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Application of Photogrammetry in Archaeology

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Abstract: A recent trend in photogrammetry is the use of unmanned aerial vehicles (UAVs) for photogrammetric purposes. A data acquisition sensor is mounted on an unmanned aerial vehicle to collect data during short-range aerial photogrammetry from a low altitude. This system is capable of filling a significant gap left by other conventional methods in the field of map production. The improvement in processes over conventional methods is the basis for this method's effectiveness. A significant portion of valuable data is obtained after the first processing stage as a result of automation in all data production processes. Real orthoimages, 3D models, and a detailed point cloud of the area are all included in this data. Drawing and mapping maps has gotten much easier, more accurate, and quicker thanks to modern software. We are looking for ways to use these kinds of methods in documenting the archaeological heritage in this article by applying this method at the historic site of Susa. The experts and practitioners in this field will benefit from this method, which is a collection of the most effective techniques for geometric measurement, analysis, and interpretations related to issues raised in archaeology.

Keywords: *Archeology, Documentation, UAV, Photogrammetry*.

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Introduction

Short-range photogrammetry surveying is a common way to record data in archaeology. An accurate model of an object's geometry can be created using photogrammetric mapping by using a collection of images of the object or complex. As a result, this method is used for documents that contain a lot of space or complex geometrical features, such as walls, pavements, sidewalks, paving stones, and architectural elements. Saving time, which is very helpful for projects, is one of the benefits of photogrammetric data recording. Photogrammetry is used in excavations to record walls, identify graves, document the environment, and locate rock art. It also produces an excellent visual result. The drone system for photogrammetry is one of the most valuable photogrammetry products. As a result, this technology in archaeology has not advanced as much as it might have. Previously, obtaining such information required a significant investment of time and money. A novel approach has been presented by experts in this field to address these constraints. UAV is the term used to describe this technique, which combines air-range photogrammetry with short-range photogrammetry. According to Sadeghian and Valadan Zoej (2006), the data collected from unmanned aerial vehicle aerial images is very helpful for mapping, deciphering aerial imagery, and creating three-dimensional models of archaeological sites. The use of this system for recording archeological discoveries has several benefits, including lower costs, high-resolution photography, the ability to be used in hazardous or inaccessible locations, and the use and creation of flat and 3D images. By conducting a hands-on project at the historic site of Susa, this article aims to discuss the uses and advantages of this kind of technology.

Research Background

Using the geometrical characteristics of photographs to map buildings, the first photogrammetric activities in the field of historical monument mapping were conducted in 1867, concurrent with the invention of photography. The use of photogrammetry to record ancient and historical artifacts from various nations significantly increased after the Second World War. The World Photogrammetry Association ISPRS assigned group 5—the fifth of its seven groups—to short-range photogrammetry in 1948.

Since then, this group has held numerous meetings and published works with titles like short-range photogrammetry in a variety of fields, including special applications of photogrammetry (Remondino, 2011). Since 1964, regular photogrammetric initiatives have been established in many nations to map cultural heritage.

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) has consistently advocated photogrammetric methods to its member nations and has taken significant steps to advance this technology and mandate that nations register their cultural heritage. The International Committee for Photogrammetry of Architecture (CIPA), which was established in 1970 with the society's recommendations, is the organization that first convened a meeting to discuss the application of photogrammetry to the documentation of cultural heritage. This committee is active in publishing books and articles about architectural photogrammetry, connecting with groups that deal with photogrammetry and cultural heritage, setting up conferences and exhibitions, and connecting experts in the field (Harrison and Limp, 2018).

As a result of this method's high capabilities, significant sites have recently used it scientifically by combining laser scanning. Examples of these projects include the photogrammetric documentation of the Palace of the Hundred Pillars of Persepolis, Radakan Tower, Bam Citadel, and Haruniye To. Additionally, in recent years, there has been some limited use of UAV photogrammetry in the field of archaeology, although this has only been done in some sites and has not yet been published in detail.

