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# Extraction of building areas with the use of unmanned aerial vehicles, calculation of building roof slopes

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**Abstract**

Extraction of building areas and calculation of roof slopes is a data set used in many areas such as urbanism, pre-disaster and post-disaster situation, city information systems, urban transformation, infrastructure, etc. The data obtained with the help of unmanned aerial vehicles is used in many sectors and fields. Being fast and economical, sensitive and detailed data production makes unmanned aerial vehicles advantageous. In our study, 540 photographs were taken with a UAV in an area of 75,000 $m^2$, various image processing techniques used in remote sensing and various analysis methods used in geographic information systems, buildings were extracted and roof slopes were classified. In the study, first planning was made for the area, ground control points were established and flights were made. The data obtained after these processes were obtained by photogrammetric methods, point cloud, digital surface model, digital terrain model and normalized digital elevation model and orthophoto data. With the help of orthophoto data with (rgb) red, green and blue bands, vegetation areas were tried to be determined with the help of red green blue vegetation index. In the normalized digital elevation model (ndsm) data obtained from the digital terrain model and the digital elevation model difference, the 3m threshold value was accepted for building detection, and the calculation was made by accepting objects higher than this value as buildings. It was tried to exclude vegetation from the valuation by masking with the help of red green blue vegetation index. After this process, morphology filter was applied on raster data. The generated building data was converted into vectorial data and a point was drawn in the center of the buildings by using orthophoto data for accuracy analysis in the study. It has been determined that there are 729 real buildings in the study area. It has been determined that there are 686 building data produced as vector data. Spatial intersection analysis used in geographic information systems was made from the name of this process. With the help of this intersection analysis, accuracy and precision were determined in the study. In addition to removing the building areas, it is aimed to determine the roof slopes. For this reason, the slope of the roof areas was calculated using the nsdm data. The slope calculation process is classified into 10% sections, and each 10% slope group is included in a class. However, a homogeneous slope data could not be reached due to the day heat, small warehouses and various materials on the roofs. For this reason, using the obtained slope data and the generated vector building data, the most repeated value of the slopes from the roof areas of the building was calculated and accepted as the building roof slope. As a result, the building areas and the slopes of the tents of these buildings were determined with high accuracy.

## 1. Introduction

Unmanned Aerial Vehicles (UAVs), which began to be produced for military purposes, it has become very effective and attractive for photogrammetry in terms of data collection, measurement and modeling when became widespread in civil use [1]. Unmanned aerial vehicles developed for non-military uses are frequently used in areas such as agriculture, mining, construction, natural disaster monitoring, meteorology, archeology, especially cartography [2-4]. Advances in unmanned aerial vehicle (UAV) technologies have made it easier to model engineering projects) [5-6]. UAV photogrammetry method was used to create the 3D point data and solid model [7-8]. Numerous methods are used in modeling processes and photogrammetry is one of these methods that is frequently utilized [9]. Extraction of building areas, determination of their number and roof slope values of buildings are one of the main input layers used in many sectors. It can be obtained with different data and methods. Building data are used building information system, disaster, city administration. In our study, it is aimed to determine the building area and slopes with the UAV data due to the fact that it is fast and economical and easily accessible. Many satellite data are used for extraction building but UAV data are more economic, sensitive and detailed because of this reasons preferred.

Especially in areas such as city management and disaster planning, it is of great importance that the building stock be put forward quickly. There are many academic studies on the extraction of building area whit uav. Automatic building footprint extraction from UAV images neural network [10-11]. Building extraction from UAV remote sensing data based on photogrammetry method, *İsprs, 2017.* Many natural or artificial objects are detected by using different methods and data sets in remote sensing and geographic information systems. Gürbüz and Türker [12] performed automatic tree detection from very high-resolution UAV images with high accuracy by segmentation and classification methods. In remote sensing, there are many studies on the extraction of building areas with the help of satellite images, lidar, aerial photographs [13]. With the help of lidar and aerial photographs, the automatic extraction of building areas was done by classification and segmentation methods. In addition to revealing the building stock, the determination of roof slopes in buildings is an important data set in the fields of energy efficiency, disaster and infrastructure. There are studies in the literature on the determination of roof slopes in buildings [14]. Ransac algorithm helped to extract building planes with Lidar data.

