Advanced UAV
http://publish.mersin.edu.tr/index.php/uav
e-ISSN 2822-6976

The possibilities of data usage obtained from UAV

Mücahit Emre Oruç *[1]

[1]Mersin University, Department of Remote Sensing & GIS, Mersin, Türkiye, mucahitemre27@gmail.com

Cite this study: Oruç, M. E. (2021). The possibilities of data usage obtained from UAV. Advanced UAV, 1(1), 15-23

Keywords
UAV
Remote sensing
Photogrammetry
Point Cloud
Orthophoto

Research Article
Received:13. 10.2021
Revised: 14.11.2021
Accepted: 19.11.2021
Published:15.12.2021

Abstract

Unmanned aerial vehicles are used in many areas with the developing technology. These areas are increasing day by day and have met with intense interest due to these increases. The systems called drone, which is one of the systems that can be controlled by unmanned aerial vehicles, were first used as both weapons and surveillance equipment in military areas where there is risk. Along with the developing technology, it has also been used by many disciplines in civilian areas. It has started to be used in various application areas with its labor capacity and low cost compared to the classical photogrammetry method in obtaining high spatial and temporal resolution images in a short time. UAVs are used in various fields such as the creation of three-dimensional earth models, high-resolution orthophoto production, transportation network planning, land monitoring, determination and monitoring of forest, mine and agricultural areas. Geometric accuracy in orthophoto maps is of great importance in cartography applications. It provides the opportunity to obtain many data that can form a basis for various disciplines. In this study, point cloud, orthophoto, digital elevation model (DEM) was produced from the images obtained by the unmanned aerial vehicle. Dilution processes due to point cloud density were carried out.

1. Introduction

With the development of technology and the increase in the demand for unmanned aerial vehicles (UAVs), the usage areas have expanded and started to attract attention from researchers and scientists. Later, as this interest attracted the attention of the civilian population, it was able to get rid of its use only in military fields and find the opportunity to be used in civilian life as well. With the development of technology, it has been realized by producing more suitable sizes and equipment for civilian users, at low costs. As it has become more affordable and widely available to civilian users, it has also found wide application for civilian and commercial purposes such as aerial photography, mapping, and scientific data collection. This has shown the effectiveness of unmanned aerial vehicles to a great extent in todays and future studies.

UAV is an aircraft that provide manual flight or act autonomously on a predetermined flight plan and return to the take-off point after completing the mission [1]. Unmanned Aerial Vehicles, also called drones, are classified as fixed wing and rotary wing according to their flight capabilities. Fixed wing UAVs are generally used for scanning large areas, and rotary-wing UAVs are used for scanning smaller areas [2].

UAVs, namely drones, help many different disciplines such as forestry, archaeology, documentation and protection of cultural heritage, wildlife surveys, environmental monitoring, traffic control and regulation, mapping, transportation, construction, energy fields and pipelines, geological fields, coastal monitoring, landscape planning, mining, disaster monitoring and prevention, rescue work, agriculture and spraying, deformation monitoring [3].

While technical academic studies were carried out on UAVs in the past, it is now becoming a sector. Different types of studies on UAVs have also begun to take their place in the literature. Titles such as R&D, cost, social ethics, UAV aviation standards regulations can be given as examples of different titles that have started to be seen in this field in the literature. Compilation, classification, standardization of terms is important for academic and industrial studies to progress healthier and easily [4].

The photogrammetric potential of UAVs has been evaluated by applying it in various studies in the recent past. It is also used in many applications today. In addition to these studies, research continues to increase the accuracy of the orthophoto maps and DEMs [5-11].

In line with these developments in UAV photogrammetry, current map production, three-dimensional (3D) modeling, production, stock and casting area cubage calculations, rock detection, geological mapping, excavation planning and installation of hyperspectral cameras, alteration and mineral detection in open mines, vertical. The method is also used in studies such as mapping inaccessible points [12-15].

Images taken with UAVs are transformed into meaningful data by means of appropriate processing software. By combining the images taken in the software, many useful data such as 3D point cloud, solid model, orthophoto, digital elevation model (DEM) are obtained. With these data, appropriate disciplines can easily perform the operations they need. In this study, a mining area was chosen as the study area. 3D model of the mine area, point cloud, orthophoto, and digital elevation models were obtained. These data were processed in context capture software by taking photos with the help of an unmanned aerial vehicle. Photos of the working area are DJI brand Phantom 4 Pro model. With the help of the photographs obtained, data that will serve as a base for many disciplines have been produced. These data will provide significant convenience in the areas where it is desired to be used.