Method

Drone photogrammetry is a new measurement platform for photogrammetry that is remotely piloted in either semi-automatic or fully automatic modes without the need for a passenger for aerial mapping. This platform is furnished with one or more photogrammetric measurement systems, including thermal, infrared, and video cameras. This system's use is growing in developed nations like America, Germany, Switzerland, Italy, France, England, and Australia, and the number of users in our nation is rising daily. Advanced image processing algorithms have made it possible to extract useful geometric data from non-metric images, which is a significant improvement over the widely used classical photogrammetry techniques. A small bird flying at a low altitude may have captured these images.

The creation of maps at the historic site of Susa using the UAV photogrammetry Technique. The stage before takeoff.

Two Main Components Make Up Flight Preparation.

The positioning of the ground control points comes first, followed by the assembly of all necessary components for flight operations. According to the guidelines in publication 119 of the nation's mapping organization, ground control points serve as permanent mapping stations whose density is built in the area. One of the three functions of these points is as control points for photogrammetric census calculations and ground referencing.

Permanent mapping stations, UAV photogrammetry control, and permanent mapping stations. The control points were denoted by colored marks known as coded targets in the aerial photos of Susa. On the other hand, the flight parameters, which are all parts of the parameters related to the type of bird, are examined based on the texture and accuracy of the map, including the height and speed of the bird, the day and time of the flight, the required image coverage, the route, and the plane's movement range (flight index), in-flight assessed, calculated, and evaluated. The output of this phase is the determined flight paths and targeted control points created by the photogrammetry team (Fig. 1).

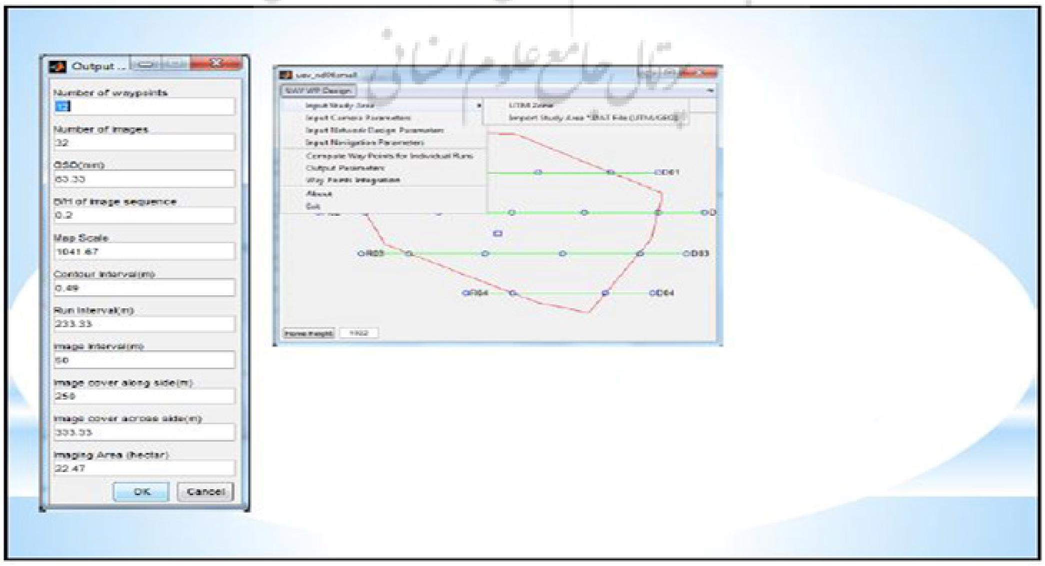

Fig. 1: Flight Design for photographing the ancient site of Susa

Flight

Following the completion of the preliminary research and the establishment of the flight parameters, the flight team was deployed in the area at a specific time and began filming and flying various portions of Shush with all of its equipment. The bird automatically moves along the defined air paths following the predetermined flight path to cover the entire area. A definition of flight paths intended for performing flight operations is shown in picture 2 as an example. The bird's automatic guidance system is given these routes, and the bird bases the performance of its flight mission on this information (Fig. 2).

Image Processing

The images need to be ready for processing once the flight operation is complete. Preparation entails removing useless images from every image. Images that are stretched, taken while the bird is sitting, or generally any image that reduces the quality of the processing result or unnecessarily lengthens the processing time should be removed from the list of images.