## 2. Study Area

The study was carried out in an area of 75,000 m$^2$ within the borders of Antalya Province Kepez District Waterfall Neighborhood this are including road, building, made human object, three exc. Figure 1 shows the working area.

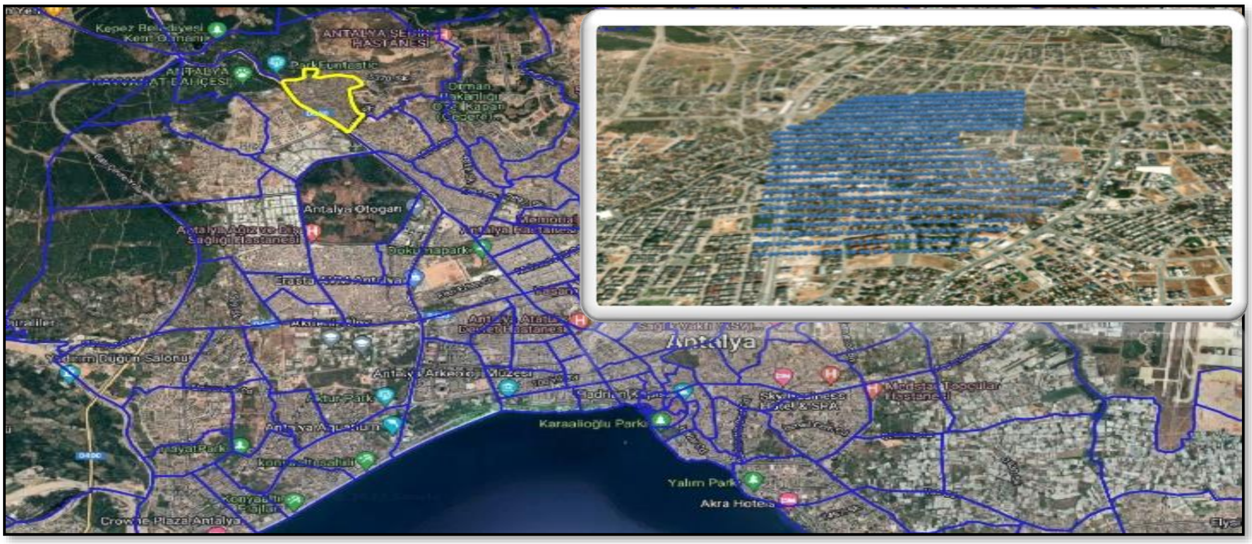
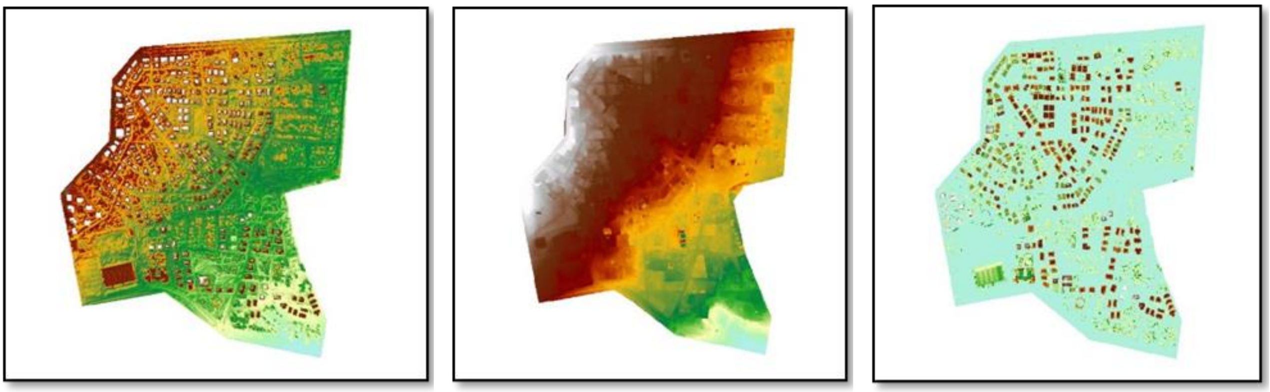



**Figure 1.** Study area.

## 3. Material and Method

In the study area, firstly, drone flight planning was made, ground control points were established, and the coordinates of the Tusaga Active Cors system were precisely measured. Mavic 2 pro unmanned aerial vehicle with 20 mp resolution was used in the study, 540 aerial photographs were taken with 100 meters flight altitude, 80% front 60% side overlap ratio. In the study, a ground sampling distance of 2.76 cm was obtained.

