Site Investigation of Alauqaiser Historic Church Using Photogrammetric Reconstruction

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Abstract: Alauqaiser Church is one of the Christian heritage sites that are mentioned extensively in historical literature. The site is described to be in the desert to the south west of Karbala, Iraq. The site was excavated by the Iraqi government to reveal most of the church building which was covered by soil for long time. However, it is believed that there could a human settlement around the church which is not investigated or determined physically on the ground. This paper aims to investigate the possibility of the existence of any settlement or development around the site and stimulate further research about this important fact. Photogrammetric reconstruction was used to prepare engineering drawings and digital three-dimensional models of the site. Pictures were captured using off-the-shelf small drone which successfully provided enough level of details to prepare precise orthophoto and digital elevation model of the site.

Results of the site's orthophoto and digital elevation model showed that there are clear footprints of physical development around the church.

Keywords: Documentation; Photogrammetric; historic heritage; Alauqaiser; archaeology; preservation

1- Introduction

"The cradle of civilization" is the name that have been used to describe Iraq. An archaeological remains of more than 10000 cultural heritage sites were founded in Iraq. Those remains belong to the Sumerian, Akkadian, Babylonian, Assyrian and Parthian cultures where some of them dates back to 5500 years ago. Through the time, Iraq witnessed the succession of empires and states which resulted in a golden age of architectural and political achievements in the middle ages. Archeological sites in Iraq belongs to different eras, some of them are ancient that dates back to the Babylonian culture and others are more recent such as the palaces that were built during the Ottoman era, in addition to the valuable buildings of the modern international architecture. Some of the archeological sites were excavated and studied while others are unexplored and suffering from negligence, destruction and looting since the beginning of the political conflict in Iraq. [1]. Therefore, proper studies and documentation of those heritage sites is required to provide a sufficient information about them that can contribute in the process of conservation, rehabilitation, and restoration when needed. The documentation process involves providing written and visual information about the cultural heritage. Recently, the 3D documentation of...
the cultural heritage was developed intensively by the improvement of the 3d scanning technologies based on sensors, data capturing methodologies and 3d modeling and representation of the historic sites. [2] In this research, Al-qusair church is documented using a photogrammetric reconstruction.

2- Literature review

2.1 Historical overview

Many of the historical relics and monuments built in Iraq are still uncharted and unknown to any historical era they belong to, because the studies about them are not detailed and sufficient enough to provide the documentation and excavation information. Al-Qusair monastery is one of the historic remains that is not explored yet. It must be studied from two aspects: first, analyzing the building individually, and second, exploring the building historical connection to its geographic context.

2.1.1 Geographic location of Al-Qusair Church

Al-Qusair church is located 155 kilometers to the south of Baghdad, 65 kilometers to the west of the holy city of Kerbala, and about 9 kilometers to the north of Al-Ukhaidir Fortress. It is located near the main street that leads to Shafatha City (Ain al-Tamur) where it could be reached from an unpaved road about 2 kilometers away from the main street. [3] Ain al-Tamur was one of the rich cities mentioned in the historical resources since the Sassanian Empire and after the Islamic conquests of Iraq. It has one of the most ancient city names in the region that is located on the way that links Al-Hirah with Levant (Syria region). Nowadays, Ain Al-Tamur is one of Kerbala governorate districts, its geographic site is located to the western side of Iraq in a semi-arid area, which has underground water that appears in a form of water springs. Shafatha city is the capital of Ain AL-Tamur district, on the edge of the historical ruins of Ain Al-Tamur area. [4] Despite that many of the water springs have naturally dried, the area still features orchards and green fields.

2.1.2 Site description

Al-qusair site consists of a religious center surrounded by a protecting fortress which houses a group of religious buildings, the biggest building is the church. This religious complex is surrounded by a human settlement which can be seen clearly through the hills and walls relics. The geographic location of these relics refers that this settlement is part of Ain Al-Tamur city, where the water was derived to the settlement from its water springs. Through the site visit, a trail of an ancient river stream could be observed passing through Al-Qusair settlement. The surrounding area is characterized to be mostly arid lands devoid of planting coverage except for some seasonal bushes.

2.1.3 Naming

It is hard to specify the origin of Al-qusair name or (Al-uqaisir) and this is due to two reasons: first, most of the current names of the ancient monuments and archaeological sites are modern and they are not mentioned in any historical resources, second, the site was rarely studied before neither on the historical level nor on the documentation and excavation level. However, the name could be derived from Qasr (which means palace in Arabic) by using its minimized term Qusair (which means a small palace), where this word was frequently used in this region.

