

Unmanned Aerial Vehicle (UAV) Photogrammetry, Observing, Analyzing And Reporting Of The Big Construction Projects, Ethiopia Applications

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Key Words: UAV, Photogrammetry, Railway Construction, DTM, DSM,

SUMMARY

The method of map production by using UAV photogrammetry is widely-used in Turkey and World in recent years. With the developing technology, the capabilities of UAV platforms increase in parallel with the scale of projects, which are done by using UAV's, almost reaches to enough magnitude in order to compete with manned aircraft platforms. In the article, it has been discussed in observing, analyzing and reporting of cut and fill productions within the scope of 270km railway Project in Ethiopia. In the result of article, it has been evaluated that the maps required by large-scale construction projects can be produced by using UAV's within high accuracies and it has some advantages in time and cost.

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1. INTRODUCTION

1.1. UAV Based Photogrammetry

UAV based systems; owing to cost-effective positional data, in the field of geoscience, every day it draws more attention. With the developing platforms and the software used, the usage areas of UAV in the mapping sector are rapidly increasing day by day.

There are many current applications for UAV in photogrammetry and remote sensing, and that the current trend in increasing demand for UAV geospatial systems appears unstoppable (Colomina, I.,2014).

1.2 History

UAV-based remote sensing studies have been carried out for many decades. In the late 1970's fixed wing remote controlled aircrafts have been investigated for first motorized UAV photogrammetry experiments (Przybilla, H. at al, 1979).

In our country, it has started to be used for the last seven years. Despite the fact that it is used very shortly in our country, the size and number of the projects realized with UAV based photogrammetry are rapidly increasing thanks to the capabilities of the UAV platforms.

Recently, unmanned aerial vehicles (UAVs) have evolved to off-the-shelf platforms for remote sensing applications and photogrammetric data acquisition. Early work started back in the 2000 with mainly model air-planes and helicopters (Hongoh, D., 2001).

The reason why the UAV system is so important is that UAV systems that integrate with GNSS technology support RTK (Real Time Kinematic) and PPK (Post Process Kinematic) measurement methods.

1.3 Usage Areas

Thanks to the speed, cost and accuracy advantages provided by the UAV-based photogrammetry, UAV systems are used in every area in which mapping are needed commonly. Following items can be considered as the main application areas.

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- Orthophoto and Current Map Production
- Construction Mapping / Production Monitoring Reporting
- Monitoring of Disaster Areas
- Military Purpose Map and Orthophoto Productions

1.4 Software Used

The most important component of the software required for mapping with the UAV-based photogrammetry is the photogrammetric bundle block adjustment software that calculates the geodetic coordinates (X, Y, Z) of the photo center points and orientation Yaw, Pitch, Roll angles (Omega, Phi, Kappa).

Another factor that affects accuracy is the accurate and precise calculation of camera parameters. This is primarily related to the calibration/quality of the camera and lens used, and the adjustment software also has a direct impact. By means of the camera parameters obtained as a result of the adjustment of the captured aerial photographs, the distortions in the images are eliminated and the desired accuracies are obtained.

The related softwares use mostly the "Bundle Block Adjustment" method. The most common softwares being used are listed below.

Table-1: UAV Software

Software	Country
Pix4D	Sweden
Agisoft Photoscan	Russia
Menci Photogrammetry	Italy
3DF Zafyr Aerial	Italy

The softwares used generally produces similar results. Based on the comparison results obtained in our previous tests, Pix4D software is preferred in our projects.

2. ETHIOPIA RAILWAY PROJECT

2.1 Project Area

The project area (Fig. 1) consists of a total of 270 km of railway construction routes between the Awash and Weldia regions in Ethiopia.



Figure-1: Project Route

2.2 Why Project Needed

Due to the fact that the ongoing excavation works in the project area are fragmented and the duration of project construction is short, some weaknesses such as monitoring of production made and budgeting are experienced.

Due to the short duration of the construction works compared to the project size and many worker working on the site at the same time, the construction works continue along the route very quickly. Within the scope of fast ongoing construction works, the following requirements were needed;

- Early detection of erroneous construction
- Controlling payments made for subcontractors
- Linking the building process with the project calendar in a more healthy way
- Contributing to team/equipment planning by calculating remaining quantities
- More effective management of the project budget.

