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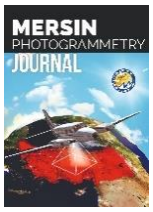

The use of unmanned aerial vehicle (UAV) data in village development plans: A case study of Aksaray Yaylak Village

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Abstract

With the increasing population, the problem of people's need for shelter has also emerged. In many settlements, structures were built without the necessary planning. Three-dimensional (3D) models of these lands should be created in order to make land management plans. Technological improvements in remote sensing have made easier the terrain modelling. To make a better land management plan of rural areas, we need high resolution maps. Unmanned aerial vehicle (UAV) is one of the methods in map production, which can obtain spatial data with high accuracy. In this study, we created 3D model of Yaylak village located in Aksaray District using UAV Photogrammetry. We created high resolution Digital Surface Map and orthophoto map of the village using the pictures obtained from e-Bee. Using these maps, the administrator of the region will decide healthy decision. This study shows us UAV can be used in preparing the necessary maps for designing the settlement area.

1. Introduction

Turkey is a country whose population is increasing every year. The needs of this growing population are also increasing. The need for shelter is one of them. In many regions, rapid construction was carried out in order to provide housing to the rapidly increasing population as soon as possible. This situation has led to the construction of buildings without making the necessary plans in a healthy way. Today, we see the consequences of not making a healthy plan in the past. Disruptions in infrastructure services, narrow roads in transportation and various problems in land use draw attention.

The development of technology has caused the peaceful life in countries with high civilization level to be known by the people in the village. This situation has led to an increase in the demands and studies have started to bring the village life to a better quality. In order to carry out these studies, the three-dimensional (3D) model of the land must be seen in the computer environment. It is not an easy task to prepare map of the wide terrain as it requires long field survey. UAV has made survey engineers life easier [1]. Using a UAV has many advantages as it is time-consuming and allows high accuracy in modelling the terrain [2]. The camera mounted on the UAV provides high resolution pictures [3]. Spatial data can be obtained using UAV with high precision and accuracy.

Classical photogrammetry techniques have some accuracy problems in large areas. Advances in remote sensing technology overcomes this problem. UAVs are economical, easy to use and practical in steep terrain [4]. Therefore, in the last two decades, UAV has been used in engineering projects frequently. Rockfall [5], landslide [6], cultural heritage [7], material deterioration [8] and terrain modelling [9-10] are the main topics which used UAV photogrammetry.

In Turkey, most village sites are poorly organized. When people found a place to construct a one-story house, they build the house without any management plan. Randomly designed buildings cause too many problems. In this study, we tried to create the actual orthophoto and DSM of a village site located in Aksaray district, Turkey (Figure 1). To generate modern settlement areas, mapping the terrain is a very important task.

