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Investigation of the effect of UAV flight altitude in map production

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Abstract

Unmanned Aerial Vehicles (UAVs) are used in many areas because of their low cost and high resolution. Although the existing maps obtained from classical measurements meet sufficient accuracy, they are no longer preferred because they require a lot of time. On the other hand, UAVs are effectively used in base map production thanks to their high spatial resolution and location accuracy. In this study, orthophotos were produced using UAV images obtained from different flight altitudes (50, 80 and 120 meters). The level of detail was determined by comparing the produced orthophotos with the observations made on the land. In addition, position accuracies at different heights were determined. In order to increase location accuracy, Ground Control Points (GCP) have been established homogeneously distributed over the land. As a result of the study, it was seen that low-altitude flights show higher levels of detail and provide greater location accuracy. However, less area was visualized in low-altitude flights. In high-altitude flights, it has been observed that large buildings can be easily viewed, but small objects cannot be detected. At the end of the study, it was seen that a more sensitive base map is produced when the vector drawings obtained from high-altitude and low-altitude flights are combined.

1. Introduction

Unmanned Aerial Vehicles (UAVs), which are increasingly used in recent years, are physically non-pilot and passengers, can only carry measurement equipment such as camera, laser scanner, GNSS (Global Navigation Satellite System) and can be operated remotely or automatically (Ulvi et al., 2020). Thanks to the cameras placed on the UAVs, measurements can be made in places where people's access is dangerous. Altought UAVs find a field of use in almost every sector, they are also widely used in the land surveying sector (Kaya et al., 2021; Şenol et al., 2020). It is widely used in the production of the base map, digital terrain model (DTM), digital elevation model (DEM), and area and volume calculations in projects where excavation-filling works are carried out. The use of UAVs in land surveying processes is more advantageous than other remote sensing platforms due to their low cost and higher spatial and temporal resolution, so they are more advantageous to be used in small-scale projects (Özcan, 2017). The most important issue in the base map production with UAV is the level of detail on the map. Accordingly, as the flight altitude increases, the level of detail decreases, and as the flight altitude decreases, the level of detail increases. On the other hand, the increase in flight altitude allows less battery usage and more area to be viewed in a single flight.

Özcan (2017) compared position accuracies in DTM and DEM production using UAV images taken from different heights. Ozturk et al. (2017), the effect of images obtained with different heights and camera angles on the position accuracy of the images; Hastaoğlu et al. (2021), on the other hand, investigated the effects of different focal lengths on position accuracy.

In this study, the detail levels obtained from UAV images obtained from different flight altitudes were compared.

2. Method

As the study area, Şanlıurfa province, Harran University Osmanbey campus, Engineering Faculty area was chosen (Fig. 1).

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DJI Mavic 2 Pro Unmanned Aerial Vehicle was used in the study area. The UAV equipment used and their features are given in Table 1. In order to increase the location accuracy of the produced orthophoto, a Ground Control Points (GCPs) was established to be homogeneously distributed over the area. GCP coordinates were measured with Stonex GPS.

Within the scope of land studies, flights were carried out from three different heights as 50, 80 and 120 m (Fig. 2). Orthophotos were produced in Agisoft Photoscan software by using GCPs homogeneously distributed over the area and UAV images. The situation in the land was compared with the obtained orthophoto data. Detail points that are important in the base map production are determined in NETCAD software over orthophoto. The rules of the Large-Scale Map and Map Information Production Regulation (BÖHHBÜY) were taken as basis in the determination of the detail points and the production of the base map.

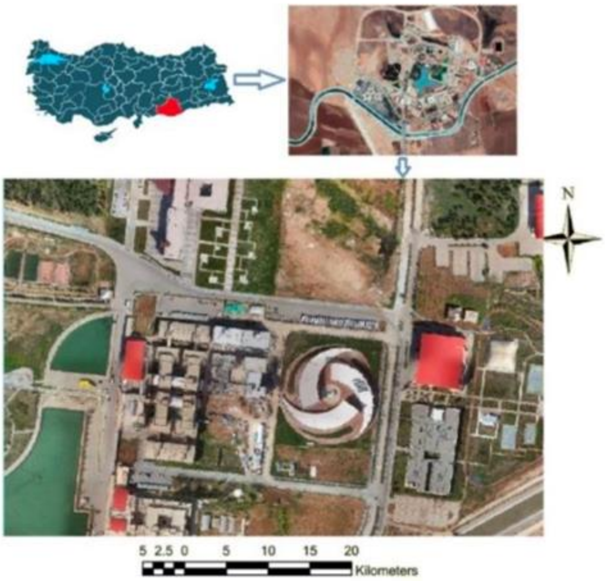

Figure 1. Study area

3. Results

In order to determine the level of detail in the land, analyzes were made on images obtained from three different heights. Detail points determined on the produced orthophotos were digitized in NETCAD software and compared with the observations in the land. It was determined which details were lost as the height level increased. While the roof of the building can be determined in the orthophoto image obtained from 50 meters and 80 meters height, it appears flat over 120 meters (Fig. 3). Stairs can also be identified at 50 and 80 meters but cannot be distinguished at 120 meters (Fig. 4). Small objects such as signage, manhole cover and small stair steps can only be seen on flights with a height of 50 meters (Fig. 5).

