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Production of orthophoto by UAV data: Yaprakhisar example

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Abstract

Unmanned aerial vehicles (UAV) are used in many areas today. It has an intensive usage area especially in the discipline of surveying engineering. Undoubtedly, UAV is the new favorite tool of photogrammetric methods, which is one of the map production methods of survey engineering, which is intertwined with technology. Due to its ease of use, time saving and sufficient accuracy, the UAV has found a place in the field of aerial photogrammetry in a short time in small and medium-sized fields. In this study, orthophoto map of Yaprakhisar village of Aksaray province was produced using UAV data. eBee SenseFlay was used in the study. The obtained orthophoto and real field data were compared. It has been observed that the results are of sufficient accuracy.

1. Introduction

Unmanned aerial vehicles (UAV) systems and applications are increasingly used by many institutions, organizations, commercial enterprises and academic circles for different purposes. In parallel with the increase in land use, management and monitoring studies, the need for location-based information is constantly increasing day by day. By using modern terrestrial, air and satellite-based technologies, the data needed together with Geographic Information Systems are collected, analyzed and results can be presented in various ways more quickly and accurately than ever before [1].

One of the methods adopted in order to obtain the spatial data needed in recent years is the use of UAVs. A UAV is a vehicle that can move automatically or semi-automatically depending on a flight plan, or is flown by remote control by a pilot on the ground or in another vehicle. UAV-based data collection and mapping can provide sufficient accuracy needed in many fields, especially agriculture, forestry, urban planning, geology and disaster management.

Depending on the carrying capacity and features of the UAV platform, it can be equipped with video cameras, thermal or infrared camera systems, multispectral cameras, LiDAR sensors or a combination of these technologies. In addition, the UAV may include GNSS/INS (Global Navigation Satellite System/Inertial Navigation System) system, barometric altimeter and compass systems. Such an integrated system is often referred to as an Unmanned Aerial Vehicle System (ISP).

There are various methods such as Global Positioning Systems (GPS), terrestrial geodetic surveys, LIDAR, terrestrial laser scanner, conventional aircraft, photogrammetry and remote sensing that produce location-based data. It is a technology that can produce accurate and sensitive data based on location in UAV. UAVs will be the most important data source generating data for many disciplines in the future [2].

UAVs are vehicles that can fly continuously automatically or semi-automatically according to aerodynamic flight principles, and move without a flight crew (pilot). The UAV can fly in remotely controlled, semi-automatic or fully automatic techniques and can carry cameras, sensors, communication equipment or other equipment. UAVs

have a much smaller structure than conventional manned aircraft, so they are much easier and more economical to transport [3]. On the other hand, real-time kinematics (RTK) positioning systems can be attached to UAVs, and thus images with more precise location information can be obtained.

A three-dimensional (3D) model should be used in applications such as virtual reality, communication, and automatic orientation. For example, during industry quality assessment, it is important to create a 3D model of buildings before and after a disaster, in tourism, architecture and 3D urban planning. In such studies, UAVs are used very effectively and efficiently [4].

Images obtained with high sensitivity in very low flight using UAVs can be produced at a lower cost than images obtained from conventional aerial photogrammetry [5]. The maps, which are formed as a result of processing the aerial photographs obtained by the photogrammetric method by eliminating the optical errors and containing the three-dimensional coordinate information, are called orthophoto maps. Measurements can be taken and drawings can be made on these maps.

In the literature, it is seen that the location accuracy can reach up to ±2 cm depending on the region, especially in orthophoto maps created from aerial photographs taken from UAVs with GPS with RTK feature. Orthophoto maps have richer detail and visual information than linear maps. With UAV technologies, production in small and medium-sized fields can be done more easily, quickly and with sufficient accuracy. It is one of the indispensable bases for many professional disciplines. In this study, the orthophoto map of the region and a 3D settlement model were obtained with the application made in Yaprakhisar village of Aksaray province and carried out with the UAV.

2. Unmanned Aerial Vehicles

For the first time in history, an unmanned vehicle was used in a military incident, which was recorded as the first unmanned aerial attack. This event happened in 1849, when the Austrians sent explosive -filled unmanned balloons to Venice, Italy. The development and production of aircraft with the aim of flying truly remotely, that is, unmanned, coincides with the First World War for the first time. Here, Unmanned Aerial Vehicles, which are defined as flying vehicles that do not contain humans and can be controlled from the ground thanks to a communication system. In short, UAVs, came into active use especially after the Second World War [6].