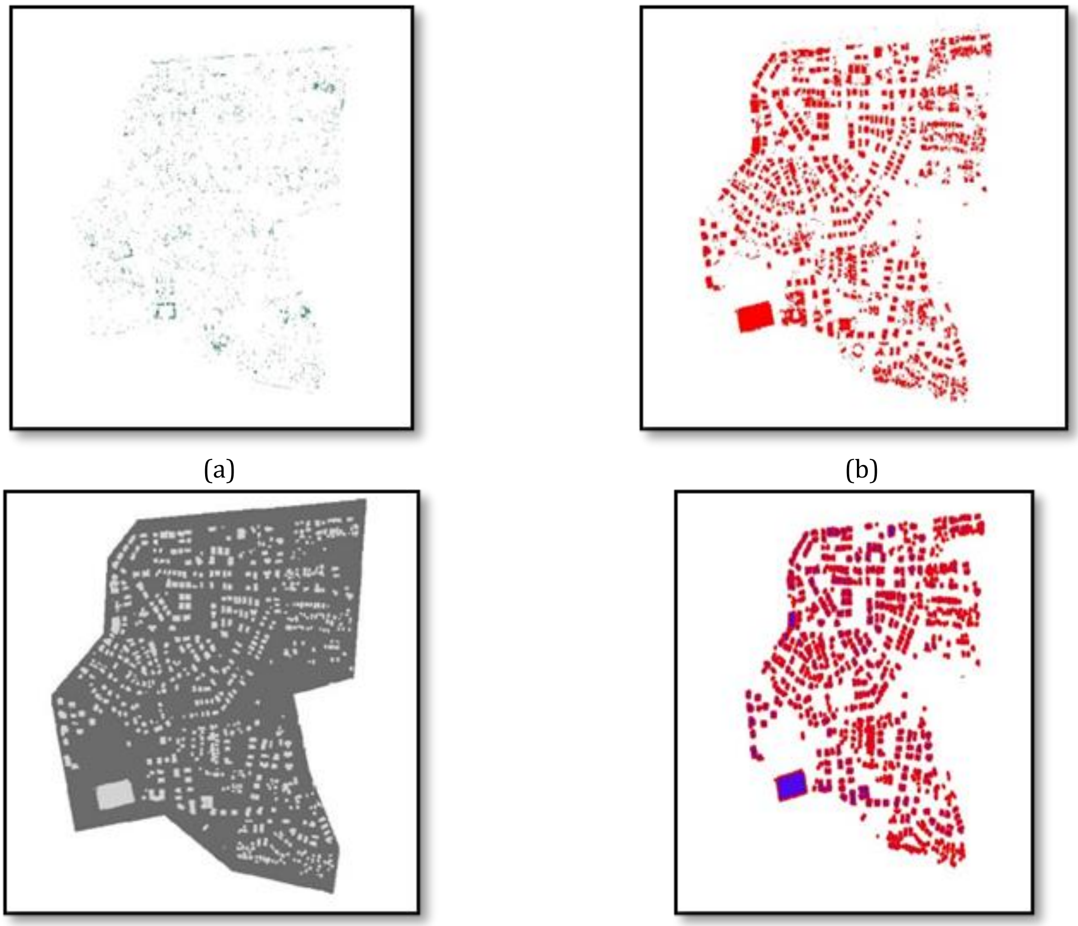
Add 540 photos agisoft software and align photos, orientation with gsp, produced dence cloud, digital elevation (Figure 2b) digital elevation model (dem), (Figure 2a) digital surface models (dsm) and orthophoto (Figure 4a). After produced dsm and dem, difference them obtained normalized digital surface model (ndsm) (Figure 2c). Ndsm data give the object elevation value. Orthophoto data contain rgb value, using orthophoto extract the tree by rgbvi index. Orthophoto used validation, add point center of the building and use it accuracy assessment.