2.1.4 Historical events

Al-Qusair is a natural extension of the Lakhmidian Kingdome. Al-Hira, the capital of the Lakhmidian kingdom, was well-known for its palaces, buildings, and monasteries. The white palace, Al-Atheib, Al-Sunbur, Al-zawraa palace, and Muqatil palace are some of the palaces mentioned in the historical resources that were found in Al-Hira city. The most well-known palaces in this region are Al-khaorneq and Al-sadeer palaces. On the other hand, the monasteries were mainly located in the suburbs and the
desert that surrounding Al-Hira city. Some of the monasteries found in the region are: Fathion monastery (north of Alnajaf city) Ibn-Mazaoq monastery (south of Al-Hira), Mart Meriam monastery (between Al-khaorneq and Al-sadeer palaces), and Al-asaqef monastery (in Alkufa city at the border of Al-hira). [5]

2.1.5 Historical events documentation

It is believed that the name (Al-Qusair) is not the real name of the site because it was not mentioned in any historical resources. The name was given later to the site and updated accordingly with the changing of the governance of Iraq through the time and the succession of the political events of the country. The word palace in Arabic (Qasr) and its linguistic derivations was frequently used in this geographic region. A group of palaces are located close to the site such as; Al-Ukhaidir palace (more specifically the palaces of Al-Ukhaidir fortress), the relics of Simeon palace in Ain Al-Tamur, and some other places called Alqusoor (which means palaces) located in Ain Al- Tamur surrounding lands.

The site could be described as a mystery due to the lack of information and facts in the historical resources about the monastery and its relevance to the size of surrounding settlement which is relatively large, or information about the current situation of the site. However, it is certain that Christians has a kind of mysticism to dedicate themselves to worship outside cities away from the dwelling area where they might be exposed to harassments and persecution. The historic research about Al-qusair church could lead to one of the following two prospects: it was either built before Islam, or in the early ages of the Islamic conquest to the region where some Christians immigrated towards Ain Al-Tamur city.

By reviewing the historical events of the region, it could be concluded that Al-Qusair church geographically belongs to Al-Hira city which its land extended to the Arab Gulf in the south and to the upper Euphrates in the north. [6]

2.1.6 Excavation season

The site was excavated by the Iraqi commission for national archeology and heritage

2.1.7 Building description:

The apparent part of the church is located among a group of ruins which represent with the church building a big monastery surrounded by a fence that has an external pillars. This complex is surrounded by a large number of ruins and buildings relics that belong to the settlement. The complex dimensions are:

- The eastern side of the fence is 148m (it has an irregular shape because it separates the church from the river) and has 11 towers
- The northern side of the fence is 90m in length and has 5 towers
- The western side of the fence is 141m in length and has 11 towers
- The southern side of the fence is 112 m in length and has 4 towers
- The total number of towers on the fence and its corners is 31 towers
- The monastery area is about 15,000 square meters

The monastery was built according to the Hirian style ( Sader and Kameen- which represent a central open space called Iwan surrounded by two buildings on the left and the right, their doors usually open to the Iwan) that dates back to the pre-Islamic era. The church adopted the Nestorianism ideology following the Assyrian Church of the East. Those monasteries and churches inside where used to house the Nestorians civilized Arabs, even after the emergence of Islam they were used as places for worship. Alshabeshty, in his book, provides a general description to the components of the monasteries which were all found in Al-qusair complex. He said; “monasteries varies according to their geographic location, some of them were built on the mountains tops, while others where located on rivers sides, some of them were close to cities and countryside while others were found isolated in wilderness. Those monasteries
were built according to specific needs, and they are either different or similar to each other according to the purpose they were built for. The size of the monastery also varies according to the number of monks and friars in them. Some monasteries have defense walls that work as a fence to provide protection against attackers. Each monastery must have at least one church in addition to dormitories and oratories, as well as some other service buildings such as silos, warehouses, food houses and other necessary facilities. One of the most important facilities that must be found in monasteries is the library and lending rooms which contain a large number of books and manuscripts about various types on knowledge in addition to the sacred books and theology books. Libraries are one of the places where monks gather to write and copy books”. [7]

2.2 Documentation

Documentation provides written and visual information about the explored site. Three dimensional digital documentation was developed recently and occurs through several stages:

2.2.1 Surveying

It is the first stage of documentation which represent collecting and obtaining the building spatial data. The documentation surveying could be achieved by using three technics: image-based (photographic), non-image-based (graphic), and combinative techniques. [8]

Photographic technique or photogrammetry is easier and faster to be recognized and translated than other techniques. The downsides of this technique is the presence of shadows in the images which hide part of the information in the site, hence reduce the results accuracy. [9]

Graphic technique, depends on recording the 3D coordination of all the points of an object using several scanning methods that can be classified into: Conventional terrestrial survey and LiDAR technique.

