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Numerical data generation using unmanned aerial vehicle: a case study of Aksaray Güzelyurt District

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Abstract

Base maps can be produced using terrestrial methods, also known as classical methods. In recent years, with the technological developments, remote sensing methods have been started to be used in the production of base maps. These methods are satellite images, LIDAR systems and aerial photogrammetry. Although these systems are innovative systems brought by technology, they have their own advantages and disadvantages. The presence of atmospheric-radiometric errors in photographing satellite images and the correction of these errors in these satellite images increase the cost. Although LIDAR systems can produce dense point cloud data representing the land topography and are an active sensing system that is not dependent on weather conditions, they are still quite burdensome in terms of cost. Unmanned Aerial Vehicles (UAV) have started to be used in many areas due to their low cost and decreasing size. Especially in recent years, UAVs have started to be used for technical data production. These technical data in the field of geomatics can be used in orthophoto map production, in the production of ready-made maps to scale, digital terrain model (DTM), digital elevation model (DEM), route creation in road projects, excavation-fill calculations, area-volume calculations and observation of environmental change. The aim of this study is to produce a base map using up-to-date technological equipment and methods. Güzelyurt District, an area of approximately 110 hectares in Aksaray Province, was chosen as the application area. The eBee Rtk model was used for taking terrain photographs. Sony camera is mounted on the UAV. The 166 field pictures were taken from a height of 150 meters, with a transverse overlap of 70% and a longitudinal overlap of 80%. These pictures were evaluated in the Pix4D program. As a result of the evaluation, orthophoto map, DEM and point cloud data were obtained.

1. Introduction

Urbanization that came with the industrial revolution in the world has caused ground rent. Therefore, the correct use of land and planning on the basis of cities and countries contribute to the development of countries [1].

The good planning of the cities of a country shows the level of development of that country. It is possible by planning all the facilities that should be in a city, such as the construction of main and intermediate roads in a city, the selection of park areas and forest areas, the selection of university places, the selection of shopping centers, the selection of nursery-primary school, secondary school areas, the selection of parking lots suitable for the population of the city and the surface of the land. In order to plan this in a comprehensive way, we need to produce the base maps, which are the basis for the planning studies at the highest level of accuracy of all the details on the earth.

The topography of the land must be accurately represented in the production of base maps. This requirement for existing maps arises from its use as a base in urban planning, in the construction of all infrastructure and superstructures, in all projects that require technical equipment. The existing maps, which are the basis for technical projects, need to be updated at regular intervals in order to be digital and the changes in the land surface to be recorded on the maps. Updating the rapidly changing topography of the earth on the existing maps can be detected faster and at a reasonable cost using remote sensing techniques.

Unmanned Aerial Vehicle (UAV), which has become more and more common in recent years are the aircrafts that do not physically have a pilot or a passenger, but can carry measuring equipment such as a camera, laser scanning device, video camera, Global Navigation Satellite System (GNSS), remotely or automatically fulfill and complete their flight. It means an aircraft that can fly without a pilot in UAVs. UAV is a vehicle that can move automatically or semi-automatically in accordance with the flight plan, or it is a remotely controlled vehicle from the station by a pilot [2].

UAV system constitutes GPS receivers, microprocessors, gyroscopes used in direction finding and measuring processes, micro-scale sensors and electronic communication equipment. Low cost, high spatial and temporal resolution data can be produced using a UAV [3].

Today, although UAVs continue to be used for military, security and intelligence purposes, they are also used for civilian purposes. These areas are orthophoto map production, base map production to scale, digital terrain model (DTM), digital elevation model (DEM), creating routes from road projects, excavation-filling calculations, area-volume calculations, observing environmental change, monitoring of weather conditions, observation of coast and coastline, detection of mining areas, agricultural applications (land classification, soil analysis, determination of product productivity) urban transformation projects, monitoring of natural disasters, archaeological studies, architecture and landscape studies, 3D city modeling, city silhouettes It is used in many technical and hobby areas such as creating movies, filming and sports activities [4].