(a) (b) (c)

**Figure 2.** a) DSM, b) DEM, c) NDSM.

With the data, only the details of the objects are obtained. By using orthophoto data with red green and blue bands, the red blue green vegetation index (rbgvi) (Figure 3a) was used to evaluate green trees and trees as buildings. This index has a value range of green red vegetation index -1 to 1, and a similar value is taken as 0.15 for areas where vegetation capacity can be selected. Agapiou [15] tried to determine the vegetation in the land by using different vegetation indexes with unmanned aerial vehicles with three prohibited areas. Vegetation areas are not excluded from the assessment by subjecting them to the normalized digital terrain model, masking with the vegetation dataset. For the deterioration of the building, a value with 3 m intervals was accepted and objects higher than 3 meters were selected with the raster calculator function (Figure 3b). In the generated raster dataset, a morphology filter was applied for the disappearance of non-building lampposts, cars and small trees that could not be detected by the modified green-red vegetation index. Morphology filters were calculated with a 2x2 grid window by choosing the erosion/erosion and dilatation/expansion parameters respectively (Figure 3c). After obtained the raster building data used raster to poly function produce vector building data (Figure 3d).

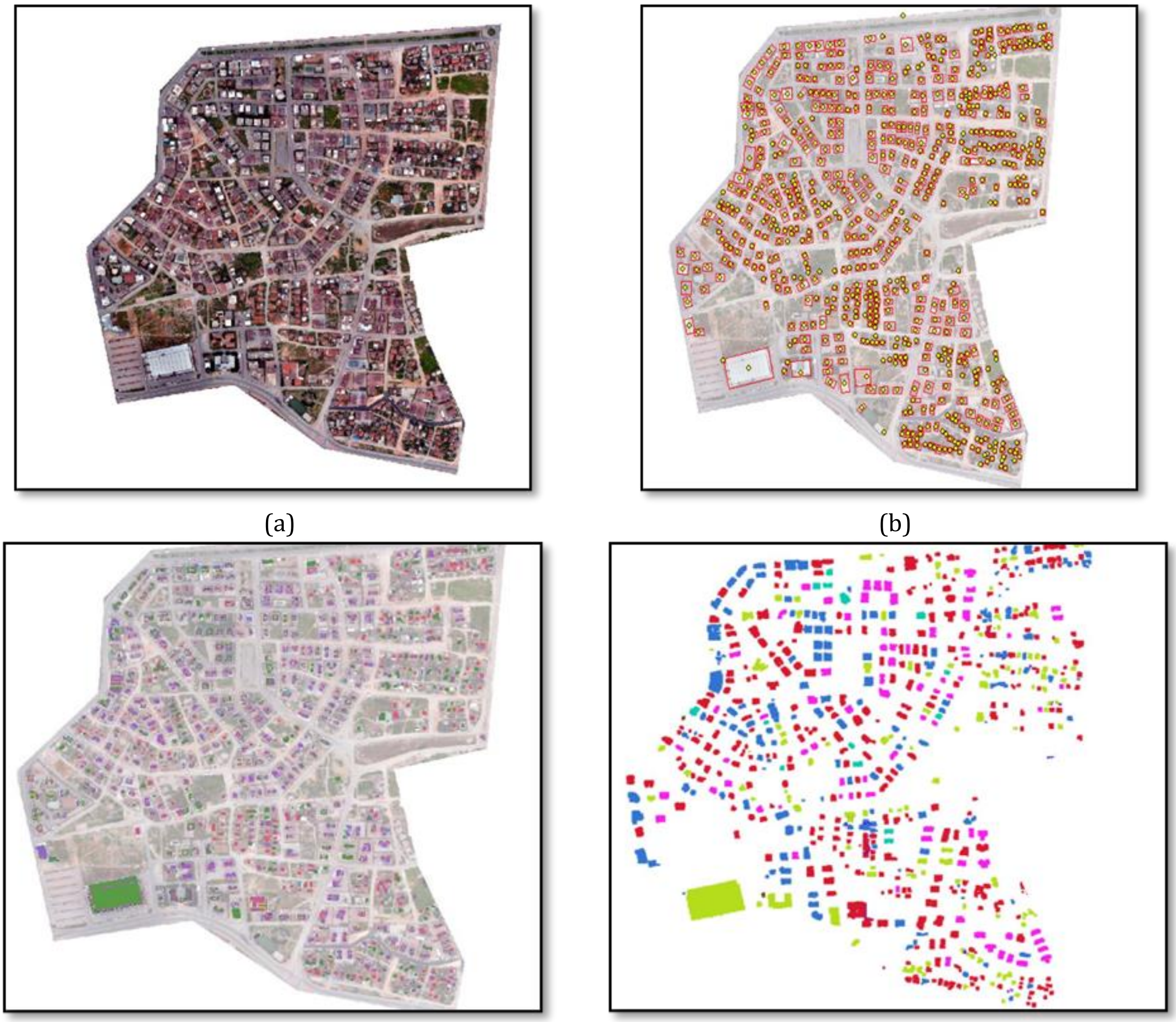


(a) (b)

(c) (d)

**Figure 3.** a) RGBVI, b) raster building data, c) masked and filtered by morphology data, d) vector data.

As seen in Figure 3c in the study, the building data were generated as raster data and used raster to poly function obtained vector building data. For this reason, in our study, it is aimed to determine the roof slopes in addition to the removal of building areas. For this reason, the slope of the roof areas was calculated using the nsdsm data (Figure 4c). The slope calculation process is classified into 10% sections, and each 10% slope group is included in a class (Figure 4d). However, a homogeneous slope data could not be reached due to the day heat, small warehouses and various materials on the roofs. For this reason, using the obtained slope data and the generated vector building (Figure 4b) data, the most repeated value of the slopes from the roof areas of the building was calculated and accepted as the building roof slope. Accordingly, the slope percentages of the roofs of 686 buildings produced and the number of buildings remaining in this percentage group; Calculated as (0-10) 240 units, (10-20) 151 units, (20-30) 260 units, (30-40) 16 units, (40-100) 19% units.



(a) (b) (c) (d)