The necessary processing is done following the sorting of the images. These procedures, which are further described by Samad Zadegan and Farzam (2003), include automatic internal, relative, and absolute justifications that produce regional point clouds, orthophotos, digital earth elevation models (DEM), and earth surface elevation models (DTM). The automatic image processing of the drone photogrammetry system, which significantly speeds up map preparation (Fig. 3), distinguishes it from other map preparation techniques in a significant way.

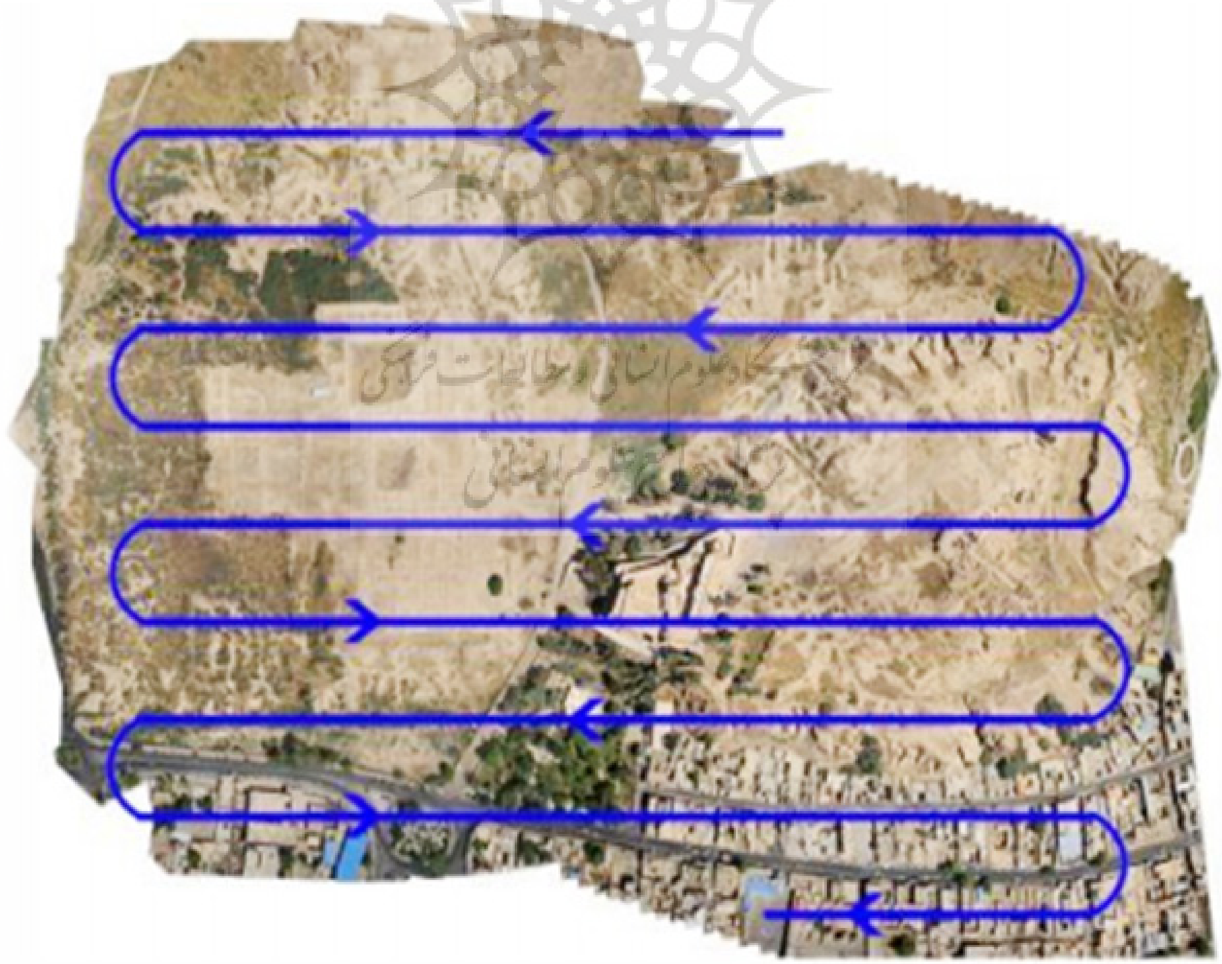

Fig. 2: The flight paths specified in the automatic flight guidance software

Fig. 3: Processing of images obtained from Octarothers

Drawing and Cartography

The necessary maps of the area are created by combining the various outputs after the image processing is complete. The procedure was as follows: from the cloud of filtered points, amount-related curves were produced, and a planar map was created by drawing on the vertical image. These two were combined to create the desired map, which was then edited to create several mapping-related products, the results of which are discussed below.

UAV Photogrammetry System Products from the Ancient Site of Susa

Dense point clouds

The point cloud of the flight area, which is obtained from the images taken from that area, is the first and most significant product produced by a photogrammetric UAV system (Eisenbeiss, 2004). The term "point cloud" refers to an extremely large and dense collection of points