2. Method

2.1. Unmanned aerial vehicle (UAV)

Unmanned aerial vehicles (UAVs) are pilotless aerial vehicles equipped with digital cameras and, unlike traditional remote sensing methods, provide high resolution temporal and spatial images at low cost. UAVs, also called by different names such as unmanned aerial system, aerial robot, pilotless aircraft, are remotely controlled aerial vehicles that can carry cameras, sensors and communication equipment.

In other words, unmanned aerial vehicles can be defined as aircraft that automatically fly in the air with the help of GPS control without the need for a pilot [16]. UAVs are remotely controlled by a pilot on the ground, and they are vehicles that fly automatically with pre-made flight planning.

2.2. Classification of UAVs

According to the technical specifications of UAVs, it is possible to make two main classifications (according to their weight, fuel-energy usage source, wing structure, automatic or remote control, etc.) and usage purposes (military and civil). Classification is given in Figure 1 as a diagram.

2.2.1 According to their weight

These are the classification types based on the maximum take-off mass, the distance that the UAV can perform, the time it can stay in the air, and the maximum altitude it can reach. Classifications based on one or more of these parameters in different combinations constitute the majority of classifications on UAVs in total. The reason why these parameters are widely preferred in classification is based on UAV applications, it is observable, measurable and functional / operational features [4].

2.2.2 According to the Fuel-Energy source

The fuel system used in this classification is decisive. Pilotless, disposable UAVs, which are fueled during production at the factory, are the first head for the fuel system. Another topic is UAVs that use a fuel system suitable for refueling from the ground station, ship deck or any other place.

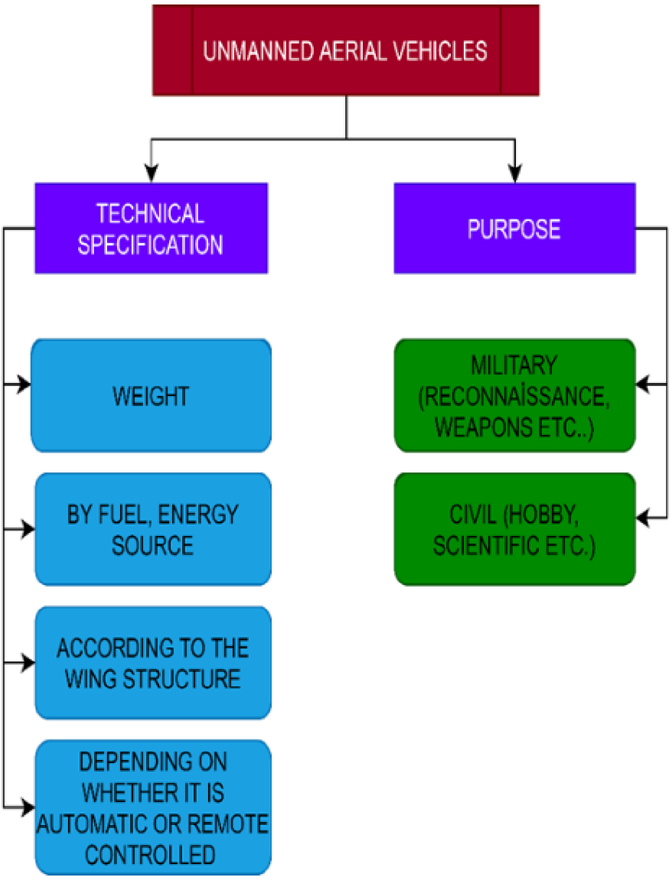

Figure 1. UAV classification

2.2.3 According to the wing structure

It is a classification made in two parts as fixed and non-fixed / rotary wing types. In general, fixed wing is preferred in the design of aircraft and helicopter type UAVs. The variable wing cap can also be divided into three subheadings such as wing size, wing position and wing form that can change during flight [4].

