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Documentation of complex structure using unmanned aerial vehicle (UAV) photogrammetry method and terrestrial laser scanner (TLS)

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ABSTRACT

Modeling objects with different sizes and geometries and analyzing metric information is more difficult than regular geometric structures. The analysis and measurements of conical, spherical, and cylindrical structures such as minarets, domes, columns, statues, and monumental tombs cannot be accurate and precise with classical methods. Three-dimensional (3D) scanning technologies such as Terrestrial laser scanner (TLS) are an important tool for modeling complex structures. Undoubtedly, 3D scanners are well suited for measuring objects with irregular and complex surfaces and are probably one of the best methods for applications with similar structures. However, the biggest disadvantage of ground base scans such as TLS is that the data of the upper facades of the structure cannot be collected due to the scanning location. This problem can be overcome by collecting data on the upper fronts of the structure by platforms such as unmanned aerial vehicles (UAV). Therefore, in our study, the data were collected by TLS and UAV photogrammetry methods, and then the 3D model and analysis of the complex structures were made by combining the obtained data. As a result of the study, 0.21-2.3 cm accuracy was calculated for point clouds produced by TLS and UAV photogrammetry, respectively. By combining the point clouds created from both data collection methods, 1.2 cm sensitivity was calculated.

1. INTRODUCTION

3D model study of structure, analysis of attribute information, and integration with information systems; It is one of the common study areas of different disciplines. Especially structures subject to object deformation come at the beginning of analysis studies. Structures are subject to deformation due to many natural or unnatural reasons (Yakar et.al, 2015; Ulvi et.al, 2020). Analysis studies of the structures that are subject to deformation cannot be done completely with classical methods. Various analyses of these structures can be made with modern methods. At this point, 3D models can be produced with various data collection methods; analysis can be made quickly and easily.

Using 3D models to extract metric information of structures with different dimensions and geometries gives precise and accurate results (Yılmaz and Yakar, 2006; Ulvi and Yiğit, 2019). Especially conical, spherical, cylindrical; Modern methods should be used to analyze and measure similar structures such as minarets, domes, columns and statues. With the developing technology, UAV photogrammetry and laser scanning technology are used more effectively in 3D model studies. These systems, which are complementary to each other, are frequently used because they provide data and methods in a fast, efficient, economical and reliable manner. (Yakar and Yılmaz, 2008; Koruaz et.al, 2011; Şanlıoğlu et.al, 2013). These systems are preferred by various disciplines because of the ability to create accurately 3D models, to see the details on the object more clearly, to examine the changes, to present and store documents digitally (Karabörk et.al, 2009, Alptekin et.al, 2019).

Studies in the literature show that aboveground objects such as structures that make up the 3D city model can be created quickly from terrestrial laser scanning data (Yakar et.al, 2006; Çelik et.al, 2020).

In addition, with the integration of UAVs, the data belonging to the missing fronts has been collected.

In the study, considering the advantages of UAV photogrammetry and TLS system compared to each other, 3D models of cylindrical columns were created, accurate and accuracy analysis were made and various analyzes were obtained. Using UAV and TLS technologies together contributes to obtaining products with high accurate. The fact that the result obtained with these systems enables the product to be used in different application areas such as being digital, visualizing and managing 3D data and presenting them in a GIS

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environment is a base map for many studies. As a result of the study, 0.21-2.3 cm accurately was obtained for point clouds produced by TLS and UAV photogrammetry, respectively. By combining the point clouds obtained from data collection methods, 1.7 cm accurately was obtained.

2. METHOD

In the study, 3D analysis of complex structures was performed using TLS and UAV photogrammetry method. The working area is given in Figure 1, the plan for the 3D model is given in Figure 2 and the work flow chart is given in Figure 3.

2.1. Study Area

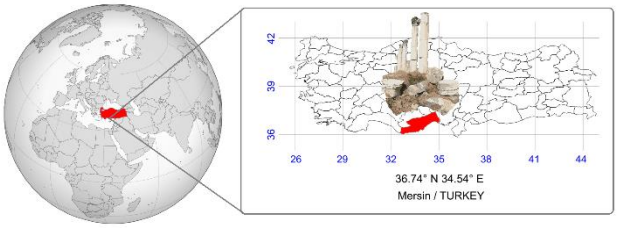

Figure 1. Study area

The study area is the Colonnaded street of the ancient city of Soli - Pompeiopolis in Mersin province.
In the study area, there are a total of 33 columns, 4 of which are in the west and 29 in the east.