UAVs are very beneficial tools in DEM construction. In oldest times robotic total station has been used in these studies [5]. Terrestrial photogrammetry is time consuming and expensive [6].

UAV has been used frequently in the last decade. Many engineering projects such as rockfall modelling [7], landslide site modelling [8-9], pond site volume calculation [10], shoreline detection [11], cultural heritage modelling [12-16], land cover classification [17], energy line detection [18], tree extraction [19] have been performed using UAV.

2. Material and Method

2.1. Study area

Güzelyurt district of Aksaray City has been selected as study area (Figure 1).

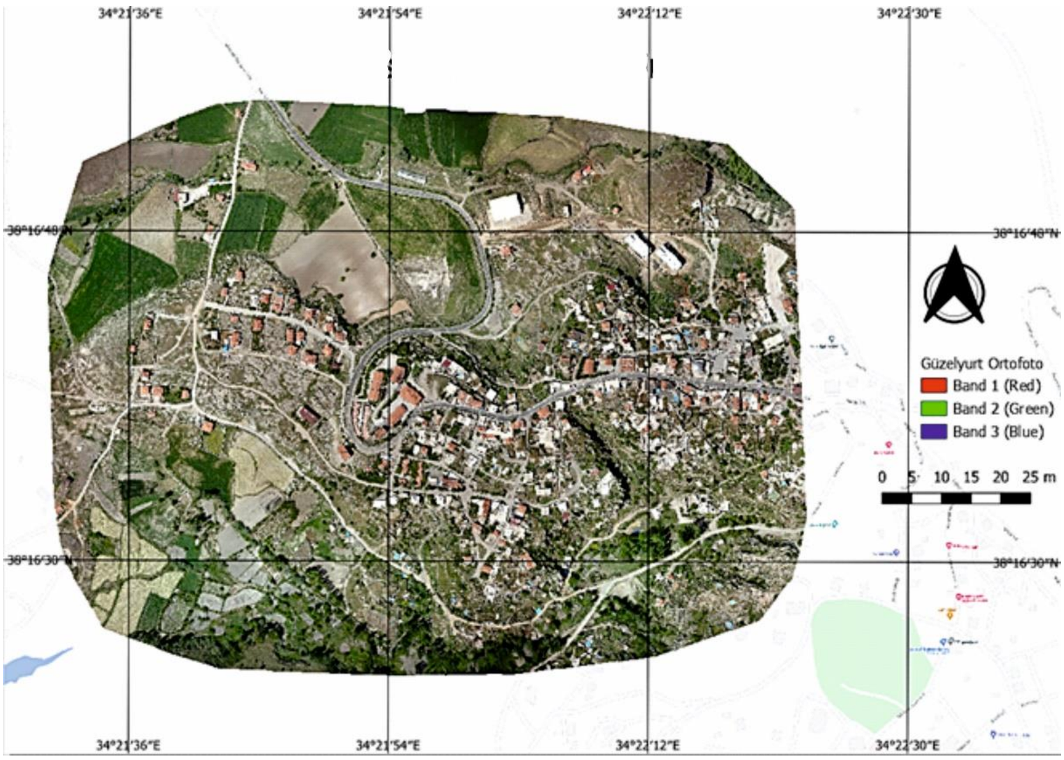

Figure 1. Study area

2.2. Materials

The eBee Rtk model was used as an unmanned aerial vehicle in the field studies. The technical specifications of the UAV used in this study are given in Table 1. The general processing steps used in the Pix4D program are given in Figure 3. GCP values collected on the land, aerial photographs recorded with the UAV, and UAV flight orientation parameters were transferred to the computer environment.