2.2.4 According to the automatic-remote control

It is an important parameter that distinguishes UAVs from other aircrafts. Considering that pilotless flight is aimed, the importance of the control system is understood more. When we look at the classifications made according to this parameter, we can list various control systems in accordance with the technological development of UAVs: Applications controlled by an operator up to a certain distance from a ground control center are called "direct control". Another classification is “observed control”. Here, the UAV can act autonomously, may be partially or completely intervened by a pilot, or observable movement can be achieved with a number of commands. Third, the incompatible - autonomous control head can be examined. Pilotless and autonomous, that is, independent movement is provided by pre-programming. What is meant by incompatibility is the inability to go beyond this pre-programming during the flight. After the programmed flight has started, no strategic change can be made in the movement or adaptation to external factors occurring during the flight. In the autonomous control system, which is examined as the fourth title, control is provided by a fully integrated UAV control system without any operator intervention. Thus, compatibility with external factors or new applications becomes possible [4].

2.2.5. Military

When considered in the broadest sense, military applications can be examined in 3 parts as land, air and sea applications. Used in military applications; Vehicles that can reach an altitude of 3000-8000 meters, have a take-off weight of 150-1500 kg, and can stay in the air between 2-48 hours are seen. Military activities are mostly in the form of control, surveillance and intelligence activities. Apart from these, another field of use in the military field is work in dangerous groups such as chemical, biological, nuclear and radiological activities.

2.2.6 Civil

UAVs have started to be used in civil-commercial applications as well as military aviation activities, so they are easily adapted to daily life and become a current topic for academic studies. It also offers very advantageous solutions for civilian users. In addition, UAVs are used in many areas such as oil lines, railway lines, control of tall buildings, agricultural spraying, product yield detection, post-earthquake imaging and many similar areas.

3. Application

3.1. Fieldwork

In this study, DJI Phantom 4 Pro (Figure 2) has been selected in a mountainous, rugged area with a mine. Before the flight in the application area, pre-flight plans were made by going to the land for exploration purposes.

Within these plans, the establishment of the ground control points (GCPs) to be placed on the land has been done. GCPs are homogeneously distributed over the land. The dimensions of the GCPs are square and 50x50 cm long points are used. After the ground control points were determined, the geodetic coordinates of these points were determined with the Topcon Hiper SR brand GNSS measuring device. A total of 12 GCPs have been established in the entire area.

Figure 2. DJI Phantom 4 Pro

The flight altitude was determined as 80 m, at the end of the flight, a total of 620 photographs were taken. Photographs can achieve more accurate image matching with 80% longitudinal and 60% transverse coverage. For this reason, all flights in the study area were carried out by considering the mentioned cover rate. In addition, all flights in the study area were completed on the same day and as soon as possible, minimizing the effect of sunlight. And the photos were uploaded to digital media for processing [17].

3.2. Office work

After the land operations were completed, the images taken were transferred to the computer environment and made ready for processing. Before transferring to the appropriate modeling software, the captured images should be checked for points to be considered. If there are corrupted photos, they should be removed in order not to affect the quality of the model to be created. After the photos were checked, they were transferred to the context capture software, which is a 3D modeling software.

The software models photos according to the Structure from Motion (SfM) principle. Structure From Motion (SfM) photogrammetric image matching algorithm, which was developed to predict three-dimensional 3D structures from the combination of local motion signals and two-dimensional image sequences, is the basic principle of new generation and widely used cloud-based image matching software [18-20].

The 3D model of the land was obtained by processing the photographs with the software. In addition to this, point cloud, orthophoto of the supply, digital elevation model and map were drawn. These data form significant bases for many studies. Thanks to these data, coordinate values can be obtained from the desired location of the land thanks to the land slope height information, 3D model and point cloud, and thanks to the coordinated model. Considering the mining area in the field, many data such as volume calculation can be obtained based on the excavations carried out in this area.

3.3. Product information

3.3.1. Point cloud

The point cloud cluster (Point Cloud Library) has a data structure that contains multidimensional data. Point clouds are generally used to represent three-dimensional data, which consists of x, y, and z coordinates. In particular, the z-coordinate only records the distance of the camera from the object surface according to the depth. Point data is mostly used to show the outer surface of some objects. Each point in the point cloud can contain normal direction or color data as well as geometric coordinates. As this data is added to points, cloud sizes increase. When RGB color data is added to a three-dimensional point cloud, this cloud can now be six-dimensional [21].

