with a broad range of drawing and designing applications [18].

4. PROPOSED PROCESS

Figure 1 presents the proposed process workflow chart, which depicts the phases of the process in four parts. Onsite survey and data collection involve assessing and recording the points within the structure and measuring and mapping the surroundings inside the building. Data points can be used to create a 3D model in two ways: 1) directly using the data into 3D modelling software (from survey and data collection to 3D model) and 2) constructing a 2D layout plan from the data points and then extending to a 3D model in 3D modelling software.
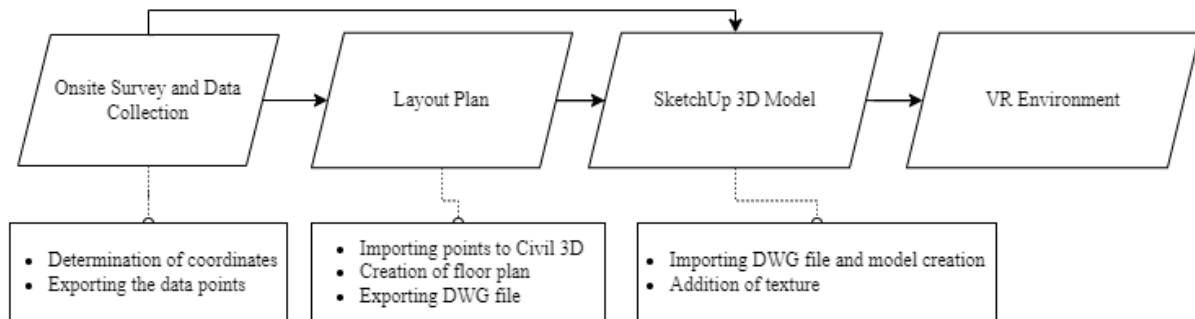

Figure 1. Workflow of a simple 3D modeling Process for mobile platform VR

We present two ways as they offer different advantages of completing the task. In case of 2D drawing creation, such as layout plan with many points, CAD user interface presents better user convenience with a flat (2D) surface compared to SketchUp which is more inclined towards a 3D perspective. Figure 2 displays a comparative example of user viewing perspective in two software. During implementation, the CAD view is more effective than the Sketchup view to create a 2D map especially when dealing with a large sized model. Creating lines from the imported points can be challenging and time consuming in a direct Sketchup view due to the visual differences. Therefore, this research used the second path with Civil 3D. Subsequently, the layout plan will be imported into SketchUp, and a 3D model will be created which can be used in a VR environment.
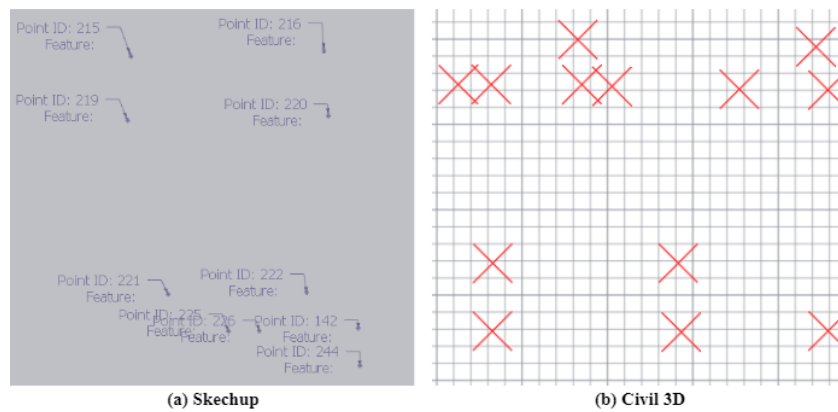
Figure 2. Comparative example of perspectives in two software

5. PILOT STUDY

The study implemented the proposed approach to develop a 3D model of the first floor of SEB (Science and Engineering Building) at the University of Nevada Las Vegas for future VR-based evacuation training. The SEB consists of relatively large corridors and hallways. We completed the onsite survey and data collection by using a total station Trimble TS525 as the first step. Each room was coordinated using the total station using the internal survey traverses. The internal survey was performed in a uniform system. We surveyed the room perimeters at the height of approximately 1m using the reflector less measurement technique. The points from the survey were exported into a CSV (Comma Separated Value) file containing XYZ coordinates or northing easting elevation (Figure 3(a)).