2.2. 3D modeling and analysis

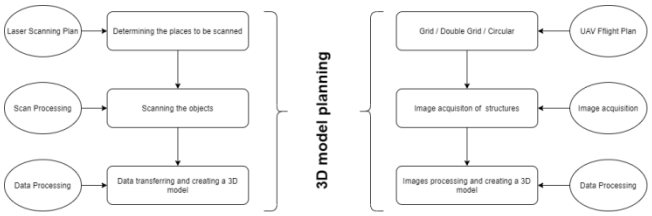

Figure 2. 3D model planning

TLS method; It is the system that is used to produce a point cloud with X, Y, Z coordinates belonging to the desired object with the object's LIDAR (Light Detection and Ranging) technology. TLS is used in studies such as documentation, restoration, restitution, reverse engineering, 3D modeling and analysis due to its features such as high accuracy, fast and short measurement, printing in digital form and forming a base for different studies.

UAV photogrammetry method, on the other hand, is basically a method of collecting data by taking overlap images using the photogrammetry method and obtaining a 3D model.

The data collection methods and work flow chart used in the study are shown in Figure 3.

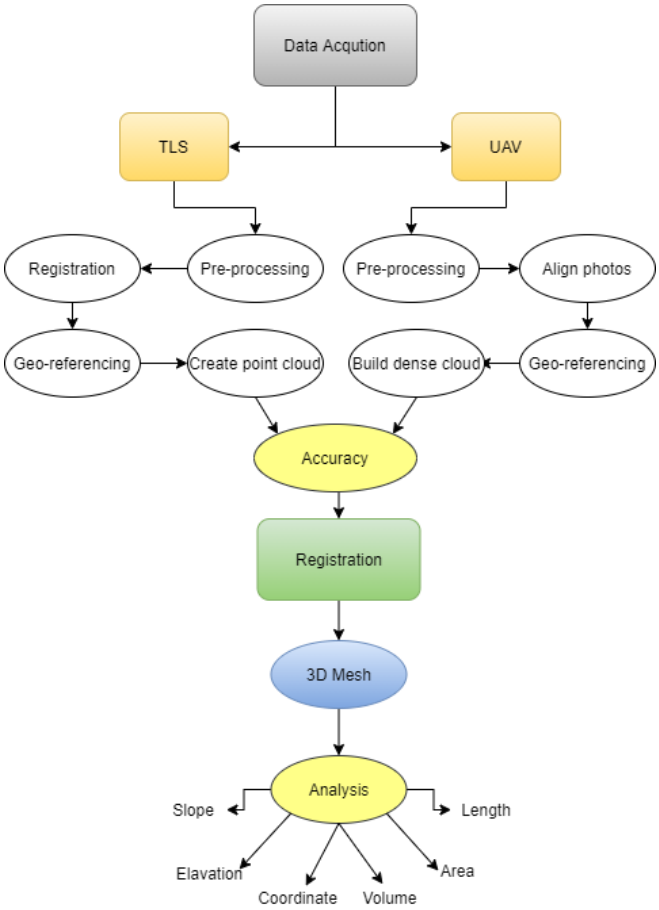

Figure 3. Work-flow chart

3. CONCLUSION

For the analysis of structures with different geometric shapes, their physical properties should be considered an appropriate evaluation tools should be selected. Rather than using a single method for spatial recording of structures, the use of hybrid methods provides significant contributions to an accurate analysis. For this purpose, firstly geodetic measurement techniques, laser scanning data collection methods such as UAV photogrammetry and TLS were used for the analysis of complex structures. However, field studies conducted with geodetic or traditional measurements cause excessive time, manpower and increase the cost. TLS and UAV photogrammetry come to the fore for faster and more accurate data collection, especially with time and cost savings.

The distance between TLS and the scanned surface directly affects the resolution of the point cloud data, and the rays coming from the laser scanning device to the surface to be scanned also affect the quality of the point cloud data. The TLS system also allows an object, structure or object to be scanned from horizontal and vertical directions to obtain a point cloud image. Therefore, it is the most preferred system in 3D modeling of structures. However, with such ground-centered systems, the data of the upper facades of the structures are missing. This problem was made by taking aerial pictures using carrier platforms such as UAVs, using the UAV photogrammetry method and producing a 3D point cloud of the structure. In this way, the data of the lower facades of the structure, UAV and upper facades were

collected with TLS. Complete 3D data of the structure was obtained with hybrid data collection methods and various analyzes were made.

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