3.3.2. Orthophoto

It can be defined as the name given to orthophoto images on which map edge information, grids, contour lines, place and position names and similar cartographic information are added. It is a photo map produced in standard or random scales by combining orthophoto image particles, obtained by adding contour curves, height information, map edge information on the orthophoto images obtained by eliminating the errors caused by the curvature effects and height differences (relief shift) in the images. In the production of orthophoto maps, combined operations such as photographic edge enhancement, color separation or a combination of these can also be applied as special cartographic operations. Orthophoto maps; It is widely used by the relevant institutions in national security projects as well as in the renewal/updating of the cadastre, urban transformation/zoning project base, agriculture, forest, disaster management information systems such as geographic information system and decision support projects.

3.3.3. Digital elevation model (DEM)

Digital surface model is a surface where all objects are included, besides the plain land surface, obtained from the location and height information of the earth, vegetation, trees, buildings [22-23]. When the flight height is less, the DEM will be obtained with more resolution [24]. Until now, too many scholars used UAV technology to obtain DEM. Many engineering projects such as landslide site [25-26], rockfall site [27], shoreline detection [28], cultural heritage modelling [29-30] and pond volume measurement [31] have been solved with this technology.

4. Results

Before the flight operation with an unmanned aerial vehicle in the field studies, land exploration and establishment of ground control points of the area to be flown were carried out. Then, the geodetic coordinates of the ground control points were measured with the GPS/GNSS instrument. These coordinates were used in combining the photos obtained from the unmanned aerial vehicle via software and converting them to the country coordinate system. These data allowed to take measurements with real coordinates on the supply. Photos were processed in context capture software. The photographs were taken from 80 m height and the overlay ratios were determined as 80-60%.

As a result, point cloud (Figure 3 and Figure 4), orthophoto (Figure 5) and digital elevation model (Figure 6) were created in the country coordinate system from the photographs, which were completed by means of software in the office environment. The data obtained will provide convenience when there is a desired measurement in the future due to the land roughness and from the mine located in the land. With the point cloud, many studies such as volume calculation of the area to be excavated on the mine site and elevation differences can be easily performed.

