FROM ARCHITECTURAL PHOTOGRAMMETRY TOWARD DIGITAL ARCHITECTURAL HERITAGE EDUCATION

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ABSTRACT:

This paper considers the potential of using the documentation approach proposed for the heritage buildings in Historic Jeddah, Saudi Arabia (as a case study) by using the close-range photogrammetry / the Architectural Photogrammetry techniques as a new academic experiment in digital architectural heritage education. Moreover, different than most of engineering educational techniques related to architecture education, this paper will be focusing on the 3-D data acquisition technology as a tool to document and to learn the principals of the digital architectural heritage documentation. The objective of this research is to integrate the 3-D modelling and visualisation knowledge for the purposes of identifying, designing and evaluating an effective engineering educational experiment. Furthermore, the students will learn and understand the characteristics of the historical building while learning more advanced 3-D modelling and visualisation techniques. It can be argued that many of these technologies alone are difficult to improve the education; therefore, it is important to integrate them in an educational framework. This should be in line with the educational ethos of the academic discipline. Recently, a number of these technologies and methods have been effectively used in education sectors and other purposes; such as in the virtual museum. However, these methods are not directly coincided with the traditional education and teaching architecture. This research will be introduced the proposed approach as a new academic experiment in the architecture education sector. The new teaching approach will be based on the Architectural Photogrammetry to provide semantically rich models. The academic experiment will require students to have suitable knowledge in both Photogrammetry applications to engage with the process.

1. INTRODUCTION

1.1 Old Jeddah Background

The city of Jeddah has a long history goes back to over three thousand years prior. The Historic city contains many heritage buildings "around 1442". Some of these Heritage buildings have been constructed since the 18th century. The city is a coastal city placed on the eastside of the Red Sea, in region known as Hejaz region, approximately in-between the northern and southern of Saudi's borders. The Hejaz region covers most of the significant cities, as well as centres of commerce in Saudi Arabia. These cities include Jeddah, Makkah, Madinah, and Taif. The city of Jeddah is considered as the economic and tourism capital of Saudi Arabia, and a welcoming port to the two holy cities of Islam which are Makkah, and Madinah. (Telmesani et al., 2009). Additionally, according to (Al-Fakahani, 2005) "Muslim and Arab writers noted that the name Jeddah is taken from the Arabic word for grandmother, while "Jed" means grandfather in Arabic". Indeed, in the north-east of Jeddah city there is cemetery known as "the cemetery of Mother Eve" which can be linked to the traditions that supposed Eve was buried by her descendants in this area.

1.2 The Evolution of Hejazi Architecture

The region of Hejaz had its importance with the beginning of Islam. This importance and the role are well related to the Prophet Muhammad life. Furthermore, the traditional architecture in Hejazi region as well as in Heritage Jeddah are mainly influenced via the Islamic culture. Moreover, Islam is a lifestyle not just a religion for Muslims. From this point of view, the whole community, culture and society are affected directly through the Islam. Furthermore, since 14 centuries ago the Hejaz region welcomed settlers from all around the Muslim world for different religion purposes; (such as Hajj and Umrah). Those Muslims passed their own tradition, culture and daily practices, which merged together with the Hejazi culture. Indeed, this merged reflected on the Hejazi cities on different ways such as in the architectural characteristics and fabric of these cities. By focusing on the Hejazi architectural characteristics, it can be noted how the Hejazi houses are rich in architectural characteristics, such as the Roshan, Mashrabiyah, Manjur Pattern and Plaster decoration (Baik and Boehm, 2017). According to Ragette (2003), "these historical houses have remarkable and simple design and architecture that represent a rich heritage, demonstrating how local craftsmen and builders adapted designs to respond to social demands and other environmental factors in earlier periods". As a consequence of this evolution, the designs of the old houses have a unique pattern, as well as being authentic and functional. Moreover, the uniqueness of pattern takes a turn for the better in reducing humidity and increasing thermal

Figure 1 Examples of the Heritage building in Historic Jeddah.

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comfort, as the buildings increase cross ventilation (Eleish, 2009).
Moreover, according to SCTA (2013), the historical houses of Jeddah have to be “understood as an urban unit active in the making of the city”, therefore these houses need to be “studied as typo-morphological responses to climate, material and socio-spatial practices”. By focusing on the Roshan, it can be found that it is the basic and primary urban unit of the historic Jeddah houses. These Roshans had a significant role in the shaping of the urban fabric, which was originally comprised of tightly knit areas integrating commercial, residential functions, and organised around the main market and the social identity of the historical city. Furthermore, SCTA (2013), pointed out, "Through its programmatic, climatic, spatial and visual characteristics, it contributed to the shaping of the urban morphology, land use patterns and the overall character of Jeddah". Furthermore, the traditional Hejaz architecture is not just representing as local method to develop buildings, it can be discarding as a collaboration between both the foreign and local knowledges. For example, traditional Hejaz architecture theme, is evident even in different parts of the Islamic world (such as Historic Cairo, Baghdad, Damascus), in Europe (Andalusia, Spain), and America (Lima, Peru) (Baik, 2017).

