From Point Cloud to JHBIM:
Jeddah Historical Building Information Modeling
Old Jeddah - Saudi Arabia

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ABSTRACT:
The historic city of Jeddah faces serious issues in the documentation, conservation, and recording of its valuable building stock. Terrestrial Laser Scanning and Architectural Photogrammetry have already been used in many Heritage sites in the world. The integration of heritage recording and Building Information Modelling (BIM) has been introduced as HBIM and is now a method to document and manage these buildings. In the last 10 years ago many traditional engineering methods were used to record the buildings in Old Jeddah. On the other hand, these methods can sometimes offer unreliable information, take a long time, and often lack completeness. This paper will look at another method for heritage recording by using the Jeddah Historical Building Information Modelling (JHBIM).

1. INTRODUCTION

1.1 Background:

Jeddah is one of most important cities in the Kingdom of Saudi Arabia; it has a long history and there are many historic buildings that were built more than 250 years ago. The city of Jeddah is a coastal city, which is located in the western region of Saudi Arabia. It is known as gateway to the two holy cities of Islam, which are Madinah and Makkah. Its geographical features contain a natural harbour in the shape of a crescent, and the city is surrounded by a series of mountains and hills. However, this coastal area is hard to navigate for ships because the coral reef surrounding the harbour, which was formed to defend the city from invasion, attacks in older periods. (ADDAS, 2009).

1.2 Old Jeddah issues:

The major issues that face Jeddah today are how the government can preserve and save them from the risk of collapse and erosion by natural and human factors, and disasters such as fires. In fact, numbers of buildings have been lost in this historical area over the last thirty years and because of that a valuable source of information and a part of the city's history has been lost. Today, many buildings are abandoned and they became occupied by squatters. Many private professionals believe that these building must be conserved, maintained and used; otherwise, they will lose their essence of history and culture (SAMI, 2013).

1.3 The Existing Solutions:

The municipality of Old Jeddah City decided to preserve and develop this area by using an approach, which depend on independent engineering survey offices. The method takes a long time and could sometimes offer unreliable or conflicting information.

The procedures for this approach start with the owners of the building choosing one of the

engineering offices that are recommended by the municipality of Jeddah. Following that the engineering office sends a project team that includes five sections to survey the location and prepare a drawing of the outlines and take photographic documentation. They use Totals Stations to obtain the dimensions of the buildings. Next, the other four sections start to do their fieldwork, and draw and write what they observe. Finally, these documents are sent to the municipality of Jeddah. The municipality sends an auditor to check reliability of the submitted reports so they can make a decision about this particular building. It has often been observed that these offices use old methods and techniques to achieve the job. To complete the Buildings reports and get the decision, the procedure may take more than a year and this is only for smaller buildings, the procedure could take more than two years for larger buildings. Moreover, this procedure costs a lot for owners and the municipality of Old Jeddah (SAMI, 2013).

1.4 Aims:

We aim at creating a full engineering drawing from a Building Information Modell (BIM), which is derived from Terrestrial Laser Scanning and images survey data. The output Information could be used for several applications and different levels of remote managing. One of the historical buildings in Old Jeddah, Farsi House, was chosen as a test case for the project.

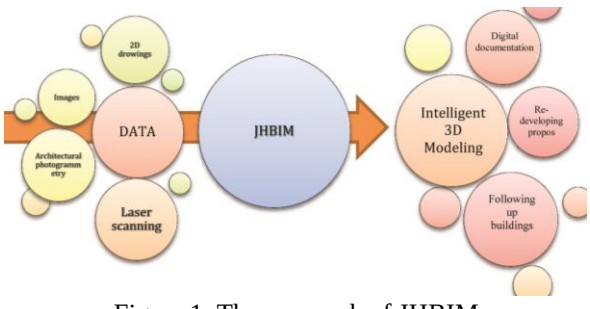

Figure 1. The approach of JHBIM.