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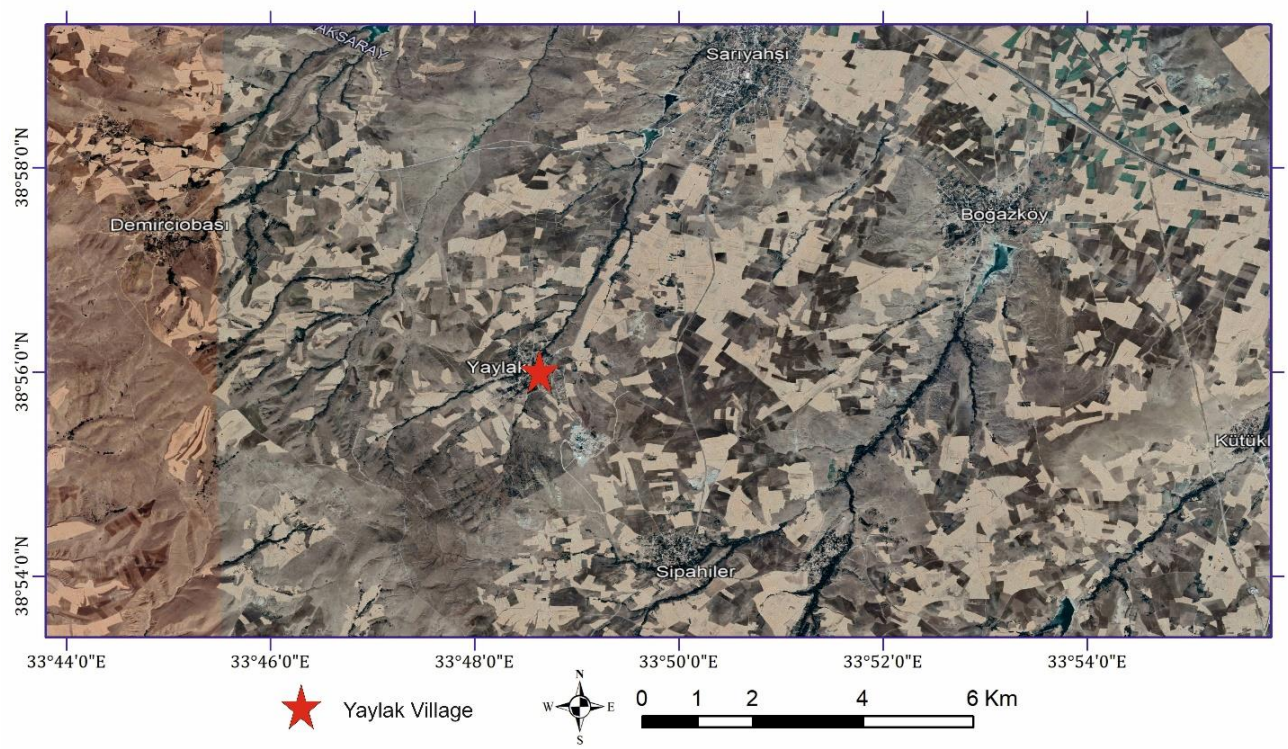

Figure 1. Location map of study map

2. Method

In order to create the risk management plan of the village site, high resolution maps are needed. One of the methods adopted in order to obtain the spatial data needed in recent years is the use of UAVs. UAV photogrammetry enables us to create the necessary maps in a short time. The software used in processing the pictures is improving.

With the photogrammetry technique, we can create 3D models of objects without touching them and without causing any damage to them. Terrestrial photogrammetry is a time-consuming method. Airborne photogrammetry is very useful when compared to terrestrial photogrammetry.

Turkey has very rough terrains due to its geographical location and geomorphological features. This situation both causes many natural disasters and prevents the settlement plans to be made in a healthy way.

In this study, we used eBee SenseFly with real-time kinematic positioning feature (Figure 2) to model the terrain. We prepared the flight mission and get the pictures. A wide area covering 2.7824 km^2 has been modelled using 814 pictures. Average ground sampling distance was 2.88 cm. We used Pix4D Mapper to produce models in a short time.

UAV photogrammetry enables the engineer's duty as it can gather data from terrain in a short time.

The lower the flight is made in UAV photogrammetry, the clearer the model will be. Since the e-bee has a high camera resolution, this problem has disappeared. The lower the flight height, the higher the number of images.

Structure from motion (SfM) algorithm creates 3D modelling of the terrain from 2D pictures. This algorithm creates a model of the terrain by finding common points on consecutive pictures. The results of processing options are given in Table 1.

The results of DSM, orthomosaic and index details are given in Table 2.