1.3 The Aims

We aim at developing a new academic method in digital architectural heritage education based on the close-range and the Architectural Photogrammetry techniques.

2. LITERATURE REVIEW

2.1 Close-range Photogrammetry

Photogrammetry has been described according to the ASPRS (American Society for Photogrammetry and Remote Sensing) as: “The art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena.” Moreover, the most well-known image-based technique is (Photogrammetry), which can provide very accurate dimension in regard to the location and the geometry of the actual element via two or more pictures in regard to the same static view taken from several angles for that element. The 2-D data image will be modelled as 3-D model in digital based on the Photogrammetry technique. This can be described as the main purpose of a photogrammetric method. Moreover, the precisely sets up the geometric connection between the surveyed object besides the 2-D pictures gained (Luhmann et al., 2006).
Furthermore, photogrammetry can be divided into different types. For example, aerial, satellite imaging, underwater or terrestrial photogrammetry. The term of photogrammetry has been applied to surveying and mapping systems from images captured at the ground position. Moreover, the Terrestrial photogrammetry can be categorised as a close-range photogrammetry in case of the distance of the camera-object is at the range of 1 cm to 1000 cm (Moffitt et al., 1980). Additionally, during the academic experiment we focused on that range to survey the Heritage buildings, and the architectural Hijazi elements, such as Roshans and Mashrabiyahs.
In last decade, photogrammetry has been used for numbers of purposes and specialised sectors. For example, in architecture, archaeology, heritage conservation, providing the 3-D city modelling, engineering photogrammetry (Jiang and Jauregui, 2010), as well as in movie production and medical applications, and video games (Malian et al., 2004; Mitchell and Newton, 2002).

2.2 Architectural Photogrammetry

Architectural Photogrammetry, according to Hanke and Grussenmeyer (2002) can be define as “a technique for gathering information of the obtaining geometric, e.g. size, position, and shape of every object, which was imaged on photos before”. Today, the developing of architectural Photogrammetry as well as the 3-D modelling techniques have been quickly progressing. For example, the developing of the new and fast techniques of providing the automated as well as the semi-automated solutions, via DSM (Dense Stereo Matching) (Furukawa and Ponce, 2010; Hirschmuller, 2005) as well as the SFM (Structure from Motion) (Agarwal et al., 2011, p. 20; Pollefeys et al., 2008; Vergauwen and Van Gool, 2006), to be provided in the engineering market. Additionally, they have a benefit over the web-based programming over offering very accurate outcomes in regard to provide the 3-D point cloud, in addition to the textured mesh surfaces. For example, Agisoft Photo Scan, Autodesk Recap®, and PhotoModeler by Eos Systems Inc. Furthermore, the full automation of the process of the picture matching and orientation has been presented in order to assist and accelerate the information processing task, which can be very difficult in cases of manual processing was used (Alitany et al., 2013).

3. ACADEMIC EXPERIMENT

The academic experiment turns to determine the efficacy and the advantages of employing the close-range Photogrammetry in architecture heritage education from different aspects. Through this research a new approach was developed as a tool for learning architectural heritage of Saudi Arabia, as well as improving and their academic performance by using photogrammetry.
The academic experiment was examined on a sample of eleven undergraduate students of both Architecture and Geomatics departments in the Faculty of Environmental Design (FED) in King AbdulAziz University (KAU) during the second semester of 2017/2018 in workshop titled “Architectural Photogrammetry: A case study of the Hijazi Heritage Building in Historic Jeddah, Saudi Arabia”. This workshop took around four weeks, and during that time, the students were involved in these experiment activities.
The surveying of Hijazi architectural elements includes several architectural elements, such as Roshans and Mashrabiyahs. Using different technologies, applications, and formats arise complicates, directly affects the methodological design of any learning experiment. For instance, it becomes necessary to design a new plan to explain the applications, which affects other topics related directly to the predefined syllabus.
The experiment is divided in two parts which were theoretical and practical. During the theoretical part, all information was given about the application of the technology, software, systems and devices were introduced, and included a suitable description of the technology and method applied to the surveyed elements. Moreover, the students had pre-training in the laboratory, and how to use and calibrate their digital camera, and the smartphones integrated cameras in order to capture about 20 to 40 pictures of the physical objects in the lab (maquette).
These pictures must cover the object geometry, angles between the pictures, and the control points determination. Moreover, during the lab the students had given exercises to be aware of the possibilities to use the and software and technology.