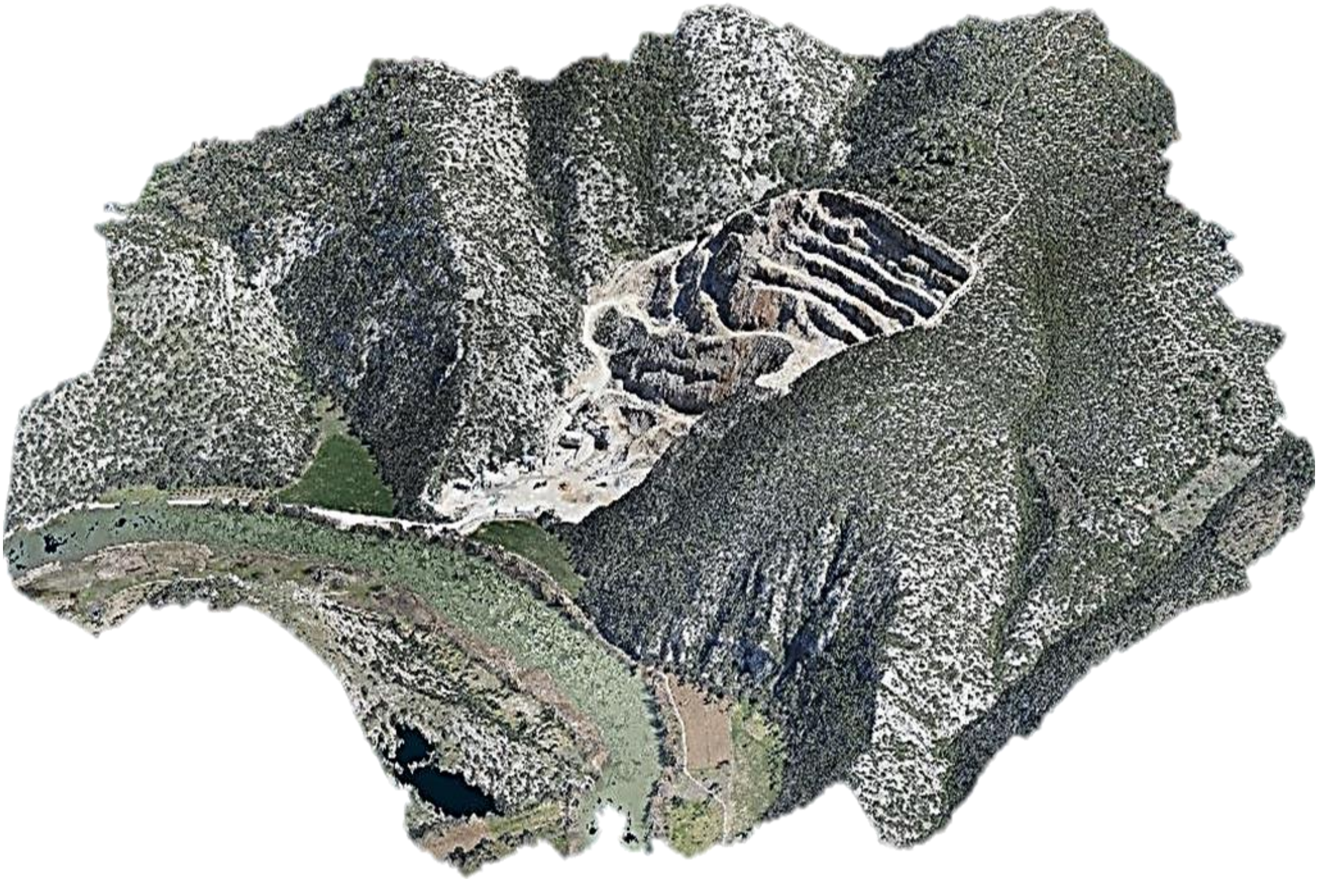

Figure 3. Entire workspace point cloud

Figure 4. Mine excavation site point cloud

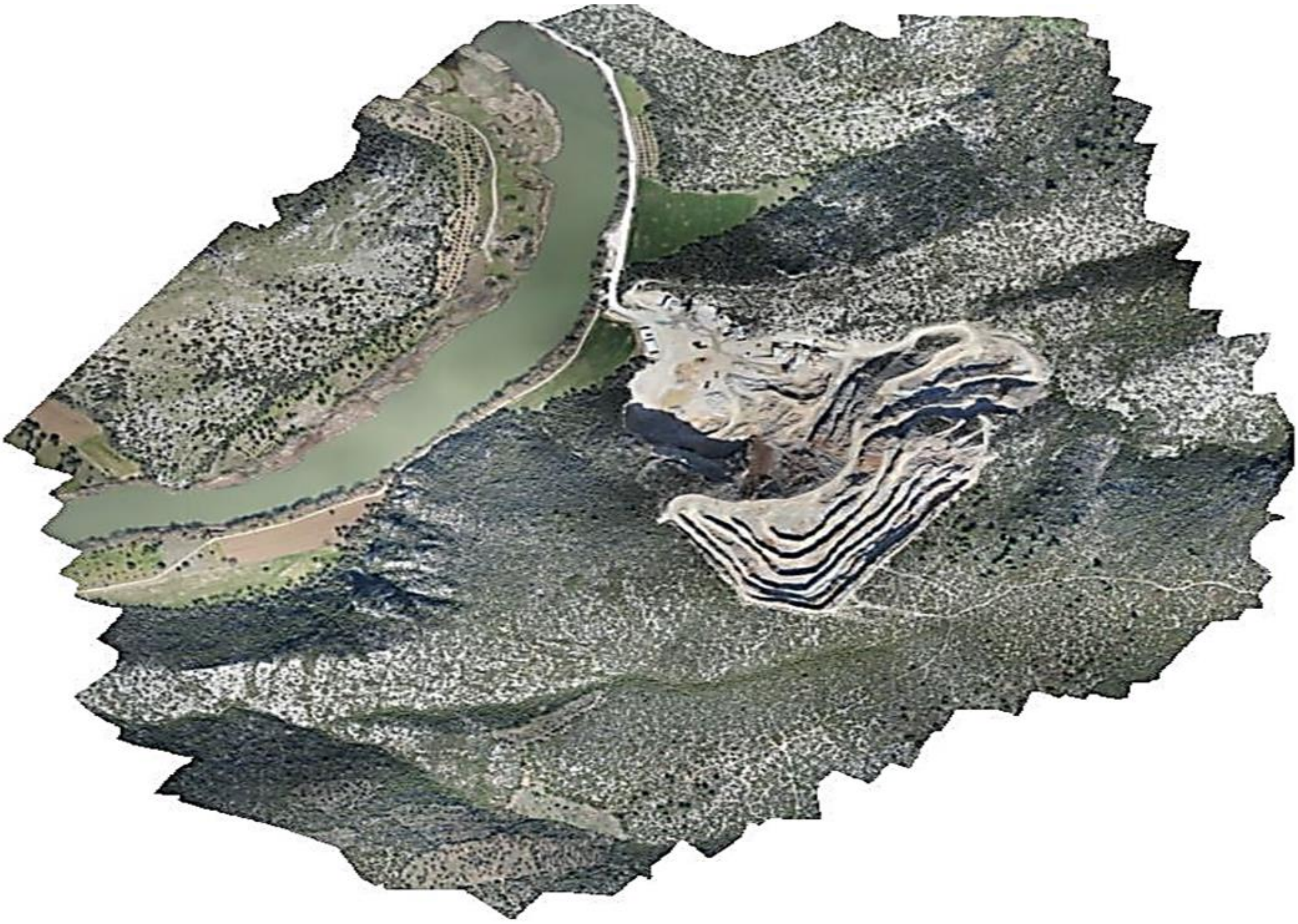

Figure 5. Workspace orthophoto view

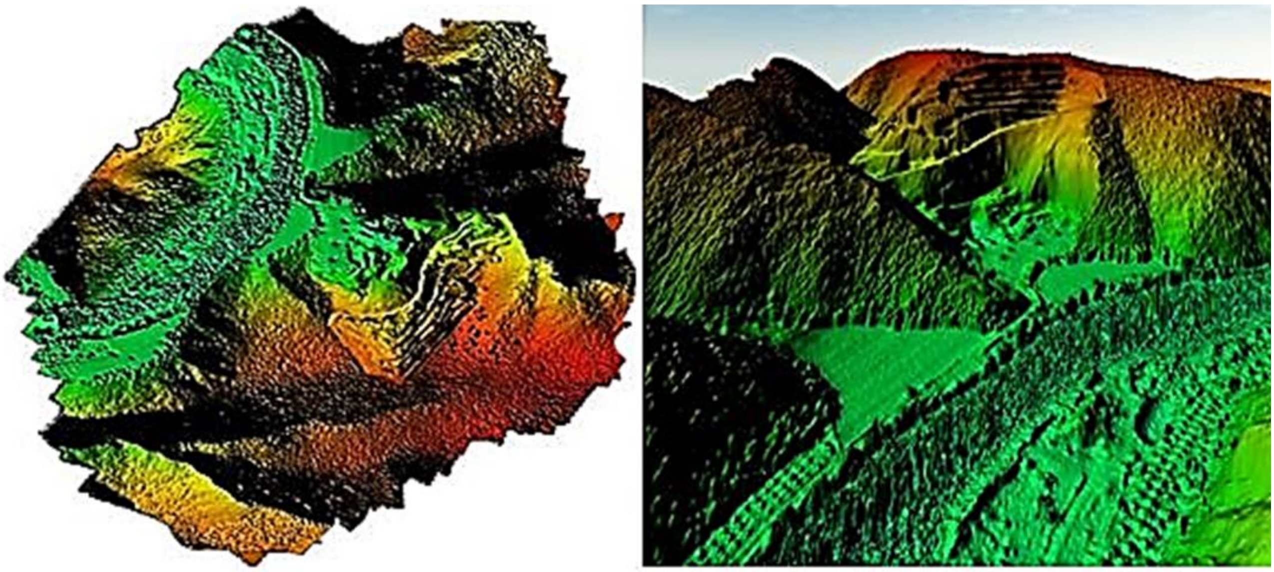

Figure 6. 2D and 3D Digital elevation model

7. Conclusion

The possibility of reaching inaccessible or dangerous areas without putting anyone in dangerous situations or dangerous areas with low cost and risk has led researchers to unmanned aerial vehicles as an alternative to classical aerial photogrammetry. In this study, three-dimensional modeling and orthophoto maps were obtained from the study of unmanned aerial vehicles. The position error of the products obtained as a result of the study was calculated as ± 3.1 cm on average, and the height error was calculated as ± 8.6 cm on average.

In obtaining three-dimensional models, it is important to take vertical pictures as well as oblique pictures. Height accuracy was therefore higher than position accuracy. It has been concluded that compared to conventional aerial photogrammetry, baseline maps of small areas, digital terrain models, digital elevation models and orthophoto maps used by many disciplines can be produced in a shorter time and more economically, with appropriate position and altitude errors, by using Unmanned Aerial Vehicles.

