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Comparing conventional and photogrammetric methods for volume calculation of stone piles: A case study in the Karacadağ Region

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Abstract

Several years ago, the erupting Karacadağ volcano spread basalt stones across the Karacadağ region, causing difficulties for farmers engaged in agricultural activities in the area. This situation led to the State Hydraulic Works aiming to provide access to each parcel of land in some villages through land consolidation efforts. During the road opening process, the stones that formed were piled up in a specific area. However, the volume calculation of this stone pile is performed using a dangerous conventional method, namely the collection of GPS points by surveyors. In this study, volume calculations were conducted using both the conventional method and the photogrammetric methods utilizing Unmanned Aerial Vehicles (UAVs) on the example of a stone pile located in the rural neighborhood of Dönemeç, affiliated with Siverek district of Şanlıurfa province. The differences and advantages between the two methods were examined.

1. Introduction

Please In engineering projects (such as road construction, building construction, mining, etc.), it is necessary to calculate the volumes of soil to be excavated and filled in order to be able to make cost estimations during land-related works. These volume calculations are typically performed using cross-sections, prisms, surface leveling measurements, and contour maps (Yakar ve ark., 2009).

Volume calculations play a significant role in engineering projects. The quantities of excavation, fill, and other volume data provide essential information and various methods are employed for these calculations. In this study, a comparison will be made between local measurements using GPS and photogrammetric measurements obtained through the use of Unmanned Aerial Vehicles (UAVs) for volume calculations. The use of photogrammetric techniques has become increasingly widespread in solving different engineering problems. UAVs contribute significantly to obtaining photographs of natural and man-made structures for photogrammetric purposes (Seki et al., 2017).

Located in the center of the Southeastern Anatolia Region, Mount Karacadağ is a volcanic mountain that has formed a vast rocky terrain as the lava cooled and transformed into basalt stones. However, in a significant portion of this area, the stones are scattered over fertile soil, making it easily cleared and suitable for agriculture. Karacadağ is known for receiving heavy rainfall, particularly during the winter months, and it has a cool climate. However, over the past few centuries, due to harsh winters, the local population turned to illegal logging, resulting in significant reduction of forest areas as a result of livestock grazing and the use of branches. Today, the region mostly appears as empty and unproductive land covered with stones. However, this area actually holds tremendous potential for organic farming, which has gained importance worldwide. It can be easily cleared and used for agriculture. Rice, in particular, is the most important crop cultivated in Karacadağ. Additionally, livestock farming is one of the main livelihoods for the people living in the Karacadağ region.

Under the scope of Land Consolidation carried out by the State Hydraulic Works (DSİ), in certain parts of the

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region, the stones have been removed from the road and piled up in a designated area to provide access roads to the fields that farmers have cleared on their own.

The basalt stones found in the Karacadağ region are used in the restoration of historical sites in Diyarbakır (Haspolat,2013).

In this study, the volume calculation of the collected stones based on road construction was carried out in the rural neighborhood of Dönemeç in Siverek district of Şanlıurfa province. Initially, the classical method was employed, where points were captured using GPS, and subsequently, aerial photographs were taken using an Unmanned Aerial Vehicle (UAV) for volume calculation through the photogrammetry method. Furthermore, the data obtained through photogrammetric method were compared with the data obtained through the classical method in terms of time and accuracy, and the advantages and disadvantages of both methods were discussed.

2. Method

The stone pile located in Dönemeç village has been selected as the study area (Figure 1). The area covered by the stones has been measured as 15,868 square meters.

Figure 1. The study area

2.1. Classic field method

In this method, a total of 433 points were collected from the field using CORS (Sokkia GNSS GRX2) equipment. During the measurement process, the surveyor had to climb on top of the stones, which posed a safety risk and resulted in significant time loss in the field.

Later, the collected points were processed in the office using CAD software and the triangulation method. This resulted in the formation of a Digital Elevation Model (DEM) with a total of 786 triangles (Figure 2). Cross-sections were extracted from the model, and the volume of the stone pile was calculated to be 133,635 cubic meters.

2.2. Photogrammetric Method

In the study, high-quality aerial photographs were taken using a DJI Mavic 2 Pro drone, resulting in a total of 510 images with a size of 6.3 GB. On the ground, seven control points were assigned using CORS (Continuously Operating Reference Station). All the processes were efficiently carried out in the field within a short period of time.