It has been decided to make precise maps with UAV, in the direction of all these needs. The main reasons for choosing UAV can be listed as follows:

- Mobilization of the UAV system is easy, fast and less costly
- Flight permits of the UAV system are much easier and faster
- They are affected much less than meteorological conditions

With this project, it is aimed to monitor and report of production on the construction site by making flights at intervals of two months. This will ensure that the top management is able to make a health decision on issues such as updating the project budget, progress payments and revision of the project plan.

3 PROJECT PHASES

In carrying out the project, the following work steps were followed.

3.1 Determination of Project Requirements

Project parameters were determined by taking the following criteria into consideration.

- Project purpose and size
- Topography and meteorological conditions
- Relevant civil aviation regulation
- Target accuracy/precision values, project duration, budget and expected products

The specified project parameters are as follows;

Table-2: Project Parameters

Parameter	Value
Project Length	270km
Corridor Width	80 m-340 m
Photo GSD	5cm
Flight Height	205m
Target Accuracy	<10 cm (horizontal and vertical)

3.2 Jeodetic Works

In the project area, in addition to the currently used ground control points (GCP) for the construction works, new control points (Fig. 2) have been established.



Figure-2: A Few Examples of Ground Control Points Air Marking

Approximately in every 500 m, GCP's are established and the geodetic coordinates of these points are determined by the RTK (Real Time Kinematic) measurement method. In the RTK measurement method, the Ground Control Points which previously produced by the static method have been installed as bases and the new points have been coordinated with the RTK method using these base stations. Coordinates of new Ground Control Points were determined with $\pm 5\text{cm}$. All ground control points are painted with white color as air marking and made ready for flight. 588 GCP were established in the all of project area.

3.3 Preparation of Flight Plans and Flight

3.3.1 Criteria's of Flights Plan

The flight planning is the first step in photogrammetric project. In order to use new technologies and to get optimum profits, it is required to prepare an efficient flight plan. Since GPS technology has been used successfully in photogrammetry, planning of a flight for acquiring aerial photographs cannot be considered as separately (Vergouw B., 2006). Nowadays, most of the planes, designed for aerial photography, have GPS and computer aided flight management system. To use these systems effectively, the first and the basic principle is preparing the flight plans in digital formats and entering these data to the system digitally. A Flight Plan (Fig.3) consists of the following criteria's;



Figure-3: An Example of Flight Plan

- Desired Ground Sampling Distance (GSD)
- Project boundaries
- Topography
- Camera and lens used (sensor size and focal length)
- Flight endurance of the UAV
- Current laws and regulations (max. flight height etc.)
- Side and forward overlap percentages

Flight plans in this project have been prepared taking into consideration the above criteria's.

3.3.2 Flight

Between 20 and 25 February 2016, a flight of route of 270 km was performed. A total of 860km was flown and 28.875 pictures were taken.

3.3.3 UAV Platform Used

The fixed-wing UAV platform used for the image data acquisition in project is shown in Figure 4, Technical Specifications in Table 3.

Fixed-wing is a term mainly used in the aviation industry to define aircraft that use fixed, static wings in combination with forward airspeed to generate lift(Vergouw B., 2006).



Figure-4: UAV

Table-3: UAV Technical Specifications

Parameter	Value
Duration of the Flight	160 minutes
Camera / Sensor	Sony A6000
Data Link Distance	40 km
Launch	Catapult
Landing	Parachute / Belly (skid) landing
Body frame material	Carbon/Kevlar
Wind Durability	33 knots
Operating Temperature	-25C between +45C

3.4 Photogrammetric Data Process Activities

After passing through the following stages beloved, results data were obtained from the photographs taken by the UAV.

- Taking of aerial photographs by using UAV (RAW, JPEG format)
- Processing RTK data of captured photos. (Post-processing)
- Detection of faulty and unnecessary photos and radiometric corrections
- Aerial Triangulation and adjustment by using Pix4D software
- Quality Control of Aerial Triangulation
- Point Cloud Generation
- Digital Surface Model (DSM) and Colored True Orthophoto Production
- Dense Cloud Classification and DTM generation
- Volume Calculations

3.4.1 Image Radiometry

The radiometric quality of the images is critical in order to enable the application of quantitative remote sensing methodologies for a successful estimation of biophysical parameters from remote sensing imagery (Berni J.A., 2013).