After completion of the onsite survey, the 3D modeling task may be carried out in the two-mentioned ways. The data collected from the total station stored in a CSV file was imported into Autodesk Civil 3D 2022 (Figure 3(b)), where a 2D layout plan was created from the coordinate points taken with the survey instrument. By connecting the points, lines were created to form a 2D layout plan of the building. Afterward, the layout plan was exported into DWG file format. The DWG layout plan (Figure 3(d)) was imported into SketchUp Pro 2022. Alternatively, using the total station point importer extension available for SketchUp, coordinate points from the survey instrument can be directly imported to SketchUp (Figure 3(c)) and the layout plan can be created using the line command.

Exporting the 2D layout plan into SketchUp, the 3D model of the building structure was created using SketchUp commands like lines, push-pull, offset, etc. (Figure 4). The texture was added to the elements within the model to make it more photorealistic.
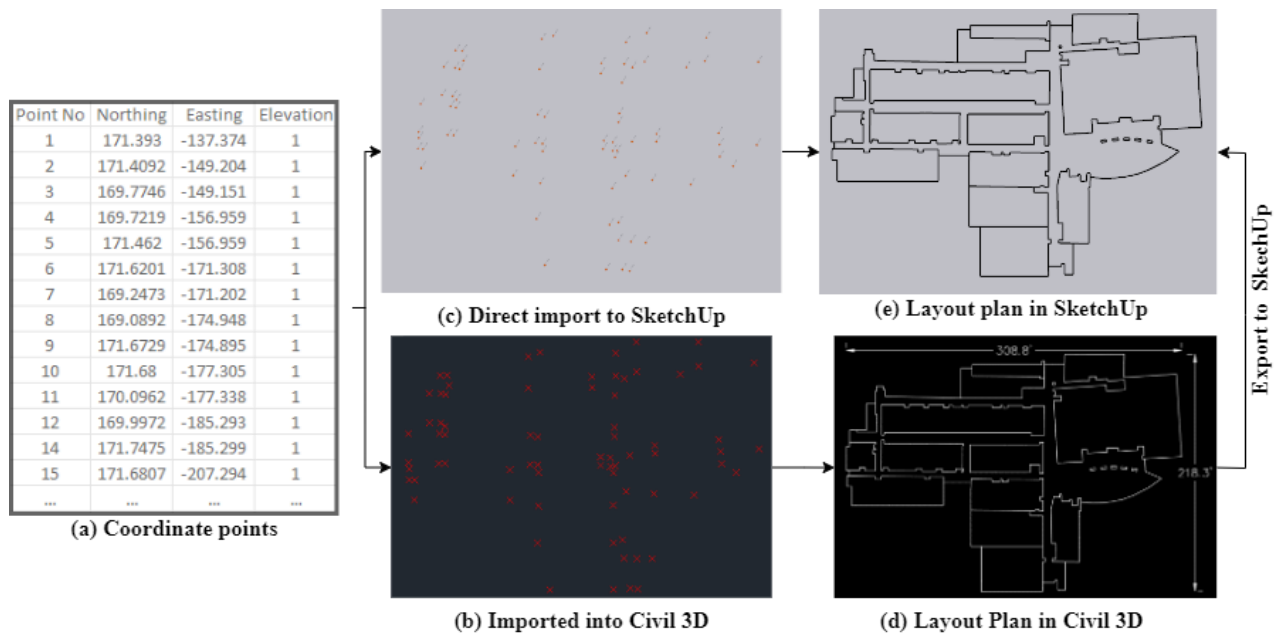
Point No	Northing	Easting	Elevation
1	171.393	-137.374	1
2	171.4092	-149.204	1
3	169.7746	-149.151	1
4	169.7219	-156.959	1
5	171.462	-156.959	1
6	171.6201	-171.308	1
7	169.2473	-171.202	1
8	169.0892	-174.948	1
9	171.6729	-174.895	1
10	171.68	-177.305	1
11	170.0962	-177.338	1
12	169.9972	-185.293	1
14	171.7475	-185.299	1
15	171.6807	-207.294	1
...	...	...	...

(a) Coordinate points

(c) Direct import to SketchUp

(e) Layout plan in SketchUp

(b) Imported into Civil 3D

(d) Layout Plan in Civil 3D

Export to SketchUp

Figure 3. Coordinate points to the creation of a layout plan.