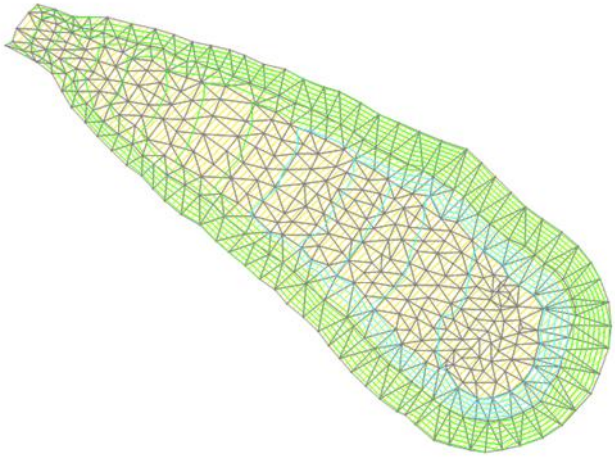

Figure 2. Triangles

Subsequently, in the office, the photographs were processed using Agisoft software to generate a 3D model of the stone pile. This was achieved by utilizing a sparse point cloud with 395,342 points and a dense point cloud with 15,837,172 points (Figure 3). A Digital Elevation Model (DEM) was then generated (Figure 4), and the volume calculation was performed, resulting in a volume of 135,500 cubic meters.

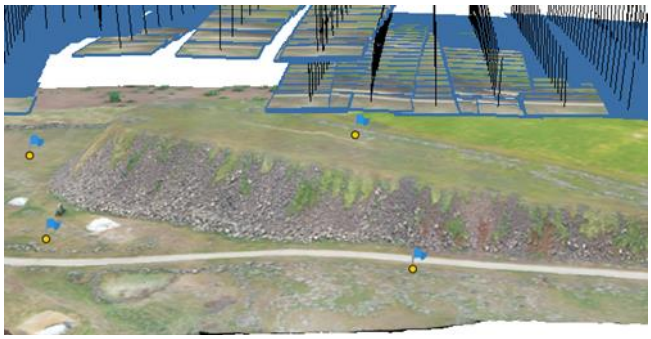

Figure 3. 3D model

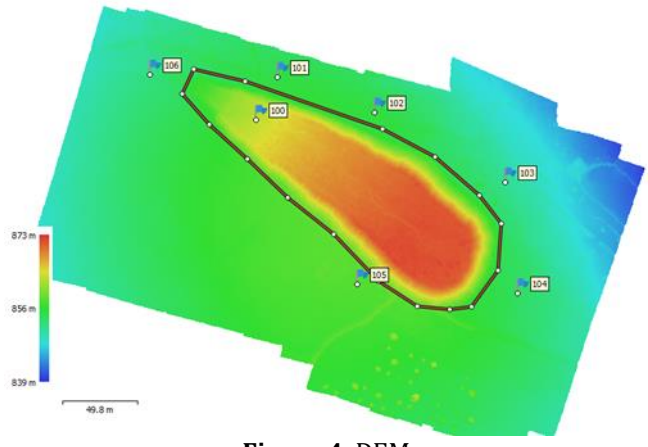

Figure 4. DEM

3. Analysis

In the study, the classic field method and the photogrammetric method were compared in terms of time and accuracy.

In terms of time, for the classic field method, the field measurements of 433 points took approximately 1.5 hours. The triangulation and volume calculation processes in the office took about 30 minutes. Overall, the classic method took approximately 2 hours.

For the photogrammetric method, the assignment of 7 ground control points and the flight time using the UAV took approximately 30 minutes. However, due to the large size of the photographs (totaling 6.3 GB), the processing time took approximately 5 hours. The total time for the photogrammetric method was approximately 5.5 hours.

In terms of accuracy, the volume of the stone pile was calculated as 133,635 cubic meters from 433 points using the classic method. On the other hand, using the photogrammetric method and analyzing 510 photographs, the volume of the stone pile was calculated as 135,500 cubic meters.

It should be noted that the measurements were conducted in May 2023, and it was found that the stone pile was old (constructed in 2019). Additionally, the presence of weeds on top of the stone pile indicated that the photogrammetric measurements might have overestimated the volume compared to the actual volume.

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4. Result

In this study, a comparison was made between the classic field method and the photogrammetric method for the volume calculation of a stone pile in the rural neighborhood of Dönemeç in Siverek district. In the classic method, points were collected using GPS, and a Digital Elevation Model (DEM) was created using the triangulation method for volume calculation. In the photogrammetric method, high-resolution photographs were captured using Unmanned Aerial Vehicles (UAVs), and a 3D model and DEM were generated using Agisoft software for volume calculation.

In terms of time, the comparison in the field showed that the photogrammetric method yielded faster results compared to the classic method, ensuring safety as well. The assignment of ground control points and the UAV flight for capturing photographs were completed in a short period, but the processing of photographs took longer.

Regarding accuracy, slight differences were found between the volume values calculated using the classic method and the photogrammetric method. The presence of weeds on top of the stone pile contributed to the overestimation of volume in the photogrammetric method.

In conclusion, the photogrammetric method is a preferred option for volume calculations in engineering projects due to its fast results and acceptable level of accuracy. However, it is crucial to assign accurate ground control points in the field and carefully carry out the photo processing phase to obtain accurate results.

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