Table 1. Properties of eBee Rtk

Property	Value
Wieght with camera	Nearly 0,73 kg
Wing span	96 cm
Equipment	Composite material
Motor	160 W DC motor
GNSS/RTK receiver	L1/L2, GPS & GLONASS
Battery	11.1 V, 2150 mAh
Maksimum flight time	40 minutes
Flight speed	40-90 km/s
Radyo link distance	3 km
Maksimum wind speed	45 km/h
Landing accuracy	5 m
3D software	Menci, Pix4D Mapper

3. Results and discussion

In this study, the flight plan was carried out in the east-west direction as four lines. Approximately 30 minutes of flight were performed from an altitude of 150 meters along these four lines. Pictures of the terrain were taken with the help of a multispectral camera mounted on the UAV and 166 terrain images were recorded on this flight.

After the field studies were completed, the obtained images were transferred into the computer environment. First of all, 166 pictures representing the land were calibrated in the Pix4D program. Ground control point (GCP) was introduced into the program and the balance of the pictures was ensured using this GCP. In the Pix4D program, these 166 pictures were used for stabilization. As a result of the calibrating processes, the pictures were balanced by 100%. In the second process step, point cloud data with LAS extension was obtained from the stabilized pictures and Digital Terrain Model (DTM) data was obtained. Orthophotos were produced using point cloud data and DTM data. GCP and detail points taken by GPS were compared with the dense point cloud data produced in the Pix4D program. Coordinate differences taken from the dense point cloud with GCP were calculated as my=1.2 cm position error in Y direction, position error in X direction mx=2.4 cm and position error in Z direction as mz=4 cm.

The images taken with the help of UAV in the study area were transferred into the Pix4D program. Combining the photos, balancing the photos according to the GCPs, generating the dense point cloud data, creating the digital terrain model and producing the orthophoto data using these data were performed in the Pix4D program.

After the photos are matched, the result of the balancing process is shown in Figure 2. As a result of photo stabilization, DTM, DEM and orthophoto were produced.

The fact that the roof of the buildings is perceived as the floor of the building while producing the base map from the photographs is among the disadvantages of the photogrammetric method. "Unmanned Aerial Vehicle Instruction-SHT-UAV" flight permit procedures should be done in residential areas where there is a settlement, and pilot capabilities should be developed in order to prevent possible accidents. Camera selection should be made in accordance with the purpose of the study. Since rainy and foggy weather will not allow photographing, the flight should be planned considering the weather conditions. In addition, investigating the presence of signal cutting devices in the work area will prevent financial losses that may occur as a result of a possible UAV accident.

4. Conclusion

In this study, the flight was carried out in an area of approximately 110 hectares in the Güzelyurt District of Aksaray Province. The eBee Rtk model was used as an unmanned aerial vehicle. In this flight plan, a flight was carried out from a height of 150 meters for 30 minutes and as a result of the flight, 166 pictures of the terrain were taken.

The pictures taken with the camera mounted on the UAV were combined using the Pix4D software and the pictures were stabilized with the help of GCP. Dense point clouds with LAS extension and DEM were generated in the Pix4D program. By using dense point cloud data DEM data and orthophoto were obtained. On the other hand, the production of the base map with the UAV allows the production of the base map with high spatial accuracy at a lower cost compared to the collection of other data. CCP designing in the field and flight operations took less time than terrestrial methods. In areas that are difficult to reach by local methods, the base map production with the use of UAV in regions such as mountainous regions or coastlines shows the advantage of the system.

Considering the spatial accuracy of the data produced by the UAV, it is predicted that it can be used as an alternative to the litters produced by terrestrial methods in the coming years.