that, in addition to the three XYZ positional components, may also carry color and be used to describe the area. The point cloud associated with Apadana Palace is displayed in the image below, and it is very dense and natural-looking. The area is continuously displayed as a result of the high density of cloud points. Less than 20 cm of points are concentrated in this sample.

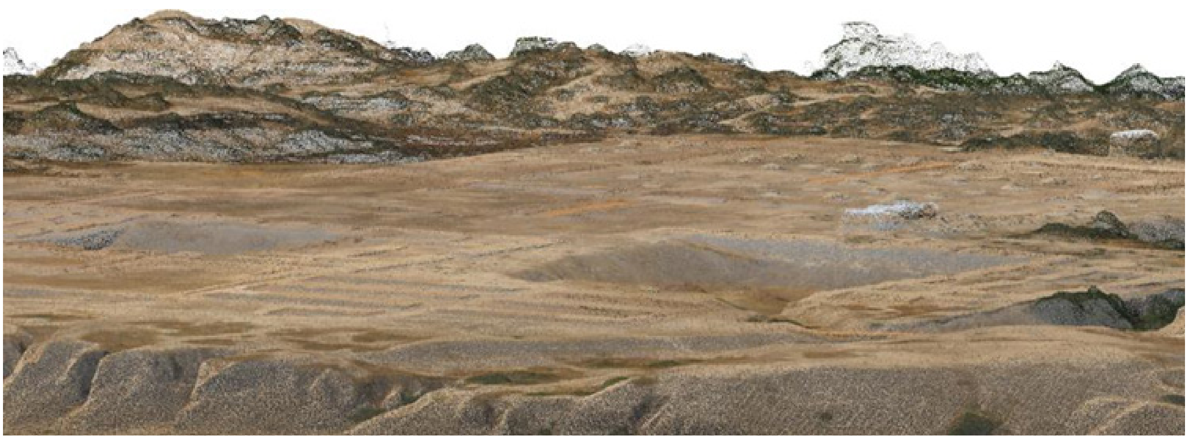
Fig. 4: Dense point cloud resulting from the processing of aerial images taken from Apadana Palace in Susa

3D Colored Model

The 3D color UAV model is one of the useful outcomes of the photogrammetry technique. Surface formation on a cloud of colored points is the technique used to create this model. This 3D model is employed in a variety of settings. Examples include 3D analyses in 3D GIS spatial information systems and virtual site view applications (Barceló et al., 2003). Figure 6 displays the 3D model created from the point cloud of Susa's Apadana Palace.

Topographic maps

The points picked by the surveyor on the ground are identical to the obtained super points; the only differences are the density and precision of the point selection. The density of points obtained from ground mapping will never be the same as the density of cloud points obtained from the photogrammetric drone system. The high point density allows for the creation of more detailed, highly accurate maps. Figure 6 shows the curve map obtained from the Apadana palace area of Shush with 20 cm intervals, and Figure 7 displays the topography final map.