1.5 Objectives

1- To determine the damages in the buildings.
2- To document these buildings as historical digital documentation, to be used for deferent purposes such as structural, Architectural, and constructional purposes.
3- To Design a system that can follow up running the Historical buildings.

2. LITERATURE REVIEW

2.1 Terrestrial Laser Scanning "TLS":

Terrestrial laser scanning systems are available in the commercial domain for more than ten years. In the last five years laser scanning is on the way to becoming accepted as a common technique of 3D data achievement, finding its position on the engineering market beside established approaches like tachometry, photogrammetry and GPS (Hosseininaveh Ahmadabadian et al., 2013).

This advanced technology and new features of 3D laser scanners have been developed in the past few years, introducing additional instrument features like electronic levels, inclination compensation, forced centering, on the spot geo-referencing, and sensor fusion (e.g. digital camera and GPS). Most of these elements are obviously equivalent to features that can be seen in total stations, however, not as advanced (Kersten et al., 2008).

Due to the fact that the large number of kinds of terrestrial laser scanning systems are difficult to find comparable information about potential and precision of the laser scanning systems in the market of technical specifications and to be able to validate the technical specifications, which are provided by the system manufacturers.

Therefore, it may be difficult to choose the right scanner for a specific application, which emphasizes the importance of comparative investigations into the accuracy behaviour of terrestrial laser scanning systems (Kersten et al., 2008).

Moreover, there are several laser scanning systems in the engineering market today and the common systems are Leica Geosystems and Trimble 3D Laser Scanner. By looking closely to these systems it could be noticed that these systems are quite similar but they have some differences between them in resolution, the

accuracy, field of view, scanning distance, scanning speed and 3D scan precision. Moreover, the 3D laser scanning which was used to this project was Leica Scan Station C10.

2.2 Combining Laser scanning and Digital Images:

For the most of new scanning systems, the camera and the image data are fitted in, these images can be used to colour the point clouds of the laser scan survey data. The point cloud can be represented the x, y, and z coordinates of the scanned object.

The RGB colour data from the images can be mapped onto range data by taking account of point translation, instrument rotation and perspective projection. Both camera and the laser must be correctly geometrical calibrated (Abmayr et al., 2005). The calibration of camera is introduced to correct the distortion of cameras lenses, and by mapping onto the point cloud any perspective contained in the images is removed. High-resolution colour images can be precisely mapped onto a geometric model represented by a point-cloud, provided that the camera position and orientation are known in the coordinate system of the geometric model (Beraldin, 2004).

2.3 Jeddah Historical Building Information "JHBIM"

Jeddah Historic Building Information Modelling (JHBIM) will be an interactive solution, representing architectures, which are based on historic data. These elements (including detail behind the scan surface) are accurately mapped onto a point cloud or image based survey (Murphy et al., 2009). The Islamic Hijazi architecture will be introduced and we document advanced scientific rules for the production of architectural features, which will supporting the design of parametric models. The use of Jeddah historic data will introduce the opportunity to develop details behind the object's surface concerning its methods of construction and material makeup. In the final stage of the JHBIM process, the prototype libraries of parametric objects are mapped onto the point cloud and image survey data using a system of cross software platform management. Jeddah Historic Building Information Modelling "JHBIM" will automatically provide full engineering drawings orthographic, sectional and 3D models. The Heritage Conservation field can bring many things to the JHBIM such as understanding of heritage buildings in Old Jeddah and the context, Knowledge of materials, construction techniques and the building pathologies, understanding that heritage buildings in Old Jeddah contain a wide range of materials and assemblies that are not documented and are not available from stock libraries of 3D model parts. Additionally, JHBIM will bring several benefits to the Heritage Conservation field such as allowing a full study of proposed renovations and changes before final decisions are made, assisting in building maintenance, aiding in budgeting for repairs and maintenance and allowing a wider public building experience as models can be viewed with free viewer software from remote locations.