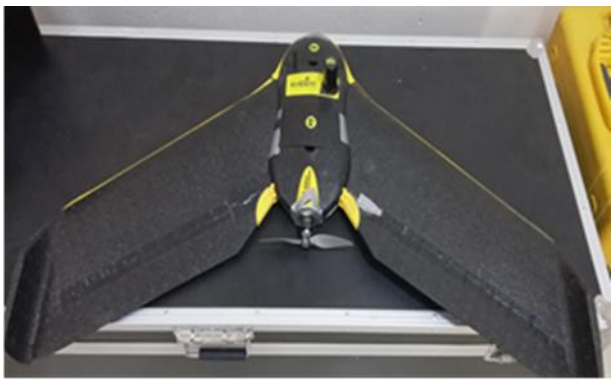

Figure 2. eBee SenseFly

Table 1. Processing options

Property	Value
Image Scale	multiscale, 1/2 (Half image size, Default)
Point Density	Optimal
Minimum Number of Matches	3
3D Textured Mesh Generation	yes
3D Textured Mesh Settings	Resolution: Medium Resolution (default) Color Balancing: no
LOD	LOD Generated: no
Advanced: 3D Textured Mesh Settings	Advanced: 3D Textured Mesh Settings Sample Density Divider: 1
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Time for Point Cloud Densification	04h:35m:46s
Time for 3D Textured Mesh Generation	01h:04m:31s

Table 2. Index details

Property	Value
DSM and Orthomosaic Resolution	1 x GSD (2.88 [cm/pixel])
DSM Filters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp
Raster DSM	Generated: yes Method: Inverse Distance Weighting Merge Tiles: yes
Orthomosaic	Generated: yes Merge Tiles: yes GeoTIFF Without Transparency: no Google Maps Tiles and KML: no
Grid DSM	Generated: yes, Spacing [cm]: 100
Time for DSM Generation	02h:12m:37s
Time for Orthomosaic Generation	05h:19m:50s

3. Results and Discussion

UAV technology and applications are increasingly used by organizations and academic society in the last decade.

Rural areas are surrounded by high mountains. This causes too many problems. UAV photogrammetry makes people's lives easier. 3D modeling of the land in high resolution provides great convenience to decision makers. The more detailed data we can see comfortably in the computer environment, the healthier we can make decisions. UAV technology allows us to prepare a 3D model of the terrain in high resolution. Completing both the field work and the modeling process in a short time is the most important reason for us to use UAV technology.

As a result of this study, Digital Surface Map (DSM) (Figure 3) and orthophoto (Figure 4) were produced in high resolution. DSM will show us the slope structure of the land and the water flow network.

Laser scanning method is also used in terrain modeling. Terrain models using airborne lidar have emerged in recent years. The fact that this method is expensive and the fieldwork and modeling processes are difficult and long makes it not preferred. Satellite image modelling is also an important element in terrain modelling. However, it is very expensive when compared to UAV technology.

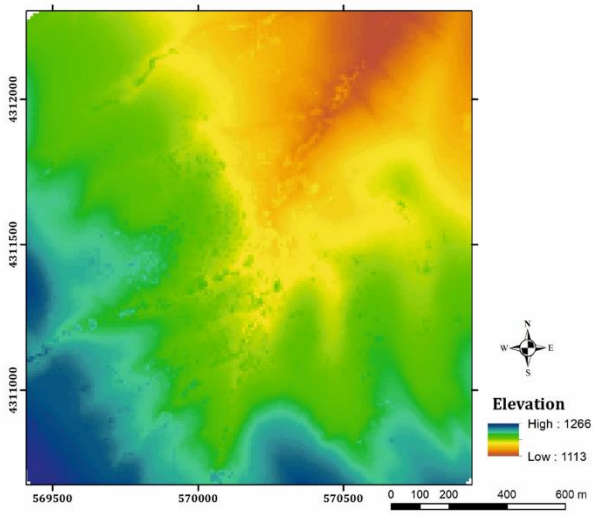

Figure 3. DSM

Figure 4. Orthophoto

4. Conclusion

In this study, we modelled a village using UAV technology with high resolution. We have quickly modeled a large terrain using 814 pictures. The development of technology has made our lives easier. A large database has been created for managers. A very high-quality data set has been created that can be used in making decisions that will increase people's quality of life. It will be possible to find solutions to the problems by using scientific methods in the village settlement. A high-quality land management plan can be prepared.

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Author contributions

Hacı Murat Yılmaz: Conceptualization, Methodology, Software **Nusret Aktan:** Data curation, Writing-Original draft preparation, Software, Validation. **Adem Çolak:** Visualization, Investigation, Writing-Reviewing and Editing. **Aydın Alptekin:** Reviewing, Editing

Conflicts of interest

The authors declare no conflicts of interest.

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