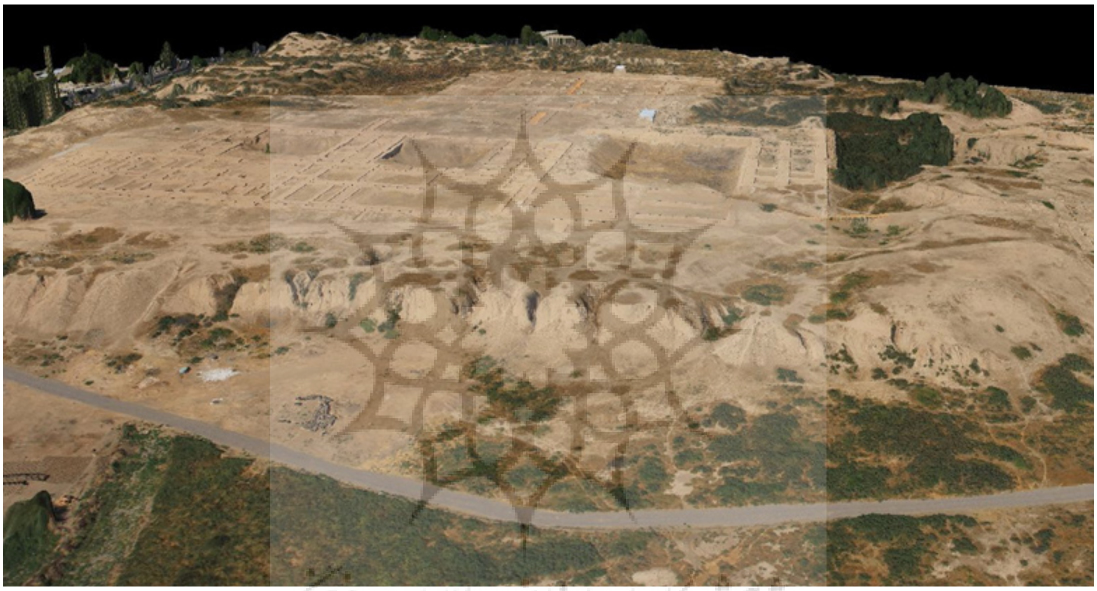

Fig 5. Colored 3D model using surface formation on color point cloud

Fig. 6: Rate curve resulting from dense point cloud processing of Apadana Palace area of Susa