3. SCAN TO JHBIM "METHOD"

3.1 Laser and Images survey data

3.1.1 Images survey:

The project started with the images survey to discover the Farsi house architectural characters. The step took from three to four days.

A professional Canon 18 Mega Pixels camera was used to take free images of the house. In fact, the house has a lot of characters such as the Roshans and mashrabiyahs. Furthermore,

Figure 2. Farsi House Roshan.

these images could be used for 3D modelling "Architectural photogrammetry" by using professional software such as PhotoModeler.

3.1.2 Laser survey

The Second steps started with scanning the Farsi house. The scanning took a week. In this step we chose best locations for scanning station and scan targets "black/white". Furthermore, the station locations are chosen in these points, which can cover the area that will be scanned so perfect visibility, can be produced. Moreover, for more accuracy and to combine the stations, three targets at least must be used in common between these laser scanner stations. The selection of suitable viewpoint positions is very important for a successful survey of such monuments since the number of potential sensor stations is usually restricted by the complexity of the structure. The collected scans have sufficient overlapping area to allow for succeeding integration. On the other hand, due to the stations locations and the Height of the building, no scans cloud points could be collected from the roof of the building and from the Roshans. The resolution for these scanning was 7 cm and the distance was 10 m for inside the house and 70 m to outside. Each scan settings and targets registering took more than 30 minutes; these depend on the target number. Moreover, the scan took less than 15 minutes; however, the scan images took more than 15 minutes.

3.2 Data cleaning "Noise" and points clouds registration:

There are different processing steps to generate the required 3D points clouds models were realized using number of software such as the Polyworks software and from Innov- Metric and Cyclone software from Leica Geosystems.

Cyclone program was used to take out the noises. The step took around week to be completed. Next, different scans corresponding points in overlapping areas were used for the registration.

3.3 Point Clouds to Autodesk Revit "Modelling":

After receiving the cloud points from the laser scan, there are many useful programs that can be used to deal with laser scanning data. Autodesk Revit was used to deal with, that because quick built and Changes to the 3D model, High Quality Construction Documents and High Level of Flexibility. Figure (3) shows the 3D points cloud for the Farsi House. The Modelling took more than month to be done.

Figure 3. 3D Point cloud model.

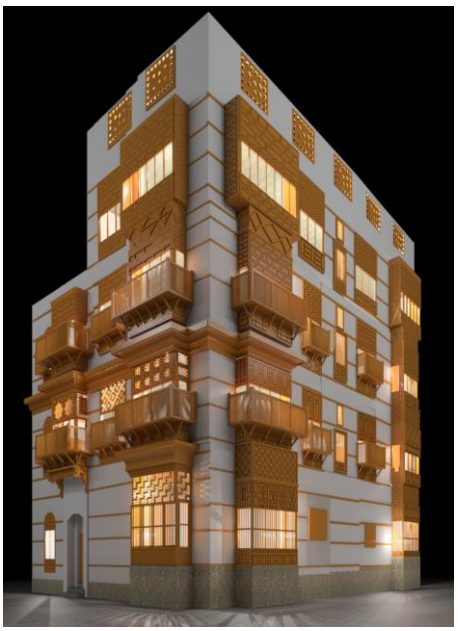

Figure 4. 3D model by Autodesk Revit.

3.4 Autodesk BIM 360 Glue

The 3D Revit model was connected to the Autodesk BIM 360 Glue on I pad. This can offer multidiscipline model coordination and clash recognition, and will providing access for stakeholders across the project lifecycle. Engineers, Architects, builders, and owners across the globe will collaborating and coordinating in real time from the office or mobile devices (Autodesk, n.d.).

Figure 5. Autodesk BIM 360 Glue.

