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Implementation of laser scanning and BIM technology in damaged buildings reconstruction

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Implementation of Laser Scanning and BIM Technology in Damaged Buildings Reconstruction

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Abstract. Building information modeling (BIM) is one of the most promising recent developments in the architecture, engineering, and construction industry. With BIM technology, an accurate virtual model of a building is digitally constructed. This model, known as a building information model, can be used for planning, design, construction, and operation of the facility. It helps architects, engineers, and constructors visualize what is to be built in a simulated environment to identify any potential design, construction, or operational issues. Also, BIM technology can be used in reconstruction of damaged and partially destroyed buildings. This is can be realized through the integration between it and various other technologies which make the process of reconstruction more efficient and constructive in saving time and efforts.

INTRODUCTION

Nowadays, one of the most popular and effective technologies which can be integrated with BIM is laser scanning, which can be applied for damaged buildings by various causes, such as military actions, earthquakes, fire or other natural catastrophes. therefore, scanning technology is becoming a critical function necessary to complete the integrated BIM cycle and provides a clear value-add for the integrated BIM workflow.

This paper will demonstrate how scanning technology can be applied to the BIM workflow for buildings reconstruction, by sending out a high density of laser beams for the purpose of positional measurement. Laser beams project outward from the scanning hardware and are measured in time of flight or phase shifts as they return to the source. The hardware measures the return time of the laser and can tell how far away a physical element is. Current scanning technology has the ability to send out thousands of beams per second, resulting in a "point cloud" of data. Scanners can also identify the R, G, B color value for a more intuitive display of point cloud information. Resulting point clouds can include millions, even billions, of data that reflect the physical environment being scanned.

Planning

Point clouds resulting from scan data are immensely powerful for analysis on their own; however, this paper assumes that the point clouds will be converted to object-based BIM models. Converting scan data into BIM models is traditionally a three-step process: First, multiple scans are captured from different scanning stations.

Second, data from multiple scanning stations is stitched together in what is commonly known as the post-processing or registration stage. Next, CAD or BIM software can be used to author object models while referencing the point cloud. Some registration software, such as Trimble RealWorks, has the capability to create content from within the point cloud by running algorithms across the data points and recognizing surfaces from it. Creating

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objects within the registration software offers the benefit of rapid creation but has some limitations surrounding the accuracy and metadata acceptance of modelled objects. Creation of object models using external authoring applications is slower and more manual but has the benefit of detailed object representation and increased metadata acceptance.

A scan plan should be made after the project objectives have been clarified. A scan plan is a set of information that outlines the scope and approach that will be taken to capture the data on-site. Often a scan plan starts with detailed analysis of precisely which elements need to be captured. In the case of scanning new work in place most scanners will desire to capture the position of each and every element. But in case of reconstruction, scanners will often have specific scopes of work about which they need more information. Identifying the exact scope of elements to be scanned helps the on-site team to prioritize their efforts and mitigate time spent capturing unnecessary elements. With a clear scope in mind a document can be created that identifies the optimum equipment location necessary to capture the desired information.