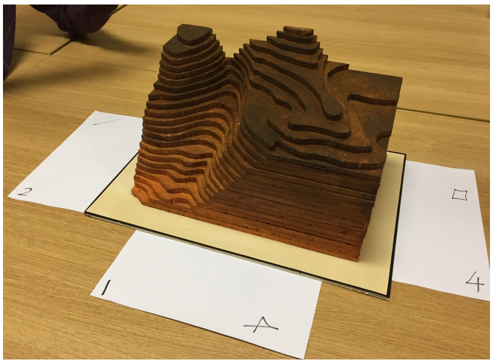

Figure 3 The physical objects that used in the lab (maquette).

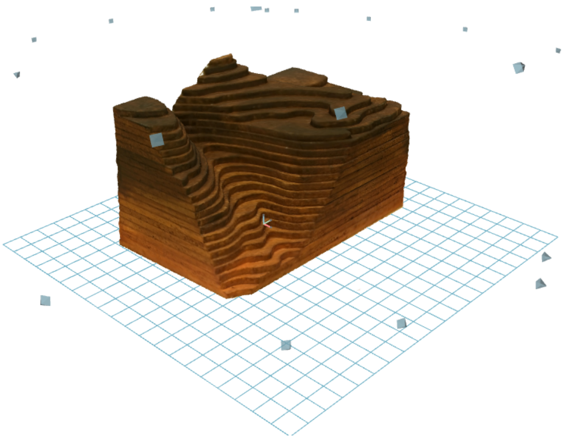

Figure 2 The locations of the cameras.

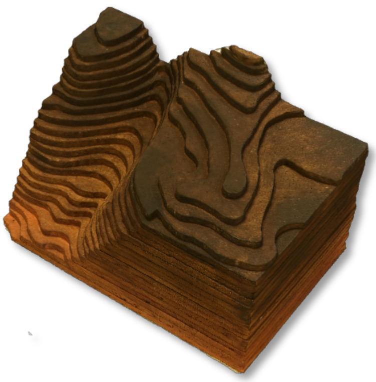

Figure 5 The result of the maqutte as 3-D model by using the photogrammetry programs.

The Second part was about the field work and the Data processing. During this part the student selected their targets; and each student should be able to capture and create their own model. This knowledge, and skills in surveying objects, is assumed to have already been acquired from previous courses in the subjects studied regarding the use of photogrammetry. In general, the workflow is not simple and that it becomes more complicated, since the only way to make any experience involving the use of a series of computer applications in the educational framework a success is for these accessible applications to students. Furthermore, based on the SFM technology used, the experiment is designed in two mains parts: 1) surveying, using photogrammetry and computer vision technologies, capturing structural lines and details; and 2) visualization, quality assessment of 3D data.

3.1 Technology, programs and equipment used

During this educational experiment numbers of cameras were used. For example, the first group used (Sony A9500) with 24 mega pixels resolution, the second group used (Cannon EOS 500D) with 15.1 mega pixels resolution. While the third group used (Olympus E-3) with 10.1 mega pixels resolution.
Regarding the programs used in the experiment, two of the professional photogrammetry programs used. The first program was Autodesk ReCap photo pro. This program is used to build the 3-D models from a collection of images, these images must be in range of (20 to 100 images). The images processing usually done over the Autodesk servers. The second program was Agisoft photoscan pro. The program is used to processes the images to produce 3-D data and visual effects to be used in many applications. The program can deal with any numbers of images; however, the processing will take more time depend on the number of the images and the CPU speed. Such as, geographic information systems, and documentation of heritage areas.

Figure 4 Example of the camers used in the experiment.

3.2 Surveying

The field work started with site investigation and selecting the Heritage buildings, and numbers of the unique Hijazi elements.
In this step the students were divided into three groups, each group picked out one of the heritage building in the area, and the architectural Hijazi elements such as the Roshans and Mashrabiyahs.
The second step, started with the site preparing and planning. During this step the students selected the best locations and time to capture the pictures for these buildings and the architectural elements. Determining the best time to capture the pictures was very important, regarding to solve the issue of the shade and shadow, and getting excellent lighting.
The third step was Data capturing. During this step, it was very important to have at least 60% overlapping between the images to be registered.

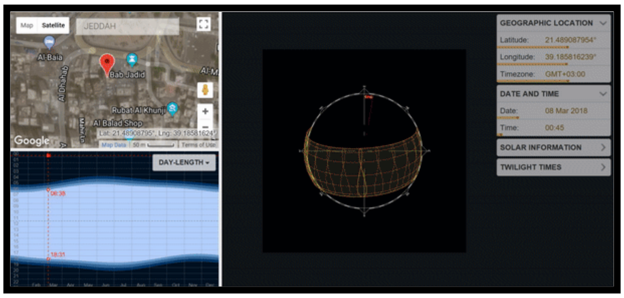

Figure 6 Determining the best time to capture the pictures.

