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Accuracy of digital maps produced from UAV images in rural areas

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Abstract

Rural areas are areas that are surrounded by high mountains and are very rough and therefore transportation is insufficient. The measurement of these areas has also caused it to be time consuming and costly. With the development of technology, the rapid development of Unmanned Aerial Vehicles (UAV) technology has begun to be used not only in the military field, but also in the civilian fields. One of these areas was rural areas. In this study, the measurement of the mine field in the rural area was made by the UAV photogrammetry method and Digital Elevation Model (DEM) and Ortomosaic were produced. Accuracy analysis was carried out with the control points measured in the field on these produced maps. In this direction, it has been concluded that UAV technology can be used in rural areas.

1. Introduction

The environments where economic activities are based on the evaluation of natural resources, where face-to-face relations are relatively more common, where the rules of life are largely shaped according to traditions and customs, where technical and technological developments and economic, social and cultural developments take place more slowly and therefore with a delay are called rural areas. Obtaining 3D location data is difficult in terms of time and cost when it comes to rural areas, hard-to-reach areas and large areas in terms of surface area [1-3].

Traditional methods have been used to obtain 3D location data until today. However, these methods, especially in rural areas, have affected the accessibility of high mountains, which show significant changes in sudden changes in land heights, but have a negative impact on accessibility [4-5].

With the development of technology, the rapid development of Unmanned Aerial Vehicles (UAV) technology has begun to be used not only in military fields but also in various civilian fields. One of these areas was rural areas. Studies such as mapping rural areas, topographic mapping of the earth, monitoring and planning of mining operations, and determination of forestry and forest areas have begun to be carried out using UAV technologies [6-7].

With UAVs, which is a remote sensing technology, it is possible to obtain high resolution data in a short time with less labor and with comprehensive analysis. Images of a work area are taken by equipping UAVs with sensors suitable for the work to be done, and data processing can be done with many software [8-9].

The mapping of rural areas with the help of UAV technology is carried out with the UAV Photogrammetry method, which is considered a sub-science of photogrammetry. UAV photogrammetry is generally a photogrammetry process using photographs taken with a camera integrated into an aircraft [10-11].

While providing more flexibility with UAVs compared to traditional data collection methods, less time is spent in the working area and also provides significant cost advantages. In addition, thanks to the Global Navigation Satellite Systems (GNSS) integrated into the new type of UAVs, the latitude, longitude and height information of the pictures taken are among the advantages of this system. In addition, the presence of a GNSS module and the ability to take pictures automatically with these UAVs contribute to a significant reduction in distortion (translation, rotation and offset). Moreover, the data obtained by UAVs with their low altitude flight capability and advanced technical imaging systems contain significantly higher resolution and much more detailed information compared to the data obtained from satellite images and manned aircraft [12-15].

There are many open source and commercial software that works integrated with UAV photogrammetry. Many of these software is based on Structure from motion (SfM) proprietary algorithms. SfM is a photogrammetric imaging technique used to predict 3D structures from arrays of two-dimensional (2D) images. In the SfM method, 3D structures are created from a series of overlapping frames. SfM in a short time; It has had a transformative impact on geoscience research, providing extraordinarily fast, cost-effective and easy 3D measurements [16-19]. The reason for this is that the SfM technique also offers the possibility of integrating photographs taken from different shooting platforms, both terrestrial and aerial, if certain working methods are followed. The main difference between traditional stereoscopic photogrammetry and the SfM method is that the calculations required to obtain the precise position of a point in 3D space are fully automated and precise positioning of the cameras is not required [20-23].

In a study by Lee & Choi [16], 89 photos were obtained by flying autonomously for 30 minutes at 100 m altitude using a rotary wing UAV (DJI Phantom 2 Vision). A digital surface model Digital Elevation Model (DEM) was created by processing the collected data. Comparison of the X, Y, Z coordinates of the five ground control points (GCP) measured by the Differential Global Navigation Satellite Systems with those determined by UAV photogrammetry shows that there is a mean square error of about 10 cm. At the end of this study, they reported that rotary vane UAV photogrammetry can be effectively used as a technology that can replace or complement existing topographic measurement equipment in open pit mines [24-26].

Doğruluk et al. [24] examined the performance analyzes of filtering methods from DEM production in rural areas. Collecting control points with field measurements for absolute accuracy assessment of filtering results contributed significantly to the results of the study. In addition, it was emphasized that the use of high-resolution optical images of the study area would be meaningful in terms of allowing different methods to be used in accuracy analysis [27].