UAVs provides a great advantage over normal aircraft due to its low production, purchasing, fuel and flight costs [7-8]. More importantly, these vehicles do not pose a risk of injury or loss of life during the mission, as they are uncrewed. For the same reason, they are lighter than conventional aircraft and can stay in the air longer with the same amount of fuel [9].

On the other hand, the disadvantages for UAVs are that their danger perception ability is not as strong as a human, that they can pose a danger if the ground control connection is broken, and that they are vulnerable to air attacks by manned aircraft. However, these disadvantages are tried to be minimized with R&D activities in data transfer and artificial intelligence technologies. On the other hand, further increasing the flight times will allow these vehicles to be used widely in the near future [10].

Uysal et al [11] aimed to produce the Digital Terrain Model (DTM) of the Şahitler Kayası Höyük using UAV photogrammetric techniques and to perform an accuracy analysis on an area of approximately 5 ha in the Şahitler Kayası location in the center of Afyonkarahisar. In their study, they established a total of 27 GCPs in the application area, 5 homogeneously, and obtained the coordinates of GCPs in ITRF96 datum by RTK method with Stonex S9 GNSS (Global Navigation Satellite Systems - Global Positioning Satellite Systems) device. Images were captured from an average height of 60 m with the Canon EOS digital camera on the UAV. As a result of their study, they evaluated the accuracy of the DTM with 30 control points and determined a vertical sensitivity of 6.62 cm. They stated that the usage of UAVs and photogrammetric techniques together will make significant contributions to the work done in this field in terms of accuracy, speed, cost and product diversity.

Şenol and Kaya [12] stated that in order to create a 3D model, a field study of the model should be done. In order to create a 3D model of a structure, they added data collection with UAV to their data collection methods. They wanted to minimize the field work with the data collection methods, and for this purpose, they were able to collect data without the need for field work. In addition, they informed that models can be created with various software from images of UAV, terrestrial and rough areas.

Unmanned aerial vehicles are divided into groups according to their various features and usage purposes. The most important reason for this grouping is to see if UAVs are suitable for the projects they are used in, in terms of purpose and features.

UAV and its applications have started to be used in many areas today. Although the first use of the UAV, which provides general convenience in every area it is used, was for military purposes, it has spread to a wide range from hobby use to project and analysis purposes. Some of the usage areas are obtaining digital terrain models, digital elevation models, digital surface models, city maps, geographic information system, land information system, three-dimensional model creation. Pond volume determination [13], landslide site [14-16], rockfall site [17], cultural heritage modelling [18-24] and soil erosion [25] are the most used ones.

3. Application

Yaprakhisar village of Aksaray province was chosen as the application area (Figure 1). The eBee SenseFly with real-time kinematic positioning feature was used in the study (Figure 2). 709 pictures were taken with a camera with 18.2 Mpixel resolution at 6.01 cm ground sampling interval. Orthophoto maps were produced by evaluating the pictures in the PIX4D mapper program. In addition, dense point cloud, digital elevation model and digital terrain model of the study area were produced. The products obtained are shown in figures 3, 4, 5, 6, 7 and 8. Accuracy analyzes were made with the help of the points measured on the obtained orthophoto and in the field.