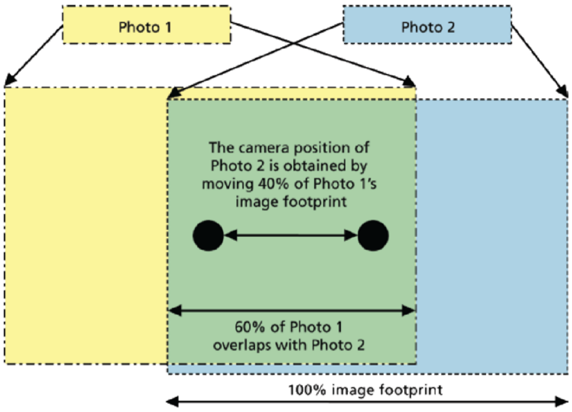

Figure 8 The consept of the overlapping between images.

Figure 7 The overlapping between two images.

Furthermore, on the site, two of the groups selected the Heritage buildings while the third group selected numbers of the Hijazi architectural elements such as Roshans and Mashrabiyahs. During this step the students learned the technique of how they can distribute the targets coded on the objects and take images for two different scales of the image survey.

The Fourth step was the registration and getting an acquired 3-D model. This step of the academic experiment has been conducted via the participants' personal computers or laptops. All the participants students learned the way to import the pictures to the photogrammetry softwares via Autodesk ReCap pro© and Agisoft photoscan pro©. Moreover, on the Autodesk website, the participants students registered and logged-in to their educational account in order to begin the procedure. Additionally, the students mostly choose to utilise Autodesk® ReCap pro. This regarding offering an automated method, friendly use, and no need for the cameras calibration. However, the limitation of just 100 images that the software allowed to import and process, need to be improved.

3.3 Modelling and Visualisation

In this part of this experiment the student involved into removing all the noises from the 3-D models. And exporting these models in different formats, to be used in different 3-D CAD applications. This can allow the student to merge different façades of these complicated structures, as well as the elements of the Roshans and Mashrabiyahs.

Due to the time limitation, the future work of this academic experiment should include modelling these façades and the architectural elements in BIM format, and presenting these models in VR and AR environment.

4. THE RESULTS

This part shows some of the students results. These results include the Heritage buildings façades and the Hijazi architectural elements. The results were so far acceptable regarding to the Hijazi architectural elements and the small objects. However, there were a lot of limitations regarding the large objects or large complicated façades. For examples, it was very difficult to capture any details from the top of the buildings' elements. This issue can be solved via UAV cameras; however, it was difficult to use regarding security reasons.

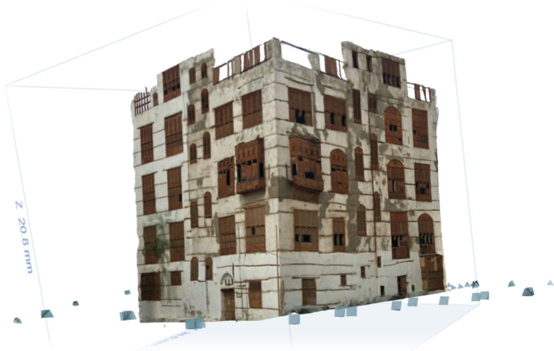

Figure 9 The locations of 100 images for Hazazi house (an example of the Heritage building).

Figure 10 The registration of the images.

Figure 11 The 3-D photogrammetry perspective for Hazazi house (an example of the Heritage building).

Figure 13 More than 42 images to model the Roshan.

Figure 12 Example of the 3-D photogrammetry perspective of the Roshan.

Figure 14 Example of the 3-D photogrammetry perspective of the wooden window.

Figure 15 Example of the 3-D photogrammetry perspective of the gate.

5. CONCLUSION

This paper considers the potential of using the documentation approach proposed for the heritage buildings in Historic Jeddah, Saudi Arabia (as a case study) based on the Architectural Photogrammetry technique as a new academic experiment in digital architectural heritage education. The academic experiment was unique; 100% were able to follow the stages of the experiment. The participants students surveyed and modelled the façades, and the Hijazi elements based on the photogrammetry technique. The participants students were divided into three groups. This academic experiment took around four weeks, and during that time, the students were involved in these experiment activities. The future work of this academic experiment should include modelling these façades and the architectural elements in BIM format, and presenting these models in VR and AR environment for different purposes of educations.

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