IMAGED-BASED 3D DOCUMENTATION OF A PERSIAN GARDEN

USING A LOW-COST TECHNIQUE

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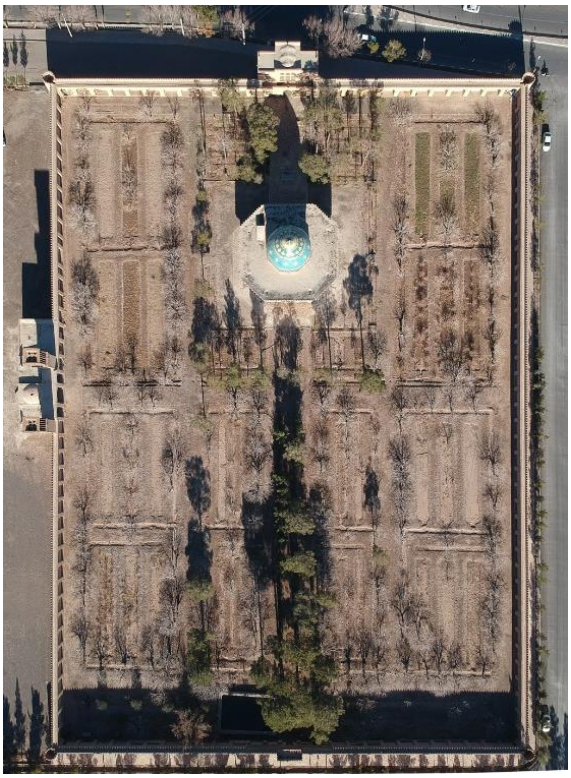
Introduction

In 2020, the authors of the paper were accredited by the Iranian National Research Institute for Cultural Heritage, the department for conservation of monuments and landscape heritage, to digitally document a number of historic gardens located in central part of Iran. This project was within a framework for documentation and preservation of landscape heritage in Isfahan province. One of the documented sites was Mosala garden (Fig. 1), which is located in the historic city of Naein. This garden was built around 200 years ago in the period when Qajar dynasty was ruling over the country. In the year 1984, the garden was inscribed on the national cultural heritage list of Iran under number 1719. The typology of the garden follows the traditional concept of Iranian gardens or chahār bāgh which is an enclosed space divided (sometimes not equally) into four parts by a building in the middle. The main structures in this garden are a domed octagonal pavilion and a pair of wind-catchers located on the enclosing walls of the site. Low-cost Imaged-based 3D reconstruction techniques were employed for the documentation of this landscape heritage and the required images were obtained by a drone. Moreover, a camera on tripod was used to acquire the images of the pavilion interior space and the parts that were not possible to be captured by drone.

Imaged-based Documentation

It has been a long time that photogrammetry and image-based methods are being deployed as a technique for obtaining three-dimensional data and textural information of objects. The surveying technique of photogrammetry extracts accurate measurements and 3D information from images taken from different angles and usually, at least two pictures are required for the data processing. Images for this aim can be acquired using terrestrial, aerial or satellite sensors and then processed following the usual photogrammetric procedure (Remondino, 2011). The accuracy of output in photogrammetry depends on the quality of the used camera and the acquired images. In addition, the capabilities of the software used for the processing of the photos is another important factor. Image-based modelling and photogrammetric systems have numerous advantages. Their applicability to multi-scale projects is regarded by many experts to be their main advantage. Moreover, compared

to scanning techniques, their main superiority is that image-based modelling sensors are generally low-cost and also portable. Photogrammetry is proved to be a flexible and relatively easy technique for surveying, while it is capable of generating reliable 3D point clouds by utilizing a dense matching algorithm (Skarlatos and Kiparissi 2012). In recent years, introduction of modern photogrammetric algorithms such as *Structure form Motion* has largely improved the results of photogrammetry methods and High resolution 3D models of archaeological sites or monuments can be generated with these algorithms in a short time and at a much lower cost than laser scanner tools (Sapirstein, 2016).



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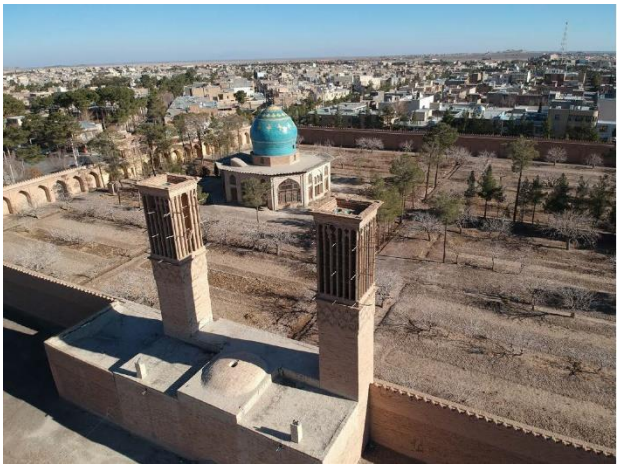

b

Fig. 1. Mosala garden, Naein, Iran a) Top view; b) View from the windcatchers looking towards the octagonal pavillion (© Authors).

Aerial Photogrammetry

Unmanned Aerial Vehicles (UAVs) can be used for low-altitude aerial photography, and for gathering geospatial information through remote sensing. Over the last years, UAVs are being deployed for the aim of cultural heritage documentation due to their reliability and ease of use (Themistocleous et al. 2015). The main advantages of UAVs in the field of cultural heritage is their capability for fast data acquisition, and their ability to reach inaccessible parts of the monuments, such as rooftops. Moreover, the low-cost of UAV systems is another advantage that makes this platform popular in the field (Eisenbeiss, 2009).