Akgul et al. [25] carried out DEM production of forest areas with UAV photogrammetry. It has been emphasized that UAVs are an important tool that will contribute to high-precision studies for forestry studies, since more sensitive data such as Lidar data of forest areas are not yet available or widespread [28-30].

In this study, UAV Photogrammetry of the open mining area, which is one of the rural areas, produced DEM and orthomosaic maps and the accuracy of these maps was examined.

2. Material and Method

A rural area belonging to the province of Burdur, shown in Figure 1, was chosen as the study area. The reason for choosing this region is that it is a rural area far from the city center, difficult to reach and not easily accessible.

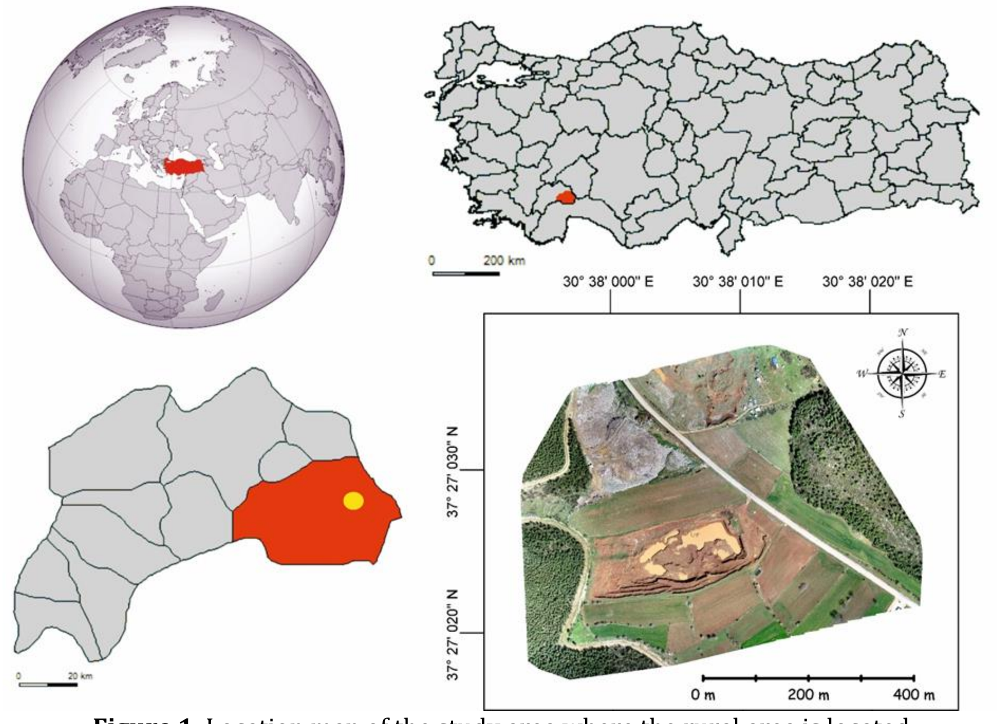


Figure 1. Location map of the study area where the rural area is located

2.1. Data collecting

In this section, 30 control points (CP) points were established in the rural area. At these CP, 18 were used as GCP and 12 as checkpoints (ChP). These points were measured with the Topcon GR5 Global Navigation Satellite Systems (GNSS) rover in the ITRF96 datum system (Figure 2).