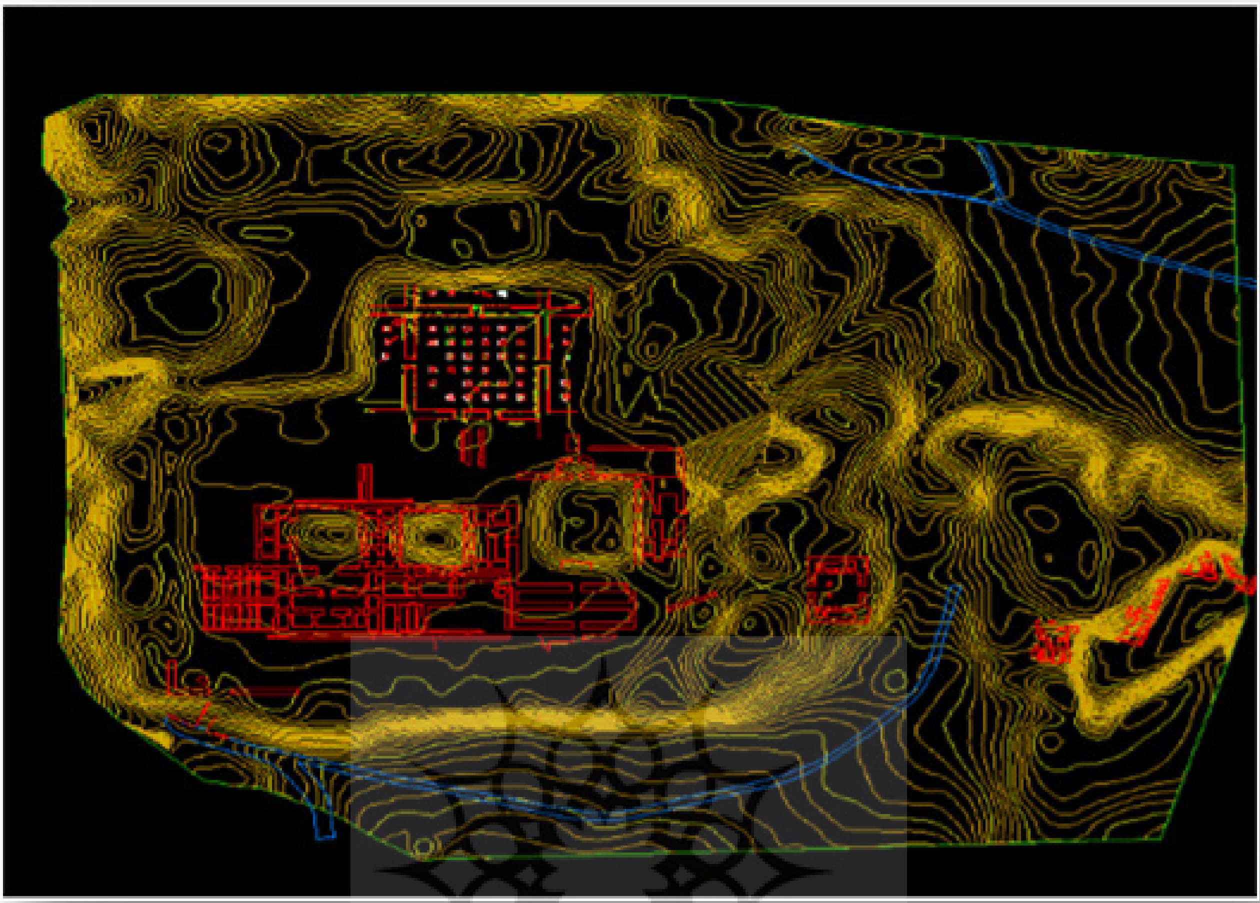

Fig. 7: Topographical map of Apadana Palace of Susa

Digital Terrain Height Model (DTM)

The Digital Terrain Model (DTM) is one of the other frequently used products of this system. Furthermore, it is a digital surface model (DSM). The infrastructure for various analyses in various fields is provided by these data, which are acquired with extremely high quality and separation power (Fig. 8).

Orthophoto or map photo

An orthophoto is a vertical, integrated image of a given area created by joining all aerial photographs together and subtracting the displacement brought on by the height disparity and perspective effect of the photographs. Of course, the orthoimage created by the UAV photogrammetry process is not simply a restoration of an aerial photo and is equivalent to a map in terms of scale and geometry because it is directly derived from the 3D color model that is also referenced with the global coordinate system (Baligh et al., 2010). so that a flat map could be created by drawing on this image. See an illustration of an orthophoto in Figure 8.

Map of drawing complications

By using the two-dimensional information of the real orthoimage, all the complications in it can be drawn, even if the 3D drawing of complications is desirable, the drawings can be transferred to the map with height information from the corresponding point cloud. Image 10 shows the drawn map plus height information.