Work Flow

For documentation of the Mosala garden, a low-cost DJI quadrotor, from Spark series was used. The weight of the drone is around 300 g and its sensor can obtain pictures with 12 mpx. The drone was manually guided to best acquire the necessary images from the site. For the interior space of

the central pavilion and the areas that were not accessible for the drone and could result a gap in the data, a camera on tripod was used. The process of acquisition on field was performed in almost half of a day and then for starting the process, images were uploaded in an imaged-based 3D re-construction software.

Currently, there are numerous software available for this purpose. In this project, PIX4Dmapper was chosen since its features perfectly matched the project aims and also provided the possibility of online processing, therefore a high-performance computer was not needed. By merging the images in the software, their geo-location and orientation data are automatically detected and therefore the processing of the images can be initiated immediately. The software is able to deliver point cloud and 3D textured mesh as output which according to the project needs can be exported in various formats. The main goal for this survey was to have a digital 3D model of the garden and generate architectural drawings of the site used for the knowledge, conservation and restoration. For generation of the documents such as sections shown in Fig. 2, the 3D mesh had to be adjusted in a 3D modelling software such as Rhinoceros. To open the file in the software a 3D Textured Mesh with .OBJ format was exported and then sections with different views were prepared.

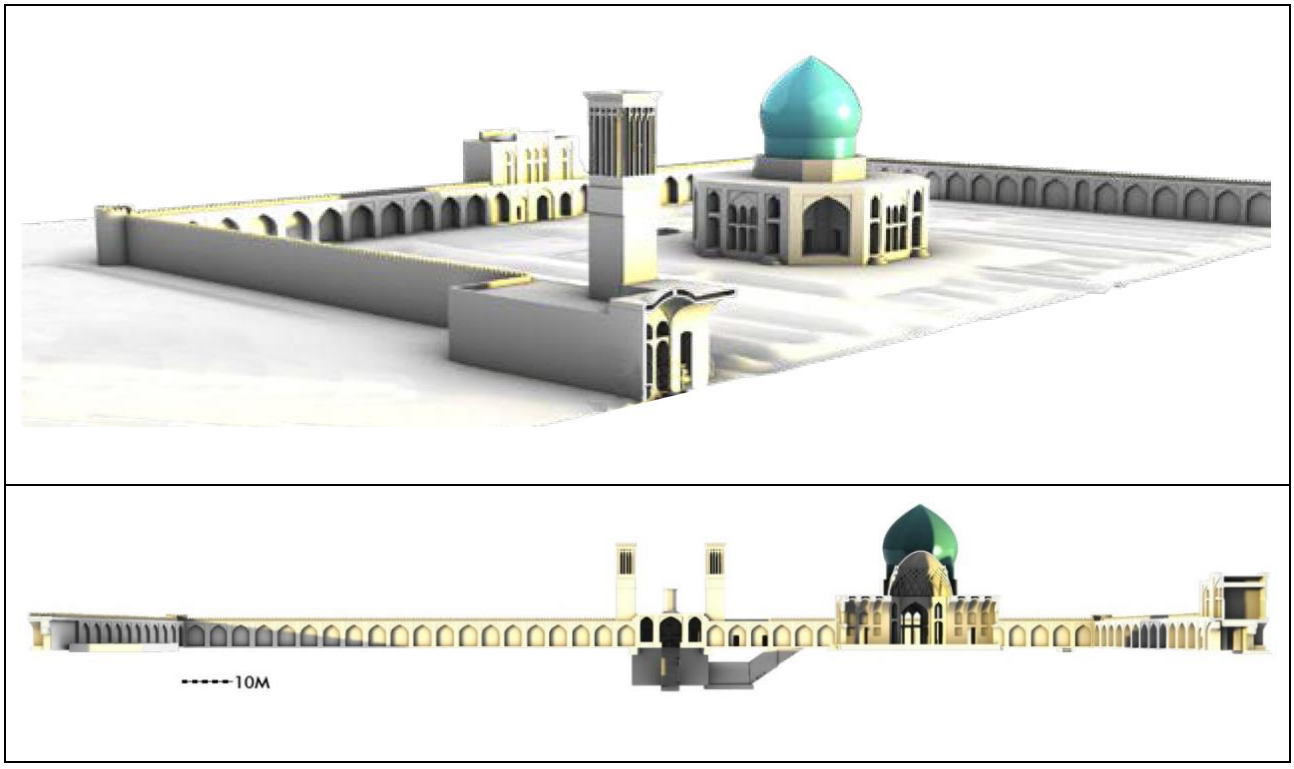

Fig. 2, Generated Sections from the Acquired 3D Model (© Authors).

Conclusion

In recent years, thanks to significant advances in technology, various digital techniques are introduced for the aim of cultural heritage documentation. Among them, the reliability of photogrammetry because of its flexibility and ease of use is proved and have made it a popular method of documentation in cultural heritage. The images for the purpose of 3D reconstruction can be acquired using different platforms. Regarding the fact that each photographic technique has a limitation, a combination of acquisition methods is a practical solution. An appropriate photography platform is selected according to the physical features and size of the surveying site.

The aim of this project was to experiment low-cost photogrammetry methods. Since the aerial photography is considered as an expensive method for acquisition of images, a light-weight drone had been employed. In addition, for the parts of the site which was inaccessible for the drone, a camera on tripod was deployed. The images were merged and processed in a 3D reconstruction software that its output was a digital 3D model which could be used for various purposes such as conservation and restoration of the site.

Author Contributions

Both authors have equally contributed to the publication of this paper.

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