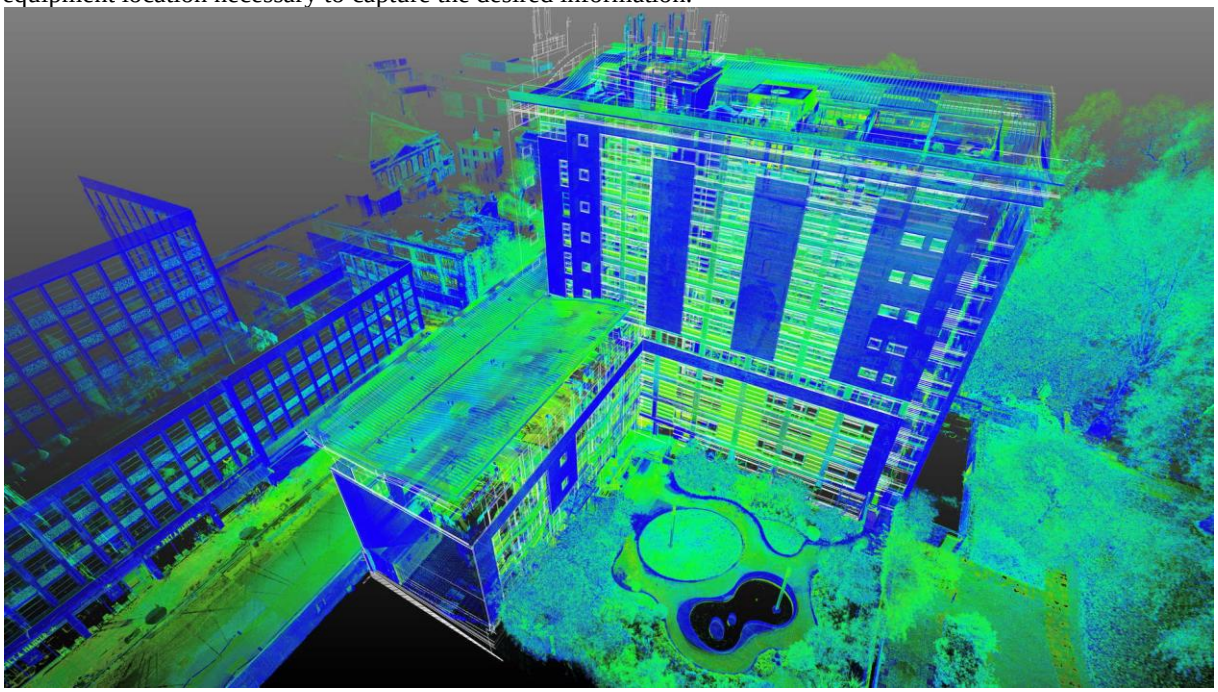

FIGURE 1. An example for building point cloud.

3D modelling

Once on-site scanning is complete and the multiple scans have been registered together, the object model creation process begins. Again, object creation can occur in the registration software or in external modeling applications. The choice of which tool to use for modeling should depend upon the desired scope outcome. For detailed scopes, such as complex structures, specific authoring applications like Tekla, Revit, and ArchiCAD are often used. Less detailed scopes can be very quickly represented using authoring applications such as SketchUp. Using external authoring applications requires a methodical approach to model creation whereby elements are created systematically and in order of importance pertaining to the scope. Attempting to recreate every single element in a single area can lead to loss of focus and failure to meet the broader objective. Many projects will see that structures are modeled first; existing to remain architectural features modeled second, and mechanical systems follow. In the case of reconstruction, modelers will be well advised to include some kind of “existing to remain” delineation so that those model elements can be viewed separately throughout the BIM use cycle.

The existence of 3D models immediately helps modelers and constructors to determine the damage degree of the building by analyzing every structural element. Therefore, founding the appropriate structural solution for it.

FIGURE 2. 3D model for damaged building.

Of special importance for design validation efforts is the support of the coordination process. reconstruction projects include a mixture of existing to remain elements with newly placed elements. The scan and model data is capable of providing detailed information about points of connection that may exist between these two work scopes. Having exact points of connection between the two work scopes allows for a more accurate coordination process.

Having an accurate 3D representation of elements from scanned data allows for further use of the data when considering the 4D time aspect associated with each construction element. Specifically, the quantity and position of each element can be leveraged to create detailed location-based schedules. Location-based schedules have a significant advantage over traditional schedules in that in they use detailed quantity and position information to represent the true work volume and position to take place during construction. Location-based scheduling is a concept that further extends into the ability to perform production control on-site and make teams proactive when managing a project schedule. The combined pro-activeness of scanning information and production control is a key component to mitigating schedule delays on reconstruction projects.

Also, scanning of work before reconstruction has proven to be a value-add as the quantifiable information coming from 3D elements allows for more detailed cost planning, or 5D as it is called. Scanning of work produces the 3D models and allows for the accurate delineation of cost assemblies associated with new and existing structural

or architectural elements. Cost components relating to the two different phases of construction may include different unit rates, different crews, and different cost buffers in order to arrive at a more accurate project estimate [1].

Laser scanning for damaged historical sites and buildings

Laser scanning is not restricted to residential and industrial buildings, it also can be used to create 3D model for the historical buildings, as it infrared thermography provides a thermal graph of a building, measuring the radiation emitted by different materials to create a multi-layered look inside the walls of a building. It can help preservationists and architects tell where things are buried, whether a support beam has cracked, or what's beneath the surface. Ground-penetrating radar helps discover structural defects in masonry and stone, and what archeological remains might be buried in the surrounding grounds. Also specialists can use endoscopy—the small, flexible tubes with lights and wires attached used in surgery—sending tiny cameras deep into walls and voids to obtain better reads of structural defects, materials, and voids. It allows preservation experts to get under the skin of a structure without causing additional damage [2].

As an example we will mention the world's largest digital model of historic monuments, which is made for the Syria's ancient city "Palmyra", as shown in figures 3,4.

Scientists from the Institute for History of Material Culture at the Russian Academy of Sciences made the model in order to facilitate it is reconstruction and help preserve it, this is by over 55,000 high-quality aerial photos in order to produce the model which is made of around 700 million polygons, it has more than 750 cloud-based points for developing the model. which helps identify whether, say, a crack in the stone is new or it was there. The model has fixed all the old cracks [3].

FIGURE 3. 3D model of Palmyra city.

FIGURE 4. 3D model for the damaged Roman amphitheater-Palmyra city.

CONCLUSION

The implementation of laser scanning in the reconstruction of damaged buildings brings an entirely new realm of possibilities to an already powerful integrated BIM workflow. The ability to capture detailed information about elements in their physical space allows for more precise use of data. Whether capturing 3D information for coordination and prefabrication or leveraging the quantity information for estimating and scheduling, laser scanning is surely a necessary endeavour to increase the accuracy of project information. Decreasing hardware costs and increased software capabilities have made scanning a competitive advantage for contractors willing to invest the time and effort into this fully integrated BIM workflow.in addition to, the crucial role in contributing to the maintenance of the heritage sites and buildings

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