Figure 4. Creation of SketchUp 3D model

The generated 3D model was introduced into a mobile app SimLabVR Viewer, which is available for both iOS and Android, where the 3D model can be accessed, viewed, navigated, and measure dimensions within the mobile app in VR environment (Figure 5). SketchUp can export model files in IFC, DWG,3DS, OBJ, FBX, SKP, etc., formats that can be utilized to export the model into other software programs. Among these formats, SKP and FBX (Flimbox) can be utilized to exchange 3D geometry and animation data. Past research implemented FBX format for geometric information for BLE-based indoor location tracking [19]. FBX files are used for VR and AR development, which can be imported into Unity. It provides a baseline API and feature set that lets one experience the 3D model in a VR environment. The baseline SketchUp model created in this pilot study is now ready to be exported into Unity which provides greater flexibility and features to develop the model for the VR environment.
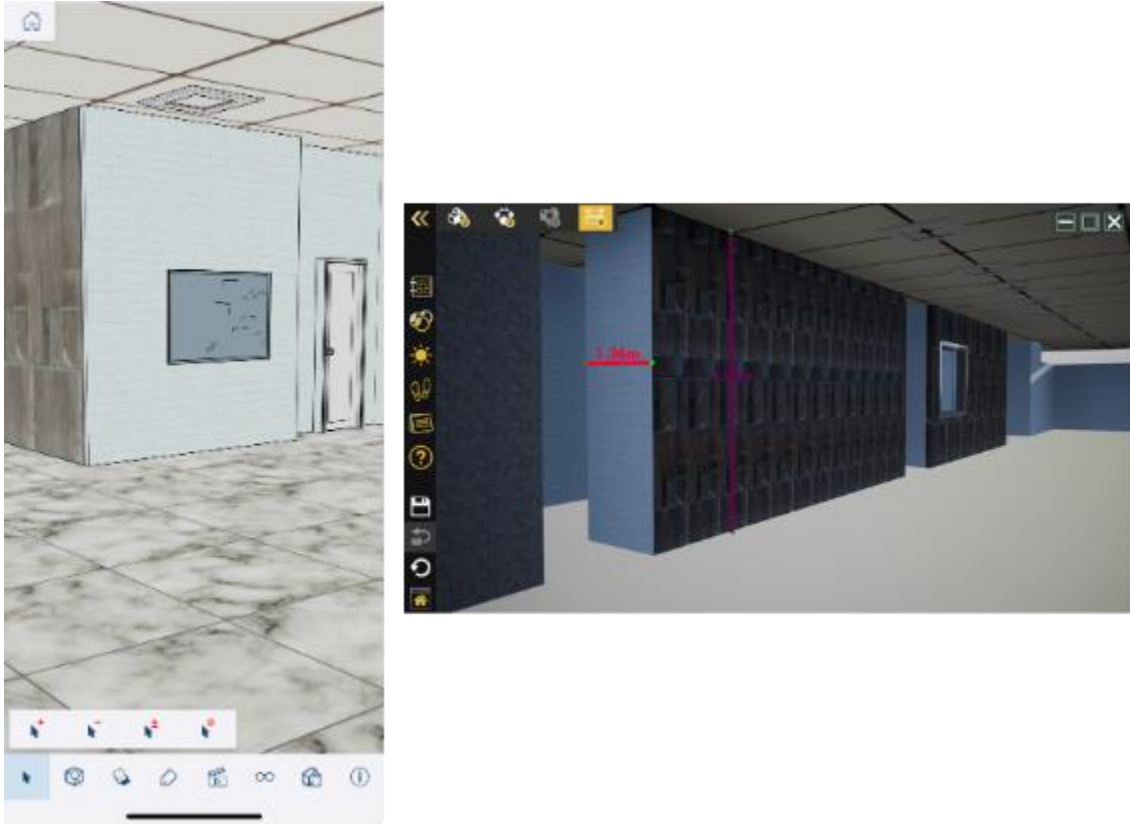
Figure 5. Generated 3D model transferred to VR environment

6. CONCLUSION

The article described a streamlined approach for developing a simplistic 3D model of a building with no existing documentation of dimensions. The primary attention was to develop a process outline and implement that process via a pilot study on an existing building to speedily generate a 3D model for mobile platform applications, such as VR. The combination of traditional survey instruments (e.g., a total station for site data collection) and popular 3D modeling software (e.g., SketchUp) proved to be a well-suited approach for the creation of a simplistic 3D model. Moreover, the process demonstrated an effective and speedy construction of a VR model for enhanced visualization and user experience. This approach is a potential alternative to traditional BIM model creation and VR accessibility. As mobile devices are now available, this study presented a cost-effective way to produce a digital model of a building structure.

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