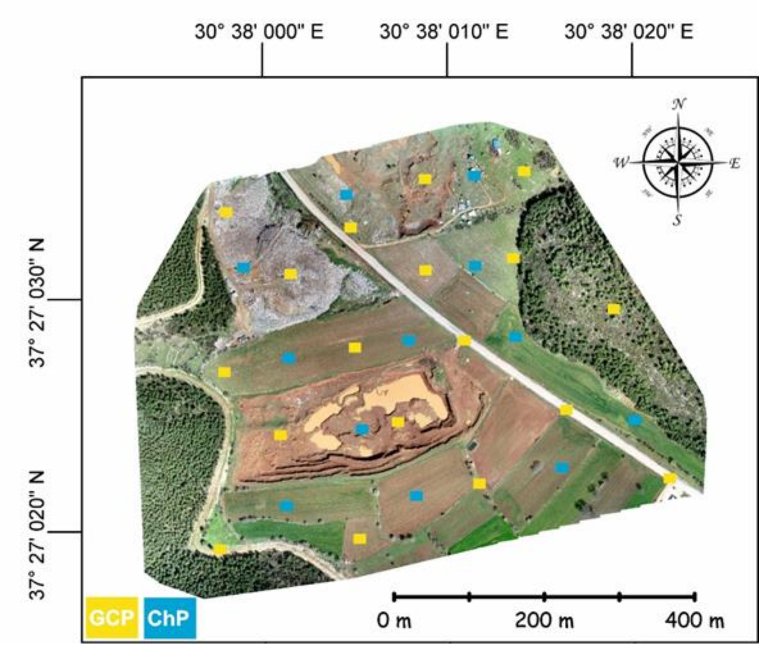


Figure 2. Distribution of GCP and ChP to study area

Phantom 3 PRO brand UAV and integrated ground control systems were used as a flying carrier platform for generating DEM data and taking high-sensitivity images (Figure 3). The photographs were obtained from different angles and overlapped from a height of 30 m. In Table 1, the technical specifications of the UAV are given.

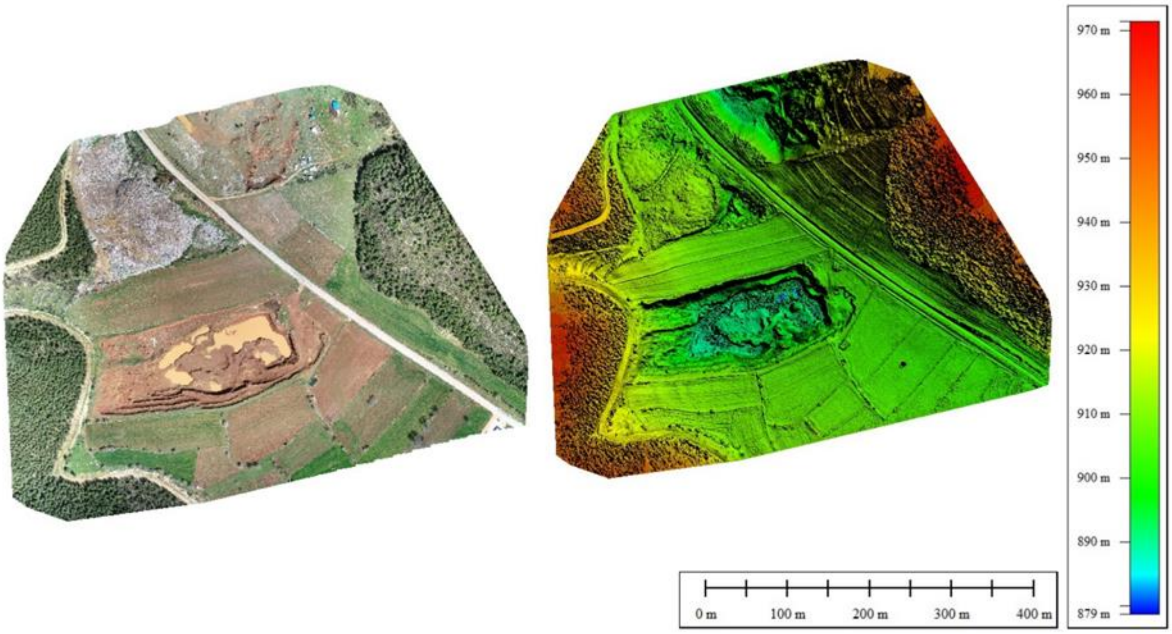
Figure 3. Phantom 3 Pro UAV

Table 1. Phantom 3 Pro UAV

Features	Value
weight	
Maximum Takeoff Speed	5 m/s
Minimum Takeoff Speed	3 m/s
Maximum Speed	16 m/s
Maximum Tilt Angle	35°
Satellite Positioning Systems	GNSS/GLONASS
Sensor size	1/2.3"
Lens	20 mm

2.2. Data Processing

Agisoft Metashape software was used for photogrammetric evaluation. First, the GCP points measured in the field were transferred to the software and the photographs were marked. Then, 3D modeling was done in Agisoft Metashape software. As a result of the study, orthomosaic map and DEM map of the study area were produced (Figure 4).