Thanks to the aerial imaging and measurement systems with the unmanned aerial vehicle, the desired data can be collected in all kinds of terrain conditions, both sensitively and in a short time. While drones can generate data that takes a few hours, people using traditional methods need days, weeks, or months depending on their workload. In addition to these advantages of the use of UAVs in mining, the data generated by the UAV is comprehensive, sensitive and can be analyzed in many ways as it provides digital transmission.

The obtained point cloud, orthophoto and digital elevation models will have many working bases. In addition to geodetic measurements, it has been seen that it can be done in difficult terrain conditions more easily and in a short time without requiring much labor.

Funding

This research received no external funding.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Alptekin, A., Çelik, M. Ö., Kuşak, L., Ünel, F. B., & Yakar, M. (2019). Anafi Parrot'un heyelan bölgesi haritalandırılmasında kullanımı. *Türkiye İnsansız Hava Araçları Dergisi*, *1*(1), 33-37.
2. Kekeç, B., Bilim, N., Dündar, S., & Ghiloufi, D. (2018) Madencilik faaliyetlerinde insansız hava araçlarının (İHA) kullanımı.
3. Yücel, D. Ş., & Yücel, M. A. (2017). Terk edilmiş kömür ocaklarında oluşan maden göllerinin hidrokimyasal özelliklerinin belirlenmesi ve insansız hava aracı ile üç boyutlu modellenmesi. Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi, 23(6), 780-791.
4. Yiğit, E., Yazar, I., & Karakoç, H. T. (2018). İnsansız hava araçları (İHA)'nın kapsamlı sınıflandırması ve gelecek perspektifi. Sürdürülebilir Havacılık Araştırmaları Dergisi, 3(1), 10-19.
5. Harwin, S., Lucieer, A. (2012). Assessing the accuracy of georeferenced point clouds produced via multiview stereopsis from unmanned aerial vehicle (UAV) imagery. Remote Sensing, 4(6), 1573- 1599.
6. Udin, W.S., Ahmad, A. (2014). Assessment Of Photogrammetric Mapping Accuracy Based on Variation Flying Altitude Using Unmanned Aerial Vehicle. IOP Conference Series: Earth and Environmental Science, IOP Publishing, 18(1), 012027.
7. Babinec, A., Apeltauer, J. (2016). On Accuracy of Position Estimation from Aerial Imagery Captured by Low-Flying Uavs. International Journal of Transportation Science and Technology, 5(3), 152-166.
8. Popescu, G., Iordan, D., Păunescu, V. (2016). The resultant positional accuracy for the orthophotos obtained with unmanned aerial vehicles (UAVs). Agriculture And Agricultural Science Procedia, 10, 458-464.
9. Kršák, B., Blišťan, P., Pauliková, A., Puškárová, P., Kovanič, Ľ., Palková, J., Zelizňaková, V. (2016). Use of low-cost UAV photogrammetry to analyze the accuracy of a digital elevation model in a case study. Measurement, 91, 276-287.
10. Ulusoy, İ., Şen, E., Tuncer, A., Sönmez, H., Bayhan, H. (2017). 3D multi-view stereo modelling of an open mine pit using a lightweight UAV. Türkiye Jeoloji Bülteni/Geological Bulletin of Turkey, 60(2), 223- 242.
11. Yusoff, A. R., Ariff, M. F. M., Idris, K. M., Majid, Z. & Chong, A. K. (2017). Camera calibration accuracy at different UAV flying heights. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 42(2/W3), 595- 600.
12. Yakar, M. (2011). Using close range photogrammetry to measure the position of inaccessible geological features. *Experimental Techniques*, *35*(1), 54-59.
13. Hugenholtz, C. H., Whitehead, K., Brown, O. W., Barchyn, T. E., Moorman, B. J., Leclair, A. & Hamilton, T. (2013). Geomorphological mapping with a small unmanned aircraft system (Suas): Feature detection and accuracy assessment of a photogrammetrically-derived digital terrain model. Geomorphology, 194, 16-24.
14. Cryderman, C., Mah, S.B., Shufletoski, A. (2014). Evaluation of UAV photogrammetric accuracy for mapping and earthworks computations. Geomatica, 68(4), 309-317.