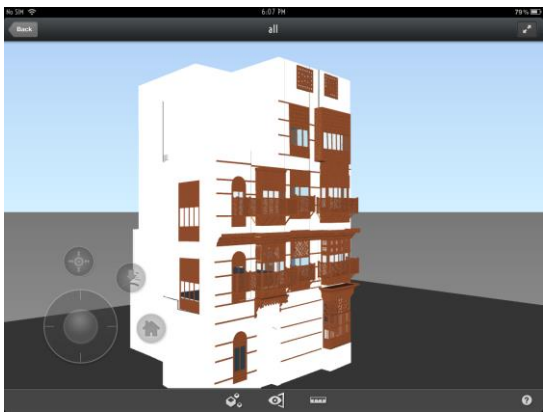

Figure 6. 3D model in BIM 360 Glue.

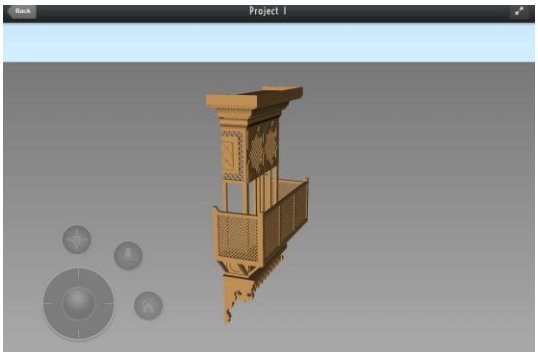

Figure 7. Roshan in BIM 360 Glue.

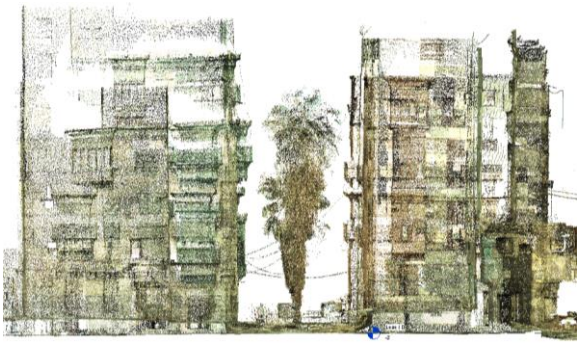

Figure 8. West Elevation from Laser Scanning

Figure 9. Rendering West Elevation from JHBIM.

Figure 10. Rendering South Elevation from JHBIM.

4. CONCLUION

The most useful technologies and tools to serve Old Jeddah issue can be found by using geospatial technologies such as Terrestrial Laser Scanning "TLS", Remote Sensing, Global Position System "GPS" and Architectural photogrammetry. Next, these data sources will be used as input to the Jeddah Historical Building Information Modelling "JHBIM" and then analyse the outcome. Through this data we can decide which buildings need to be maintained, which cannot be maintained and which must be demolished. Additionally, 3D models from JHBIM can enable remote reviewing of the interior and the exterior with better understanding than one shown in 2D flat drawings. Moreover, we can save time "4 D", cost "5 D", and represent the reality in a few hours and more reliably than before.

4.1 Limitations and Difficulties

There were many difficulties faced this research which related to the equipment, house and the historical area and here some:

1- Only one laser-scanning device in Jeddah city and it was busy with other projects at King Abdul Aziz University.

2- The cyclone's License was not active for all laptops in Geomatics Dep.

3- The 3D modelling needs a long time to be done in a professional way.

4.2 Further Work

The work should be expanded in future to cover other buildings and houses in Old Jeddah to form a complete documentation system. All extracted information from the constructed 3D models, such as maintenance activities, house structural condition, could be stored in database for spatial modelling and follow-up purposes. Furthermore, the system could be linked with fire systems and security systems to protect these building from the dangers. Further spatial information, related to the house system, such as road infrastructure, landmarks, hotels and other services would be entered as layers in ArcGIS for comprehensive landscape modelling. This system upon completion will be a necessary tool for all boards in the field of urban planning and heritage management, for assessment, maintenance, and monitoring of each house.

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