Photographs obtained using UAV (Fig. 4). were recorded in RAW data format. Thus, it is possible to improve the obtained photographs with radiometric correction processes. Radiometric correction was performed by CaptureOne software and photographs shown in Fig.5 and Fig.6 were obtained.

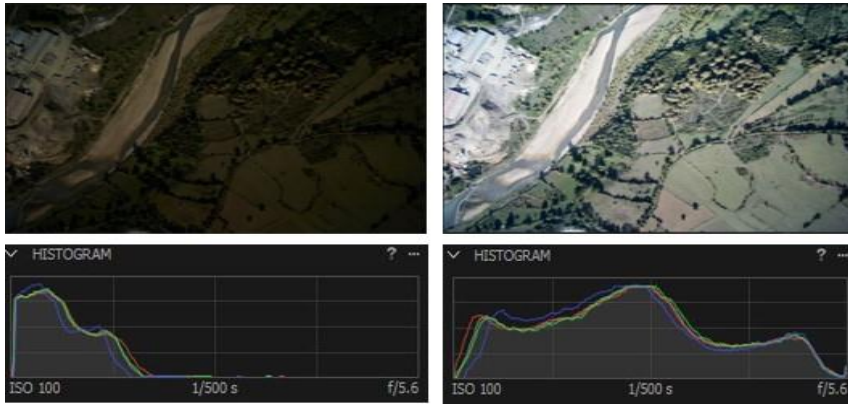


Figure-5: Before Correction Figure-6: After Correction

3.4.2 Block Adjustment and Aerial Triangulation

Automatic Aerial Triangulation (AAT) to determine the orientation of the captured images usually is the first step of photogrammetric evaluation. The traditional, long established and proven photogrammetric AAT software was not able to process UAV blocks (Qin, R., 2013). Commercially UAV software systems to solve this task are available for more than a decade (Tang, L., 1997).

Pix4D software is used for Bundle Block Adjustment. The main purpose of the aerial triangulation (Fig.7) is to find the geodetic coordinates (X, Y, Z) and orientation Yaw Pitch Roll angles (Omega, Phi, Kappa) of the photo center points using GPS, IMU data and ground control points.



Figure-7: Steps in Data Process

In this stage called "Initial Processing"(Fig.8), the algorithms and operations applied to the background can be listed as follows.

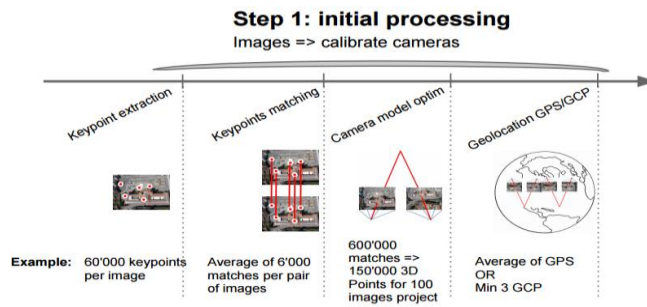


Figure-8: Initial Processing

- Keypoint Extraction: Finding similar points between pairs of images
- Keypoint Matching: Matching up this keypoints with images
- Camera Model Optimization: Calculation of camera internal and external parameters
- Geolocation GPS/GCP: Geolocation of photographs using GPS and ground control points

The adjustment results (Fig.9) for a sample block of approximately 15 km long are realized as follows.

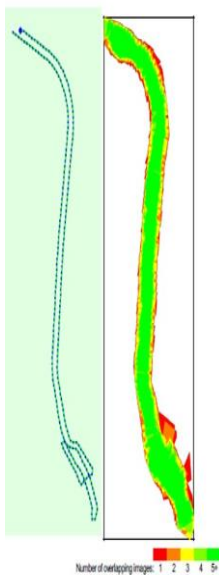


Figure-9: Adjustment Results

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Table-4: Root Mean Square Errors of Ground Control Points