Figure 1. Study area

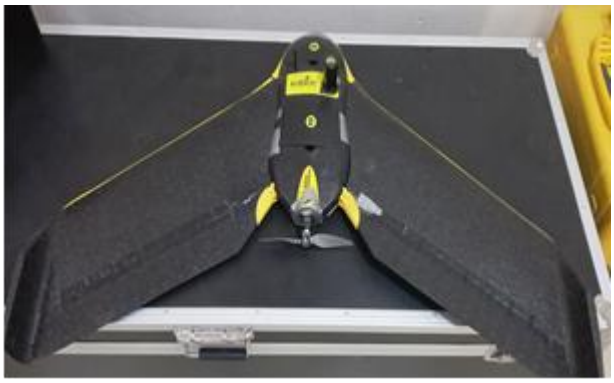

Figure 2. eBee SenseFly

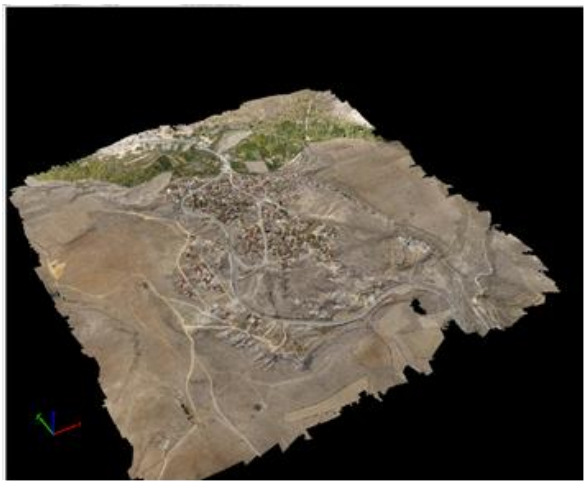

Figure 3. Dense Point Cloud

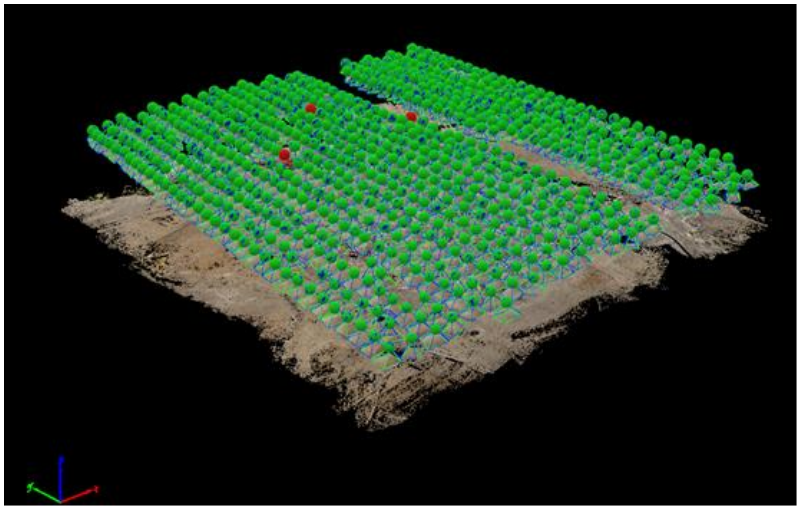

Figure 4. Picture locations

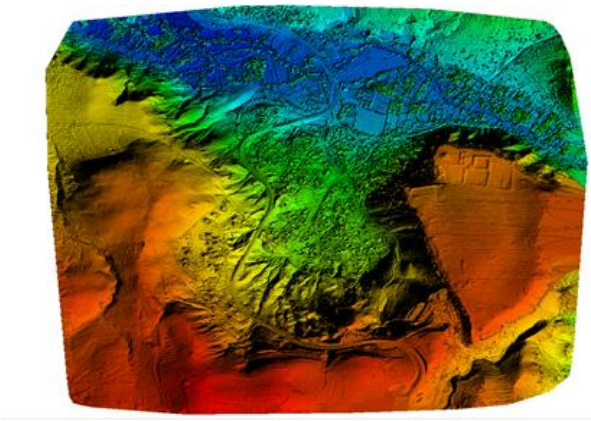

Figure 5. Digital Terrain Map

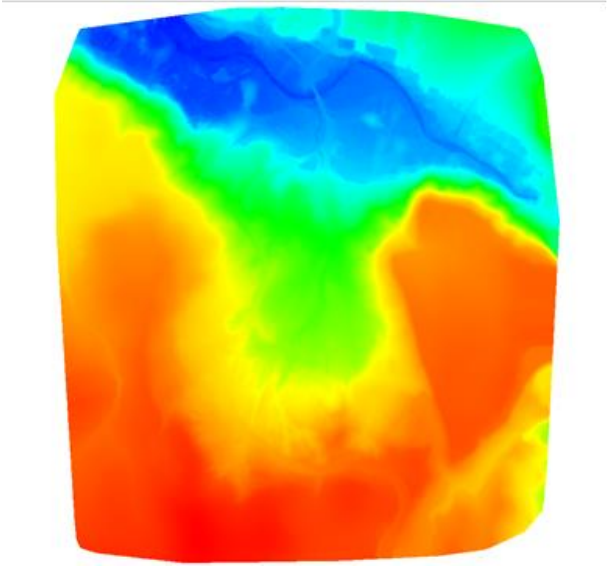

Figure 6. Digital Surface Map

Figure 7. Orthophoto

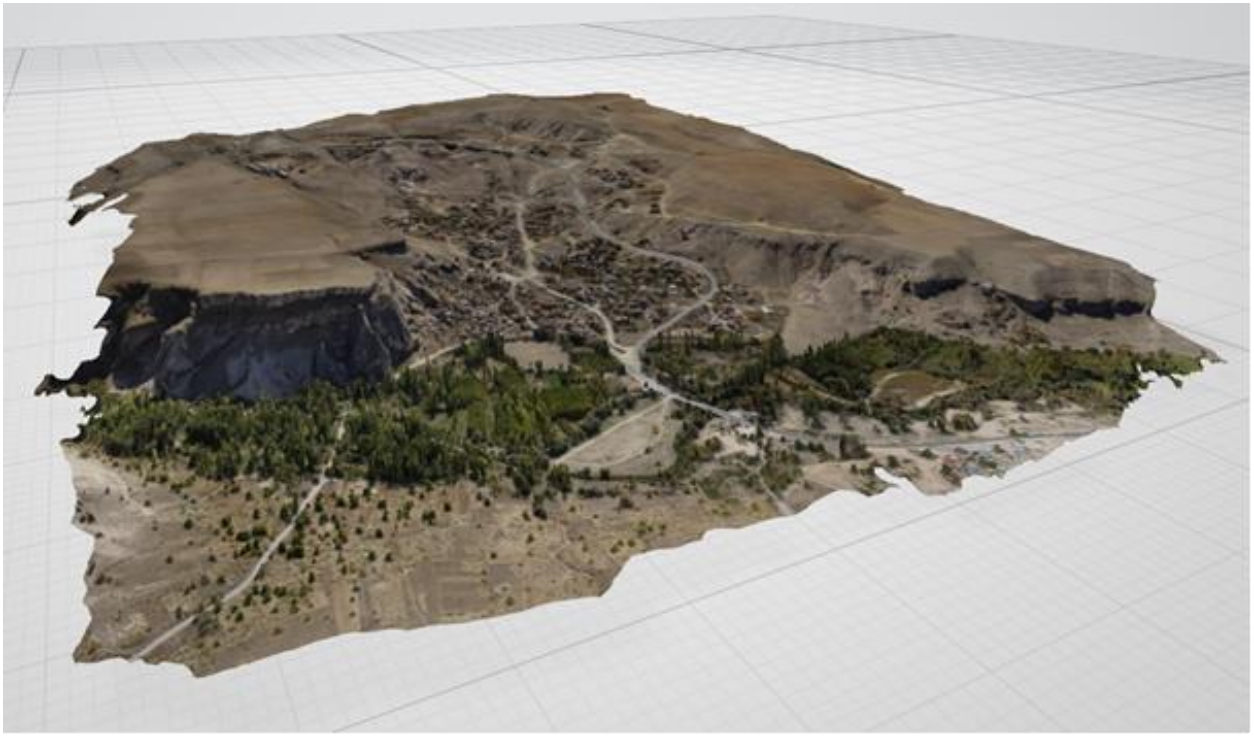

Figure 8. 3D Model of the study area

4. Results

An area of 3.2246 km^2 was used in the study. After block balancing, the mean square error was 1.392 cm. In the control measurements made at the detail points, it was determined that mx= 1.467 cm, my= 1.467 cm, mz= 2.739 cm. Due to the high difference in height in the study area, the height error was higher than the position errors. In addition, a detail overlay was made on the orthophoto map obtained from the study area and the existing map and it was seen that the results were quite sufficient (Figure 9 and Figure 10).

Figure 9. Detail overlay on the produced orthophoto and the existing map

Figure 10. Close view of the detail point

5. Conclusion

In this study, orthophoto map, three-dimensional model, digital terrain model and digital elevation models of Yaprakhisar village of Aksaray province were obtained. As a result of the study, it was revealed that the orthophoto map produced was of sufficient accuracy as stated in the literature, and the detail overlapping made with the existing existing map produced by the geodetic method of the study area. UAV is successfully applied in obtaining spatial and visual data that will be required for many engineering projects. In addition, many disciplines are able to obtain the necessary data and make the necessary analyzes and planning in appropriate accuracy, time and cost-effective studies with UAV data.

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Author contributions:

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

Conflicts of interest

The authors declare no conflicts of interest.

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