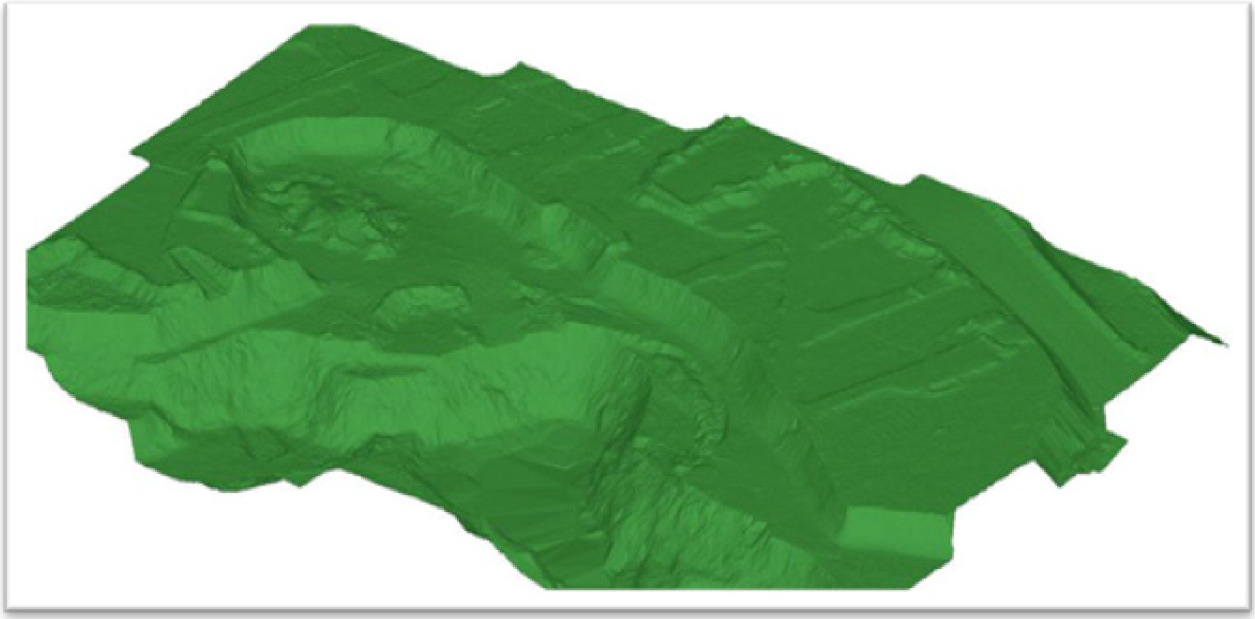

Fig. 8: A digital model of the earth with the removal of artificial effects in the area