GCP Name	Error X (m)	Error Y(m)	Error Z (m)	Projection Error (pixel)
149360 (3D)	0.001	0.002	0.007	0.766
149660 (3D)	-0.001	0.004	-0.015	0.590
150480 (3D)	0.024	-0.031	0.055	0.373
150730 (3D)	-0.067	0.045	- 0.077	0.228
151000 (3D)	0.065	-0.017	0.057	0.866
151480 (3D)	-0.024	0.011	0.029	0.430
151870 (3D)	0.033	-0.039	-0.032	0.005
152450 (3D)	-0.028	0.040	-0.058	1.311
152870 (3D)	0.028	-0.023	-0.047	0.328
153230 (3D)	0.000	0.005	-0.000	0.520
153900 (3D)	-0.019	-0.022	0.006	0.365
154010 (3D)	0.029	0.003	0.005	0.649
154050 (3D)	0.013	0.026	0.036	0.179
154100 (3D)	-0.016	0.007	0.019	0.261
155520 (3D)	0.021	0.006	0.022	0.496
155650 (3D)	-0.011	-0.002	0.003	0.708
157400 (3D)	-0.000	0.001	-0.000	0.436
157750 (3D)	0.005	-0.012	-0.006	0.412
158050 (3D)	-0.020	-0.016	0.009	0.377

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158400 (3D)	0.008	-0.005	0.004	0.396
158600 (3D)	-0.025	0.002	0.009	0.120
158900 (3D)	0.013	0.003	-0.031	0.748
159100 (3D)	0.002	0.012	0.045	1.258
159350 (3D)	-0.012	-0.014	0.006	0.477
159981 (3D)	-0.009	-0.004	0.021	0.308
160790 (3D)	0.006	0.003	0.008	0.425
161350 (3D)	-0.007	-0.003	0.003	0.344
162100 (3D)	0.011	0.004	0.006	0.480
163220 (3D)	0.006	-0.003	0.004	0.415
163610 (3D)	-0.003	0.007	-0.007	0.334
163981 (3D)	-0.009	-0.012	0.000	0.500
163982 (3D)	0.026	0.017	-0.036	0.505
2203 (3D)	-0.008	-0.004	-0.007	0.191
156400 (3D)	-0.000	0.002	0.002	0.316
2204 (3D)	0.002	0.001	0.002	0.249
BH157950 (3D)	0.019	0.025	0.051	0.615
BH159600 (3D)	0.009	0.010	-0.002	0.156
2208 (3D)	-0.012	0.005	0.002	0.286
Mean (m)	0.001014	0.000779	0.003312	
Sigma (m)	0.021329	0.016103	0.027617	
RMS Error (m)	0.021353	0.016121	.027815	

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As can be understood from the table, the horizontal and vertical root mean square errors (RMSEs) of Ground Control Points were realized as +/- 2 cm and +/- 3 cm. and the camera parameters are also calculated as follows.

Table-5: Camera Parameters

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	3.752.228 (pixel) 16.000 (mm)	2.736.000 (pixel) 11.667(mm)	1.824.000(pixel) 7.778 (mm)	0.00 0	0.00 0	0.00 0	0.00 0	0.00 0
Optimized Values	3.788.726(pixel) 16.156(mm)	2.632.044pixel 11.223 (mm)	1.769.007(pixel) 7.543 (mm)	- 0.01 9	0.03 0	- 0.01 6	- 0.00 1	- 0.00 2

3.4.3. Point Clouds and Digital Surface Model (DSM) Generation

Digital surface models (DSM) and orthophotos are the two main mapping products of UAV photogrammetry and remote sensing. In principle, once images are oriented and, possibly, calibrated, deriving DSM and orthophotos are routine tasks that have already been automated in photogrammetry and remote sensing since more than 20 years ago (Krzystek, P., 1991). Technically point cloud is a data base containing points in three-dimensional coordinate system. However from the typical workflow perspective the only important thing is, that point cloud is a very accurate digital record of an object or space. It is saved in form of a very large number of points that cover surfaces of a sensed object.

In aerial adjustment, Point cloud is generated from photographs of which geodetic coordinates (X, Y, Z) and orientation Yaw Pitch Roll angles (Omega, Phi, Kappa) are combined and precisely calculated. The Pix4D software generates point cloud in the form of DSM after balancing, and is offered to the user with a Point Cloud frequency option (Fig..10).