15. Eltner, A., Kaiser, A., Castillo, C., Rock, G., Neugirg, F., Abellán, A. (2016). Image-Based surface reconstruction in geomorphometry–merits, limits and developments. Earth Surface Dynamics, 4(2), 359-389.
16. Kahveci, M., & Nazlı, C. A. N. (2017). İnsansiz hava araçlari: tarihçesi, tanimi, Dünya'da Ve Türkiye'deki yasal durumu. Selçuk Üniversitesi Mühendislik, Bilim Ve Teknoloji Dergisi, 5(4), 511-535.
17. Öztürk, O., Bilgilioğlu, B. B., Çelik, M. F., Bilgilioğlu, S. S., & Uluğ, R. (2017). İnsanız hava aracı (İHA) görüntüleri ile ortofoto üretiminde yükseklik ve kamera açısının doğruluğa etkisinin araştırılması. Geomatik, 2(3), 135-142
18. Özcan, O. (2017). İnsansız hava aracı (İHA) ile farklı yüksekliklerden üretilen sayısal yüzey modellerinin (SYM) doğruluk analizi. Mühendislik Ve Yer Bilimleri Dergisi, 2(1), 1-7.
19. Sefercik, U. G., Tanrikulu, F., & Atalay, C. (2020). Sfm tabanlı yeni nesil görüntü eşleştirme yazılımlarının fotogrametrik 3B modelleme potansiyellerinin karşılaştırması. Türkiye Fotogrametri Dergisi, 2(2), 39-45.
20. Oruç, M. E. (2021). Küçük objelerin modellenmesinde videogrametri ve fotogrametri yöntemlerinin karşılaştırılması üzerine bir çalışma. Türkiye Fotogrametri Dergisi, 3 (2), 62-68. DOI: 10.53030/Tufod.1019385
21. Özbay, E. (2018). Nokta Bulutu Verilerinden Nesne Ayırt Etme, Yüksek Lisans Tezi
22. Akgül, M., Yurtseven, H., Demir, M., Akay, A. E., Gülci, S., & Öztürk, T. (2016). İnsansız hava araçları ile yüksek hassasiyette sayısal yükseklik modeli üretimi ve ormancılıkta kullanım olanakları. Journal of the Faculty of Forestry Istanbul University, 66(1), 104-118.
23. Yilmaz, H. M., Mutluoğlu, Ö., Ulvi, A., Yaman, A., & Bilgilioğlu, S. S. (2018). İnsansız hava aracı ile ortofoto üretimi ve aksaray üniversitesi kampüsü örneği. Geomatik, 3(2), 129-136.
24. Çelik, M. Ö., Alptekin, A., Ünel, F. B., Kuşak, L., & Kanun, E. (2020). The effect of different flight heights on generated digital products: Dsm and Orthophoto. *Mersin Photogrammetry Journal*, *2*(1), 1-9.
25. Alptekin, A., & Yakar, M. (2020). Heyelan bölgesinin İHA kullanarak modellenmesi. *Türkiye İnsansız Hava Araçları Dergisi*, *2*(1), 17-21.
26. Kusak, L, Unel, F. B., Alptekin, A, Celik, M. O., & Yakar, M. (2021). Apriori association rule and *K*-means clustering algorithms for interpretation of pre-event landslide areas and landslide inventory mapping. Open Geosciences, 13(1), 1226-1244. https://doi.org/10.1515/geo-2020-0299
27. Alptekin, A., Çelik, M. Ö., Doğan, Y. & Yakar, M. (2019). Mapping of a rockfall site with an unmanned aerial vehicle. Mersin Photogrammetry Journal, 1 (1), 12-16.
28. Ünel, F. B., Kuşak, L., Çelik, M. Ö., Alptekin, A., & Yakar, M. (2020). Kıyı çizgisinin belirlenerek mülkiyet durumunun incelenmesi. *Türkiye Arazi Yönetimi Dergisi*, *2*(1), 33-40.
29. Mirdan, O., & Yakar, M. (2017). Tarihi eserlerin İnsansız Hava Aracı ile modellenmesinde karşılaşılan sorunlar. *Geomatik*, *2*(3), 118-125.
30. Alptekin, A., & Yakar, M. (2021). 3D model of Üçayak Ruins obtained from point clouds. *Mersin Photogrammetry Journal*, *3*(2), 37-40.
31. Alptekin, A., & Yakar, M. (2020). Determination of pond volume with using an unmanned aerial vehicle. *Mersin Photogrammetry Journal*, *2*(2), 59-63.