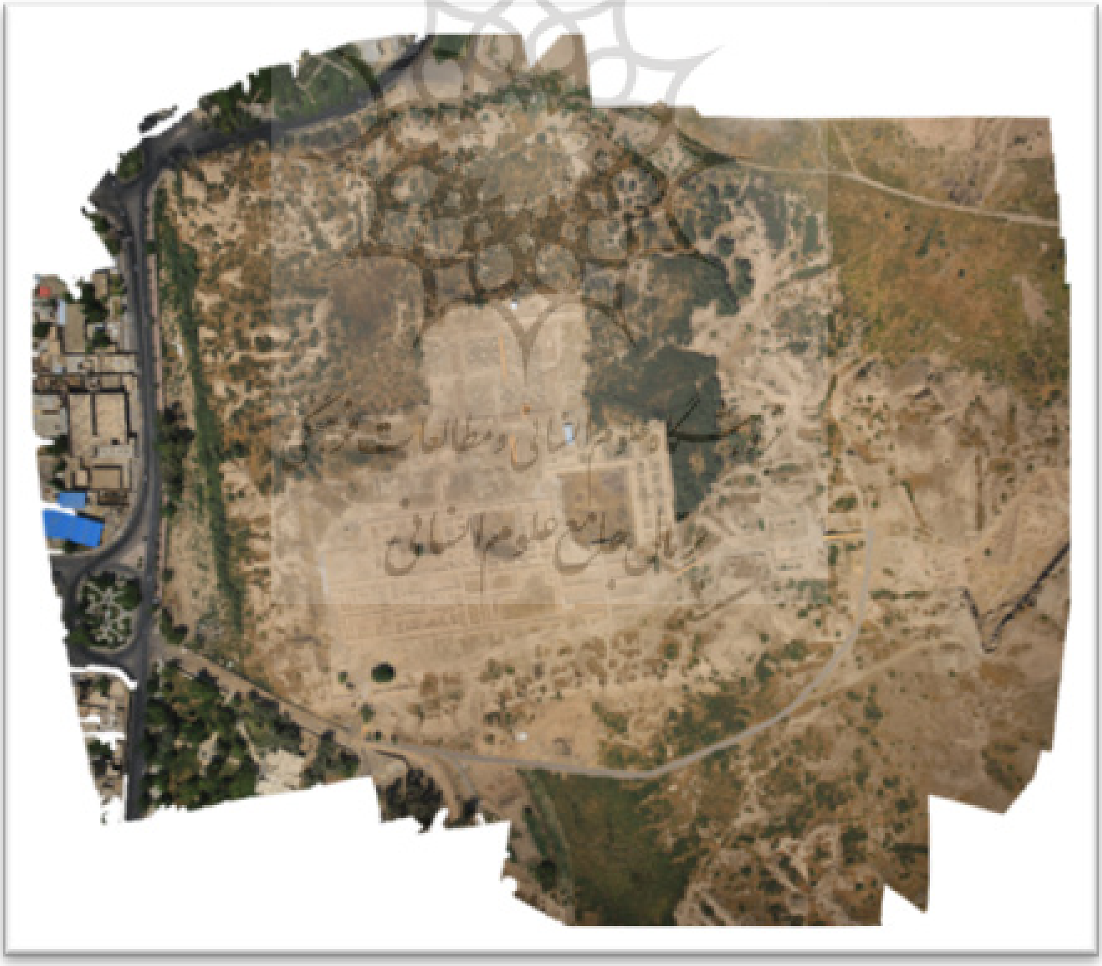

Fig. 9: True orthoimage of the Apadana Palace area of Susa

Fig. 10: Map of drawing complications with height information obtained from point cloud and real orthoimage

Features of UAV Photogrammetry System

The two primary components of UAV photogrammetry are flight and photogrammetry. By using inexpensive equipment in both parts, this method differs from the traditional photogrammetry method. Light unmanned aircraft are used for flight, and commercially available non-metric cameras are used for photogrammetry. The application of sophisticated image processing algorithms that have recently been developed in the field of machine vision leads to the extraction of valid data in quantitative and qualitative terms.

The complexity of this method's implementation is undoubtedly much greater than that of traditional mapping techniques like ground mapping, laser scanning, GPS kinematic surveying, and others, but when used correctly, its outcomes cannot be compared to those of traditional mapping techniques. Very quick data generation, no need for direct access, and unparalleled output quality are the three key characteristics of this method (Boroumand and Norolah Doost, 2006).

High Speed

Since data acquisition is done by aerial photography, flying is a major advantage. Because the data acquisition process will be accompanied by a very high speed. At the same time, the major change in the complexity of regional complications will make traditional methods a serious challenge.

No Need For Direct Access

Due to difficult natural obstacles (hard mountains, river banks, etc.), many lands are inaccessible directly. or because of legal constraints (competitors, international boundaries, etc. Furthermore, these birds are among the most effective exploration tools in situations with physiological restrictions.

Output Caliber

In contrast to conventional mapping techniques, the outputs of this method are distinctive because of the sophisticated and automatic image processing algorithms used. The color 3D model, the dense cloud of points, the actual orthoimage, and the coverage map that were produced from it cannot be compared to the results of conventional methods in terms of accuracy, accuracy, and coverage of all necessary complications. Dense point clouds can also yield DEM, DTM, and DSM results. Therefore, if a project's scope matches the requirements for UAV photogrammetry operations and the required location information is subject to the three criteria of time, difficult access, or quality, this approach is advised as the best choice.

Conclusion

Due to its distinct features, the drone photogrammetry system has been able to distinguish itself from more traditional and common ways of producing spatial data. This method is thought to be nearly identical to land mapping techniques due to the level of accuracy and cost. Contrarily, the costs of the system slightly rise when compared to equivalent ground mapping methods due to the use of a variety of specialties at very advanced levels to perform flight services and process the acquired images. However, this method's capabilities and capacities will be expanded for wider areas as a result of the use of a variety of specialties. In a sense, it is clear that even though this method offers accuracy comparable to that of ground methods, it is more cost-effective over a wider area.

In contrast, this method is distinct from independent terrestrial methods in terms of output quality. It is extremely beneficial for some applications to create a real orthoimage of a region because it can be seen as a documentary in various periods. The use of drones for photogrammetry can be considered one of the most cutting-edge technologies currently being used throughout the world in the mapping industry, according to the information provided above.

This system can be considered appropriate for land mapping in all areas, particularly large and inaccessible areas because the accuracy obtained in this method is extremely high and at the level of 1:200 maps, as well as taking into account the unimaginable outputs (such as vertical image, very dense cloud of points, elevation model of the earth, etc.) which result from this method.

Conflict of Interest: The authors declare that they agreed to participate in the present paper and there is no competing interests.

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