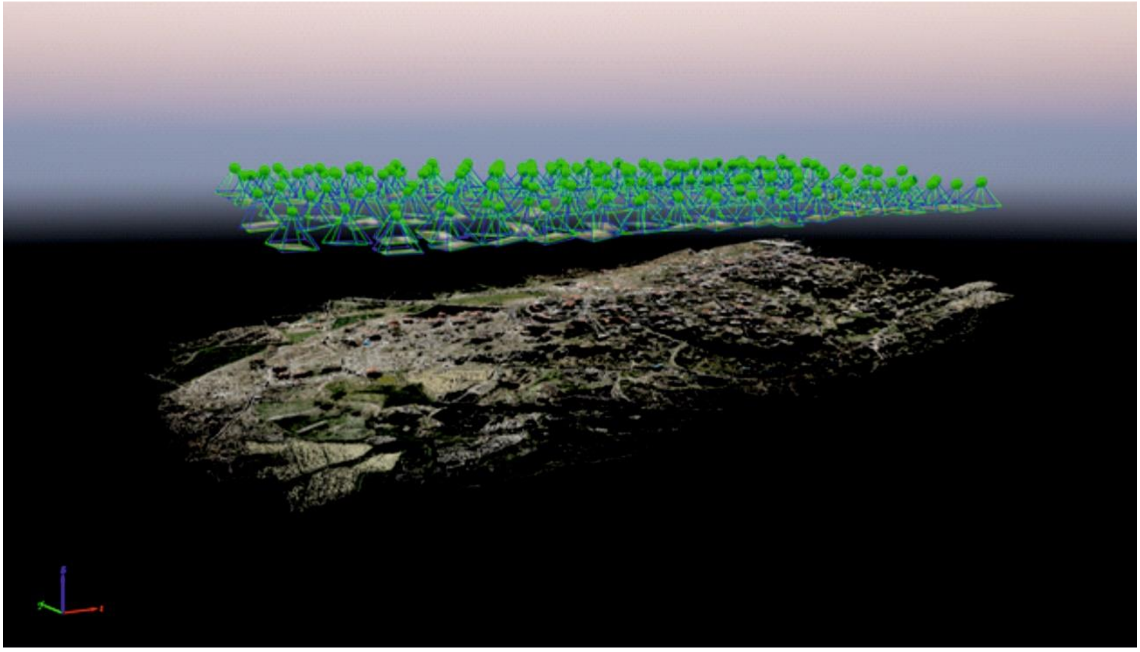

Figure 2. Balance operation in Pix4D

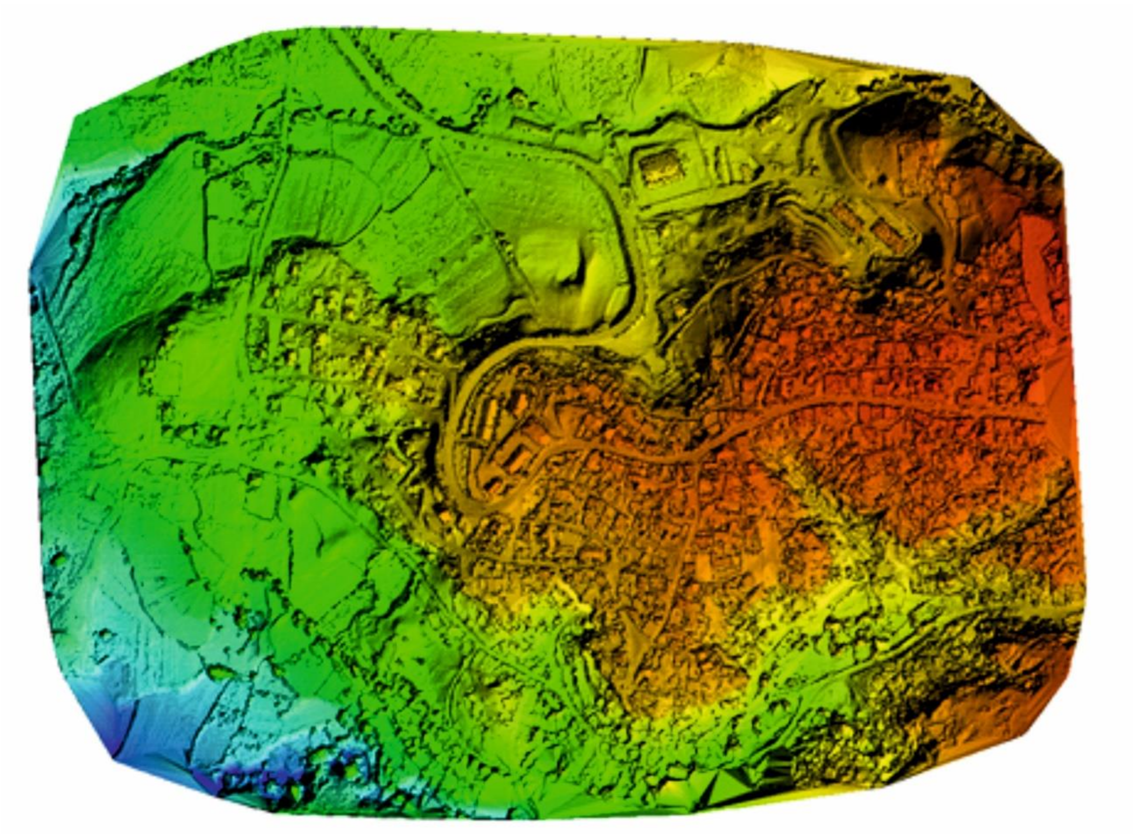

Figure 3. Digital elevation map

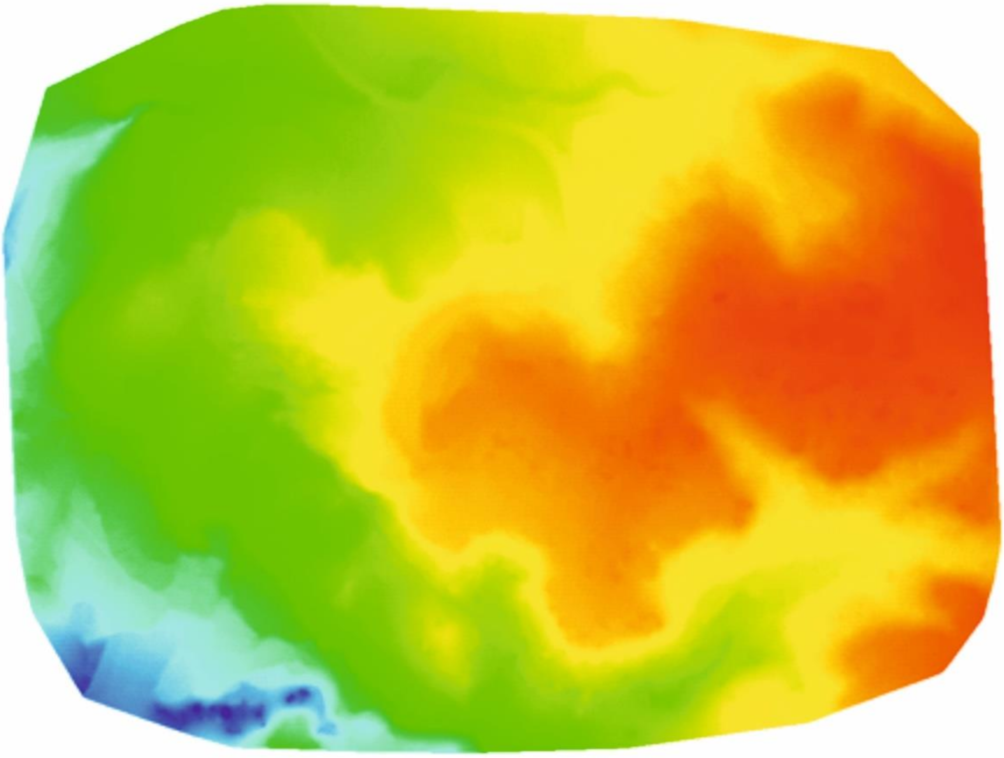

Figure 4. Digital surface map

Figure 5. Orthophoto

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Author contributions

Efdal Kaya: Conceptualization, Methodology, Software, Data curation, Writing-Original draft preparation, Software. **Müjdet Güngör:** Visualization, Investigation, Validation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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