(a) (b)

Figure 4. a) Orthomosaic map of the study area, **b)** DEM map of the study area

2.3. Accuracy Assessment

18 GCP and 12 ChP were homogeneously established in the study area. The coordinates of these points were measured by GNSS rover. These coordinates are accepted as reference coordinates. Square mean error equations were used in the accuracy analysis. The accuracy of the photogrammetric project was calculated using control points not used in georeferencing [19-20-21]. In this context, orthomosaic and DEM control points were defined and their coordinates were compared with the GNSS coordinates examined, and $RMSE_x$, $RMSE_y$, $RMSE_z$ horizontal accuracy measures were obtained as defined in the equations given below:

$$V_{x,y,z_i} = X,Y,Z_{ChP_i} - X,Y,Z_{GNSS_i} \quad (1)$$

$$RMSE_{x,y,z} = \pm\sqrt{\frac{[VV]}{n-1}} \quad (2)$$

Table 2. Error-values and RMSE of ChPs

ChP	VxVx	VyVy	VzVz
1	8.10	11.50	15.20
2	3.60	4.80	14.50
3	9.30	12.80	21.00
4	8.70	9.20	19.00
5	8.60	9.80	18.70
6	6.90	5.80	16.40
7	11.60	8.70	21.80
8	7.90	11.80	17.80
9	8.00	5.20	11.80
10	11.80	4.80	23.80
11	13.10	14.70	5.70
12	4.20	7.80	8.70
RMSE	3.04	3.12	4.20

In line with these data, the mean position errors in the x, y and z coordinates of the digital map produced using the UAV photogrammetry technique were found to be ±3.04, ±3.12, and ±4.20 cm, respectively.

3. Discussion and Conclusion

This study showed that this is readily possible with UAV photogrammetry technology in rural areas. UAVs can be used without problems on such terrain. UAVs allow practical, very fast, accurate, and cost-effective measurements in difficult and impassable terrain conditions. The 3D model was created in a short time. It provides a highly practical solution for monitoring mining area progress, identifying discrepancies, making good decisions for the future, and planning in light of those decisions. Examining the accuracy of the output products produced at the same time indicates that they can be used within the scope of the study.

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Conflicts of interest

The authors declare no conflicts of interest.

References

1. Agüera-Vega, F., Carvajal-Ramírez, F. & Martínez-Carricondo, P. (2017). Assessment of photogrammetric mapping accuracy based on variation ground control points number using unmanned aerial vehicle. Measurement, 98, 221-227.
2. Ulvi A., Yiğit, A. Y., & Yakar, M. (2019). Modeling of Historical Fountains by Using Close-Range Photogrammetric Techniques. Mersin Photogrammetry Journal, 1(1), 1-6.
3. Ulvi, A., Yakar, M., Yiğit, A. Y. & Kaya, Y. (2020). İHA ve yersel fotogrametrik teknikler kullanarak Aksaray Kızıl Kilise'nin 3 boyutlu nokta bulutu ve modelinin üretilmesi, Geomatik, 5, 1, 22-30.
4. Gülmez, A. & Vaheddoost, B. (2020). Dijital Yükseklik Modeli ve HEC-RAS Simülasyonu Kullanarak Hurman Çayı'ndaki Potansiyel Taşkın Ovasının Haritalanması.
5. Uysal, M., Polat, N., Toprak, A. S., & Yakar, M. (2013). 3d modeling of historical doger caravansaries by digital photogrammetry.
6. Ravi, R. & Habib, A. (2020). Fully Automated profile-based calibration strategy for airborne and terrestrial mobile LiDAR systems with spinning multi-beam laser units. Remote Sensing, 12(3), 401.
7. Şasi, A. & Yakar, M. (2018). Photogrammetric modelling of Hasbey Dar'ülhuffaz (Masjid) using an unmanned aerial vehicle. International Journal of Engineering and Geosciences, 3 (1), 6-11.
8. Yakar, M., Yılmaz, H. M., & Mutluoğlu, Ö. (2010). Close range photogrammetry and robotic total station in volume calculation.
9. Yilmaz, H. M., Yakar, M., Gulec, S. A., & Dulgerler, O. N. (2007). Importance of digital close-range photogrammetry in documentation of cultural heritage. Journal of Cultural Heritage, 8(4), 428-433.
10. Tahar, K. N. (2013). An Evaluation on Different Number of Ground Control Points in Unmanned Aerial Vehicle. Photogrammetric Block XL. 27–29.
11. Tercan, E. (2017). Karayolu Projelerinde İnsansız Hava Aracı ile Üretilen Sayısal Arazi Modelinin Değerlendirilmesi: Bucak-Kocaaliler Yolu Örneği. Mehmet Akif Ersoy Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 8(2), 172-183.
12. Zhang, W. & Li, Q. (2006). A preliminary simulation to study the potential of integration of LIDAR and imagery. In Remote Sensing for Environmental Monitoring, GIS Applications, and Geology VI (Vol. 6366, p. 63660W). International Society for Optics and Photonics.
13. Yakar, M. (2011). Using close range photogrammetry to measure the position of inaccessible geological features. Experimental Techniques, 35(1), 54-59.
14. Mırdan, O. & Yakar, M. (2017). Tarihi Eserlerin İnsansız Hava Aracı ile Modellenmesinde Karşılaşılan Sorunlar. Geomatik, 2 (3), 118-125.
15. Kanun, E., Alptekin, A., & Yakar, M. (2022). Cultural heritage modelling using UAV photogrammetric methods: a case study of Kanlıdivane archeological site. Advanced UAV, 1(1), 24–33