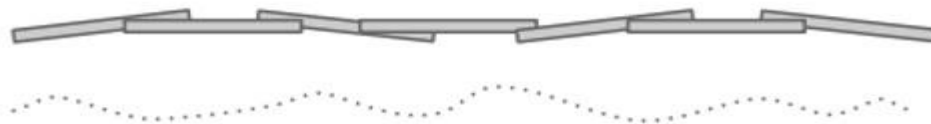


Figure 10. Photos-Point Cloud Schematic

For this project, Point Cloud Generation has been referred as 2 pixel intervals.

3.4.4. Point Cloud Classification and Digital Terrain Model (DTM) Generation

The most critical and longest process in the project is point cloud classification. The raw point cloud generated in Pix4D is divided into Ground and Default classes by the operators. The process steps in the Point Cloud classification "(Fig.11) are as follows:

- Application of the automatic classification macro to the Raw Point Cloud for batch processing in Terrasolid Software
- Rough Orthophoto Creation
- Cleaning and / or correction of defect points in the ground class that are automatically separated
- Quality Control of Point Cloud Classification
- Final Orthophoto Creation

The obtained DTM cannot be used directly in CAD / GIS software because of it is composed of many points. For this reason, sampling should be done without compromising on neither accuracy nor loss of data. This process is called "Model Key Point" creation Creating "Model Keypoint" (Fig.12) to point of the sparse model without losing details of the terrain.



Figure 11. Point Cloud Classification

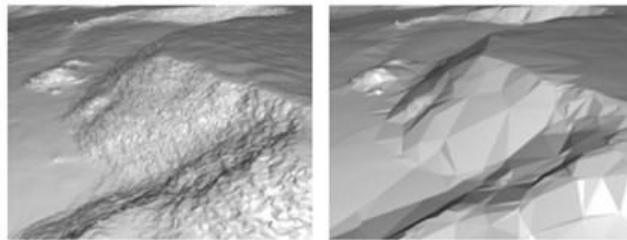


Figure 12. Model Keypoints

3.5. Orthophoto and Digital Surface Model (DSM) Production

Following the production of Point Cloud, DSM has been developed. The DSM data consisting of all the details on the ground was created in Geotiff format. Through the Pix4D software "Mosaic Editor" tool, the final orthophoto production has been completed by eliminating both color and geometric defects. In the Fig.14, the conceptual difference between DSM and DTM has been tried to be expressed. Often they can be confusing and also misinterpreted to mean the same thing.

3.5.1 Digital Terrain Model (DTM)

A DTM is that represents the elevation of the bare earth without taking into account any overground features (e.g. trees, buildings). The DTM data of the Kombolcha/Ethiopia station area in the scope of the project is shown in Figure 13.

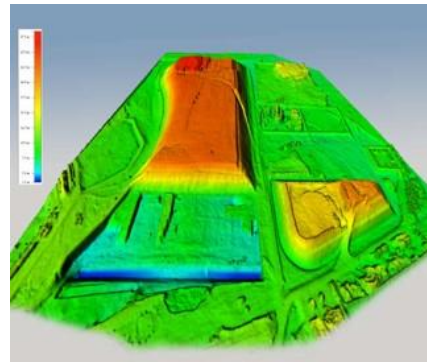


Figure-13: DTM (Digital Terrain Model)

3.5.2 Digital Surface Model (DSM)

A DSM is that represents the elevation of the surface a remote sensing system will first meet (i.e. when aerial photography is undertaken the top of a building, forest, etc.). Thus, the resulting DSM includes (Fig. 14) the elevation of the bare earth terrain plus the natural (e.g. trees, shrubs) and man-made features (e.g. buildings).

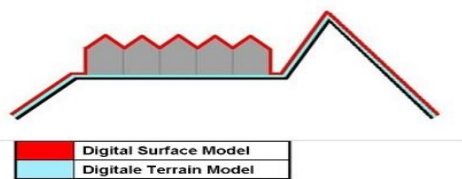


Figure-14: Conceptual Display of DTM & DSM

Digital Terrain Models (DTMs) are getting more and more important in geographical data processing and analysis: they allow modelling, analysis and visualization of phenomena related to the territory morphology. DTM accuracy should be consider to purpose of projects. The term precision is considered as a component of accuracy, related to the scale, resolution, and also to the generalization of datasets (Podobnikar T. 2005)

3.6 Calculate the Volume of Cut/Fill and Analyzing &Reporting

One of the result products of digital terrain models is volume. Calculating the volume can be calculated as described below in different ways according to data rate and data order. (Yanalak, 1997).