The conventional survey includes hand and tachometric survey where the measurements are done using simple tools such as tape and laser distance measure. This method is used for the buildings facades that have low level of details. On the other hand, LiDAR technique is the most existing innovative and common techniques for providing measurements and documentation for sites and objects where the system create an enormous number of point cloud that increase the accuracy of the results. [10] The process of recording the points requires more than one scans that overlaps to cover all the required site [11]

Combinative technique which is a combination of the photographic and graphic techniques. [12]

2.2.2 Registration

It is the second stage of documentation which is also called cloud alignment. It represents translating the multi-point clouds into common reference coordination systems using a proper registration algorithm (which is aligned from the coordination systems of the multiple scanner stations used to sample the required object from different positions) [13]

Objects recognition could be achieved by two methods, material-based and shape-based method. Material Based method depends on decomposing image into its basic features (color, texture, structure) which occurs in three steps; representation, matching and classification. [14] Shape-based method is a complementary method depending on identifying the buildings and environment elements either linear or nonlinear by using shapes and figures. It occurs in three steps; shape representation, shape matching, and shape classification. [15]
2.3 Case studies

There is a growing need to document and conserve the global cultural heritage sites because they are suffering from negligence, damage from wars, vandalism, natural disasters, and etc. therefore, digital documentation and 3D modelling of cultural heritage sites is widely adapted around the world. Laser scanners are the most used technology for heritage documentation due to its availability and accuracy. [16].

Widerski and Daliga reported a three-dimensional documentation to the Wisłoujście Fortress (a historical defensive object in Poland) to perform a detailed analyses of the building and to investigate the accuracy of the results when using a close range photogrammetric method. The kitchen chamber was selected to be studied. For the surveying stage, the photogrammetric method was selected to collect the data and prepare the documentation. It consisted of ten orthophotoplans for the walls, cookers hood, floor, and ceiling. The next stage was preparing the drawings for the documentation based on the orthophotoplans. The measurement was complied with the national survey reference system. The room has a complicated geometry form, therefore, 134 ground control point was positioned to ensure the accuracy of the 3d model. The factor that effected the quality of the final documentations in this research was the accuracy of the coordinates of control points. The results showed that 90% of the control points had an error of no more than 2mm in the X, Y, and Z axis. Using the close range photogrammetric method helps to collect the data in a relatively short time compared to the traditional methods, provides an accurate results and a highly detailed documentation, and produces a 3d model that could be used widely [17].

Cheng, Yang, and Yen in their research used BIM for the documentation and refurbishment of Jing-Tong Train Station and Taipei Xia-Hai City God temple, in Taiwan. That was achieved by using special application of BIM called HBIM (Historic Building Information Modeling). They considered using 3d laser scanner technology to generate the point cloud of the site and the environment. By using a proximity algorithm and human intervention the points cloud was transformed into surfaces that match the real world. By the generating of the 3d parametric model of the historical sites, the process of refurbishing and renovation became more efficient. It was found that the roof of the temple and the plafond need renovation, based on that the roof structure will be reconstructed because part of the roof is missing and does not match the original design of the temple [18].

Mariana Calin and her team presented a 3d documentation and modeling of two of the most important heritage monuments in Romania: the rock sculpture of Decebalus Orsova and the Sphinx from Bucegi Mountains. Two Terrestrial laser scanners were used for the surveying stage. The point cloud data was filtered and prepared for the registration process where the 3D data was aligned into a common reference frame. Mesh integration stage then followed the alignment stage by combining all the attained 3d views. A 3d digital model was resulted from the point cloud modelling process with its texture. The resulting model has all the information required for preserving and protecting the monuments. [16].

A study occurred in Iraq, two sites were considered; indoor site in the Iraqi national museum, and outdoor site to the interior facades of Al- Mustansiriya Heritage School. In this research, Mohsin and Fanar chose the terrestrial laser scanning (TLS) for the surveying stage in order to reduce the time and effort consumed for recording the data. As for the registration stage, two fine registration methods had been applied: Nearest Neighbour Iterative closest point (NN-ICP) and Levenberg-Marquardt Iterative Closest Point (LM-ICP). The creation of the final model passed through several steps; the cleaning and filtering of point clouds, meshing, and filling the holes. The results showed that the average registration error was found to be, (3.9 mm) for NN-ICP method and (2.6 mm) for LM-ICP method. Root Mean Square Error the laser scanning technique were (6mm) at minimum range of (3.5 m) for the indoor site and and (12 mm) at minimum range of (7 m) the outdoor site. [13]

3- Alauqaiser Documentation
Photogrammetric reconstruction technique was used in the documentation process of Alauqaiser historical church. The process started with photographing the area using DJI Phantom Pro drone Figure (1) to capture a larger view of the area from low altitude.

The overlapping captured images were processed using collinearity equations to reconstruct an orthophoto of the area as shown in figure 2 which was, then, used to investigate the site.

A detailed and careful close-up studying reveals clear footprints of urban settlement used to be around the church site as shown in figure 3.
4- Conclusion and future work

Photogrammetric reconstruction proved to be one of the powerful techniques in documentation and field investigation research. Using drones in the photogrammetric reconstruction process is a huge added value due to the high spatial as well as radiometric accuracy resulted from low altitude flying. The research concluded to clear evidence of sized settlement used to be around Alqusair historic church which demands more attention from researchers and authorities to explore the site. Geomatics can provide more help in the process by integrating other state of the art techniques such as ground penetration radar to investigate buried ruins of the settlement and other buildings.

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