**Figure 4.** a) orthophoto, b) vector and accuracy data, c) slope, d) slop classy.

## 4. Results and Discussion

By using orthophoto (figure 4a) data in the study area, the actual building data was determined as 729. It has been determined that there are 686 building data produced as vector data (figure 4b). Spatial intersection analysis used in geographic information systems was made from the name of this process. Used in geographic information systems overlay analysis give us accuracy. With the help of this intersection analysis, in the study, true positive (TP) for the data produced and validation data for accuracy and sensitivity analysis, false positive (FP) for those in the produced data but not in the validation data, false negative (FN) for those who are in the validation data but not in the produced data. those who did not were evaluated as true negative (TN). Accordingly, TP:644 units, FP:42 units, FN:59 units TN:0 was calculated. The accuracy of the study (A) is formulated as A:(TP+TN) /(TP+FP+FN+TN). Accordingly, it was calculated as D=0.86 and it is seen that the buildings were produced correctly from 86% as a percentage. İn this study real building data count 729, produced 686 and overlay analysis result 644 produced data intersect the real data.

## 5. Conclusion

This study shows us that using UAV data and processing them give us many data. These data obtaining that many object extraction as building. It is seen that the changes and roof capacity can be calculated with high accuracy with the data pieces produced from the images obtained with the support of the unmanned aerial vehicle. Various analyzes can be made with the members of these datasets, and the use of these analyzes in many industry and engineering disciplines should be evaluated. Difficulties were experienced in the study, especially when the changes intertwined with the high and non-homogeneous vegetation were removed, and by using various remote sensing and service information system techniques, these results can be obtained to be renewable. However, especially with devices that can take near infrared and thermal band images in addition to rgb bands, vegetation in indoor areas with vegetations and buildings can be masked with much higher accuracy. In addition, it is stated that successful results can be obtained in the extraction of buildings and objects with systems that obtain lidar data. In addition to these abundant equipment and data sets, it is aimed to use the widely used artificial intelligence and deep learning method in the extraction of automatic objects.

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**Conflicts of interest**

The authors declare no conflicts of interest.

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