Considering the flight altitude and overlap ratios, some buildings can only be seen in flights from 120 meters altitude (Fig. 6).

As seen in Fig. 3-6, flight altitude is an important factor in perceiving details. Flights from a height of 50 meters gave better detail but could not detect some building corners. In flights made from a height of 120 meters, all the buildings were easily viewed, but small objects could not be distinguished. Base maps to be done by combining details obtained from different flight altitudes of an area give more accurate results. In Figure 7, the vectoral details obtained from three different heights are overlapped to see all the details.

Figure 2. View of the study area from different heights

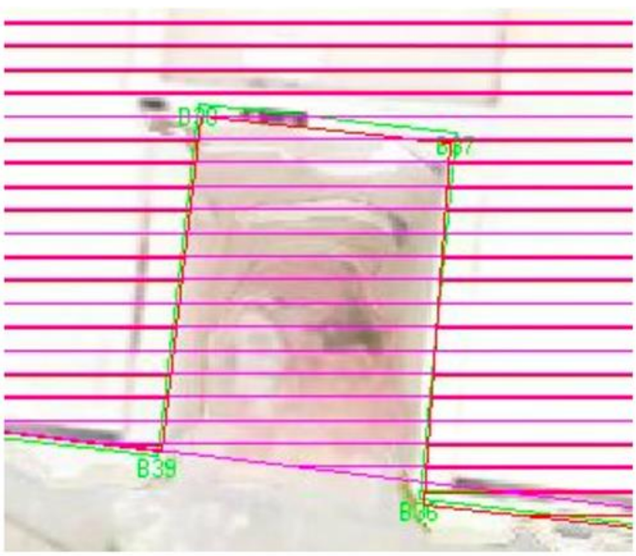

Figure 3. Building roof distinguishable from 50 and 80 meters

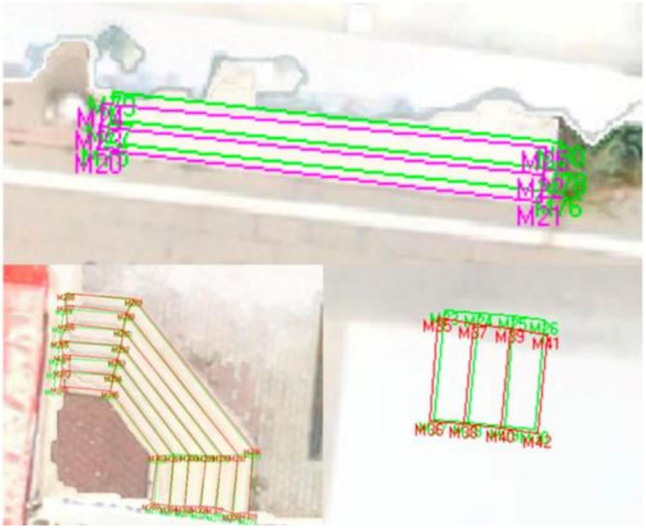

Figure 4. Stairs indistinguishable from 120 meters altitude

Figure 5. Stair steps that can only be distinguished from 50 meters altitude

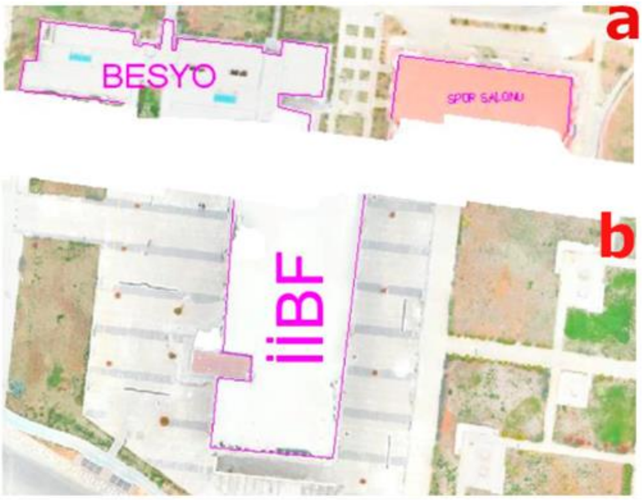

Figure 6. (a) missing building corners at 50 meters height, (b) building visible from 120 meters

Figure 7. Combination of different details

The measurements taken from different parts of the land were compared with the measurements obtained from three different heights. The smallest amount of slip between points is 2.2 cm and the largest amount of slip is 19.4 cm. The amount of slip at all points is 6.9 cm on average.

4. Conclusion

UAV images are unquestionably advantageous for create base map. It is used in many studies because its temporal and spatial resolution is very high compared to other remote sensing platforms and its cost is low. In this study, orthophoto production was performed on UAV images obtained from different heights. Depending on the flight altitude, detectable detail levels were determined and position errors at different altitudes were determined. If the flight altitude was 120 meters, more area was displayed, but small details could not be detected. Details from different heights were combined to obtain more detail. Position accuracies vary between 2.2 cm and 19.4 cm depending on height. The average position accuracy is 6.9 cm.

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