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Production of road maps in highway projects by unmanned aerial vehicle (UAV)

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Abstract

Unmanned aerial vehicles (UAVs), which are used in many areas of use today and are among the contemporary measurement systems, have recently been used in highway projects. In highway projects, there is a direct correlation between the accuracy and precision of the existing digital maps and the calculation of the geometric components of the horizontal and vertical (profile-long-section) lines of the project route, followed by the determination of the excavation filling amounts (cubage), also expressed as soil movement. The data collected by the unmanned aerial vehicle was used in this study to conduct research for the creation of route maps (strip data), which serve as the foundation for highway projects. The study region, which was 2 km of the Mersin-Findikpinar Provincial Road project route, was part of the road system of the 5th Regional Directorate of Highways. According to the pre-determined flight plan, the UAV was flown at a height of 195 meters to capture 70% transverse and 85% longitudinal superimposed pictures in a 200 m wide corridor roughly 100 m to the right and 100 m to the left of the route chosen in the study area. A Digital Terrain Model and Route Map of the chosen corridor were created as a consequence of the photogrammetric analysis of these images. The volume computation was carried out using a sample highway project in a common area established between the high-accuracy 1/1000 scale baseline maps of the study area produced by the terrestrial method and the baseline maps produced by the UAV photogrammetry method. Digital Terrain Models (DTMs) have been contrasted. The location accuracy of the orthophoto map created by determining the coordinates of the detail points in the field with the RTK GPS technique was measured in addition to the YKN used as a reference, and an approximation cost comparison between the two techniques was made.

Introduction

Transportation is generally defined as the displacement of passengers and goods [1-4]. The highway, which is one of the transportation routes, is the land strips, bridges, tunnels, all kinds of art structures, protection structures, and other areas open to the public in order to allow traffic flow for the safe, fast, and comfortable transportation of passengers and goods. Highways, as in the past, have a great share in the development and prosperity of societies today [5-8]. The contribution of this system, which is realized with a large investment, to the national economy depends on the appropriate selection of the highway route and low construction, maintenance, and operating costs. In this respect, there is a need for those who use the highway to study and know the elements constituting it very well.

The existing maps, which are used as a base for highway projects, are composed of streams, hills, roads, ETL, etc., covering a corridor with a width of approximately 200 m. They are strip-like maps showing structures. Stream, ditch, slope, etc., which are defined as critical land sections on the highway project routes in the current maps in question. In order for the sections to reflect the real terrain and for the accurate calculation of the soil volume amounts, it is important that the current map digital elevation model sensitivity is high [8-10].

In the production of highway route maps and digital terrain models, generally, labor-intensive traditional terrestrial methods or classical aerial photogrammetry are used. In addition to these methods, the use of advanced technology remotely controlled UAVs (Unmanned Aerial Vehicles) is also important when evaluated in terms of time and workforce [10-15].

The highway is one of the most important infrastructure investments made by human beings. The common space of human beings is the forward journey of societies. The history of the roads starts with the first person and goes on and on, developing from the past to the future. The path to this cause is the most important infrastructure that forms the basis for the development of a country and the socio-economic development of society. The use of UAV technology on highways, especially on the routes where mountainous and dense forest areas are hit, enables the production of maps at a low cost in a short time. UAVs on Highways; production of digital base maps of project routes, production of maps of landslide areas, production of maps of intersection areas, etc. frequently used in applications.

Material and Method

In addition to the polygon stones, 51 YCP points were established in the study area, 23 of them were used in Balancing and 51 of them were used as check notes in orthophoto accuracy analysis. The desired land topography is an undulating land structure so that the soil movements (excavation and fill amounts) on the highway project routes can balance each other. For this reason, this section of Mersin Fındıkpınarı Provincial Road, which has a wavy land structure, was preferred in order to make a more accurate comparison in the soil movement evaluation (excavation-fill) of the DTM (Digital Terrain Model) to be obtained in this study as the study area. Before the field studies, the UAV (Revolving Wing) to be used in the application, digital camera (integrated with the UAV), GNSS device, and (cloth tarpaulin and line paint) to be established as ground control points in the evaluation of the photographs obtained by the UAV were provided (Figure 1).

Figure 1. Ground Control Point Facilities view

Results

In this study, the cubage of the project route was determined by using digital terrain models produced in both methods of a route of approximately 1.5 km in the section of Mersin Fındıkpınarı Provincial Road, which was produced by the digital method in 2014, with the terrestrial method. Inroads running under the MicroStation V8I program were used in this sample project work. Highway project route geometric elements outline; consists of Horizontal Geometry, Vertical Geometry, superelevation, and cross-section. In this study, the DTM model produced by the terrestrial method using the same design parameters of the same route, and the DTM produced by the UAV Photogrammetry method was used. The excavation volume of 107682.456 m^3 and the fill volume of 75908.986 m^3 were calculated at the project site, which was obtained by using DTM produced by the Terrestrial Method, and there is an excess of 31773.469 m^3 of excavation. 108951.136 m3 excavation and 74768.338 m^3 fill volume were calculated on the project route obtained by using DTM produced by the UAV Photogrammetry method (Figure 2). The amount of soil advance obtained as a result of the application was calculated and the comparison results are given in Table 1.

Table 1. Excavation Fill Amounts Comparison.

Items	Geodetic DTM	UAV DTM	Difference
Splitting Volume (m^3)	107686.456	108951.136	1268.68
Fill Volume (m^3)	75908.98	74768.338	-1140.648

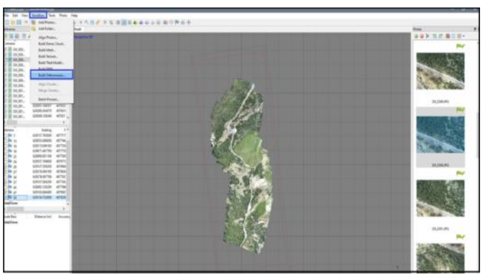

Figure 2. Agisoft Workspace DTM and Orthomosaic Build Menu

Conclusion

In the accurate evaluation of the orthophoto map produced with Agisoft Photoscan software, the GCP points were established in the study area, and in addition to these points, 30 points in total, 81 points from which GPS/RTK measurement technique coordinates were obtained in the field. In the determination of these 30 detail points, the existing building corners, wall points, mid-road line details, etc. points are used. The coordinates of these points, which are accepted as exact coordinates, on the orthophoto map were determined using NetCAD software. The square mean errors and mean position errors of these points used in the orthophoto map accuracy assessment were calculated as my = ± 2.76 cm, mx = ±2.64 cm and mP = ± 3.81 cm. When these results are examined, the calculated values are; According to Large Scale Map and Map Information Production Regulation and Technical Specification for Highways Terrestrial and Photogrammetric Map Engineering Services, it was observed that it remained within the error limit (± 7 cm) determined under the heading of detail measurement accuracy. A cost evaluation was made between the terrestrial method and UAV Photogrammetry in the production of the current map of the study area, which has an area of approximately 50 hectares. The approximate cost of the map produced using the Rotary Wing UAV was found to be 4682.10 TL, and the approximate cost of the map produced by the terrestrial method was 9648.53 TL.

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