16. Lee, S. & Choi, Y. (2015). On-site Demonstration of Topographic Surveying Techniques at Open-pit Mines using a Fixed-wing Unmanned Aerial Vehicle (Drone). Tunnel Underground Space, 25(6), 527-533.
17. Yakar, M., Yılmaz, H., Yıldız, F., Zeybek, M., Şentürk, H. & Çelik, H. (2010). Silifke-Mersin Bölgesinde Roma Dönemi Eserlerinin 3 Boyutlu Modelleme Çalışması ve Animasyonu. Jeodezi ve Jeoinformasyon Dergisi, (101).
18. Yakar, M., Dogan, Y. (2019). 3D Reconstruction of Residential Areas with SfM Photogrammetry. In: El-Askary, H., Lee, S., Heggy, E., Pradhan, B. (eds) Advances in Remote Sensing and Geo Informatics Applications. CAJG 2018. Advances in Science, Technology & Innovation. Springer, Cham. https://doi.org/10.1007/978-3-030-01440-7_18
19. Doğan, Y. & Yakar, M. (2018). GIS and three-dimensional modeling for cultural heritages. International Journal of Engineering and Geosciences, 3 (2), 50-55.
20. Yılmaz, H. M., Mutluoğlu, Ö., Ulvi, A., Yaman, A. & Bilgilioğlu, S. S. (2018). İnsansız Hava Aracı İle Ortofoto Üretimi Ve Aksaray Üniversitesi Kampüsü Örneği. Geomatik, 3 (2), 129-136.
21. Şahin, İ., & Yakar, M. (2008). Farklı kaynaklardan elde edilen sayısal yükseklik modellerinin ortofoto doğruluğuna etkilerinin araştırılması. Harita Dergisi, 74(140), 45-59.
22. Ulvi, A. (2021). İHA Fotogrametrisine Genel Bakış: Geleneksel Topoğrafik Harita Yapımı Tekniği ile Maliyet Karşılaştırması. Bilecik Şeyh Edebali Üniversitesi Fen Bilimleri Dergisi, 8(1), 458-471.
23. Yakar, M., Kabadayı, A., Yiğit, A. Y., Çıkıkcı, K., Kaya, Y., & Catin, S. S. (2016). Emir Saltuk Kümbeti fotogrametrik rölöve çalişmasi ve 3boyutlu modellenmesi. Geomatik, 1(1), 14-18.
24. Doğruluk, M., Aydin, C. C., & Yanalak, M. (2018). Kırsal Alanlarda SYM Üretiminde Filtreleme Yöntemlerinin Performans Analizi: Hava LiDAR Uygulaması; İstanbul Örneği. Geomatik, 3(3), 242-253.
25. Alptekin, A. & Yakar, M. (2020). Heyelan bölgesinin İHA kullanarak modellenmesi. Türkiye İnsansız Hava Araçları Dergisi, 2 (1), 17-21
26. Akgül, M., Yurtseven, H., Demir, M., Abdullah, A. K. A. Y., 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.
27. Yakar, M., & Yilmaz, H. M. (2011). Determination of erosion on a small fairy chimney. Experimental Techniques, 35(5), 76-81.
28. Ulvi, A. (2021). The effect of the distribution and numbers of ground control points on the precision of producing orthomosaic maps with an unmanned aerial vehicle. Journal of Asian Architecture and Building Engineering, 20(6), 806-817.
29. Ulvi, A. (2022). Using UAV Photogrammetric Technique for Monitoring, Change Detection, and Analysis of Archeological Excavation Sites. ACM Journal on Computing and Cultural Heritage.
30. Yakar, M. & Doğan, Y. (2017). Mersin Silifke Mezgit Kale Anıt Mezarı Fotogrametrik Rölöve Alımı Ve Üç Boyutlu Modelleme Çalışması. Geomatik, 2 (1), 11-17.