- Calculating the volume of excavations from contour lines
- Calculating the volume using Parallel Cross Sections
- Calculating the volumes by Random Distributed Data

In our project, Cut / Fill volumes were determined according to Volume Account with Parallel Sections. In the following figure (Fig.15); the surfaces defined as red line shows the project height, the surfaces referred to as black line shows the actual digital terrain height obtained with the UAV flights.

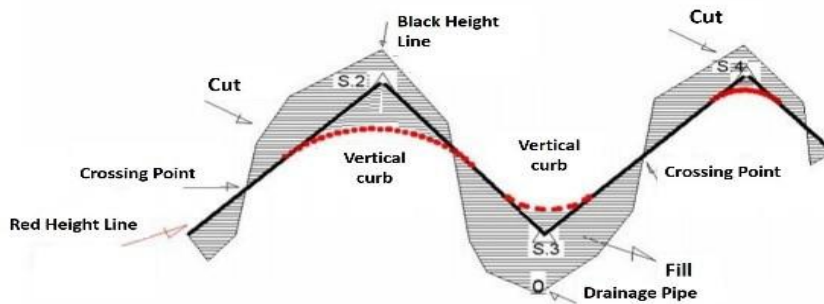


Figure-15: Project Surface

The scanned area between 2 red&black lines is cutting and filling areas. Where black height is greater than red height, the terrain will be cut up to the red level, where black height is below the red height, these areas will be filled up to the red level.

Calculations the volume of cube were performed using Bentley InRoads software. By using excavation level (Fig.16), project level and raw terrain level (Fig.17) Obtained with flight data are used; amount of excavation and remaining excavation amounts as of the date of the flight are reported on each kilometer basis.

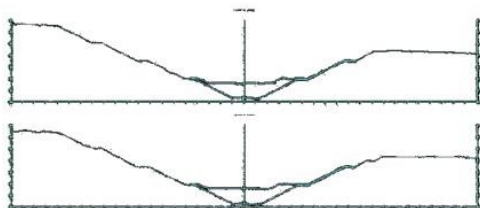


Figure-16: An Example of Cross Section



Figure-17: Example of Length Section

Orthophoto and DTM data of the station area are shown in Fig.18 and Fig.19. Cube calculations in this area were made by taking the cross sections with 5m intervals (Fig.20).

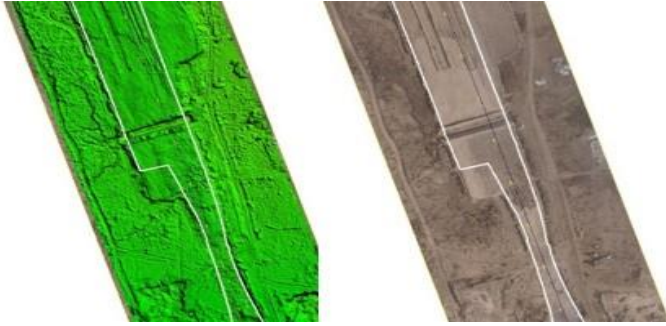


Figure-18: Station Region DTM Figure-19: Station Region Orthophoto

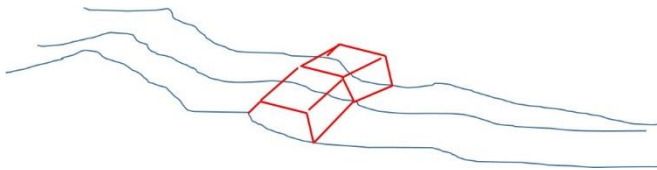


Figure-20: Cross Section with 5 m. intervals

CONCLUSIONS

Owing to the final products obtained at the end of the project, project managers made better planning and made more accurate decisions, At this point, the possible cost and time losses were prevented. The duration of the project was 40 days including total flights considering the high accuracy of the obtained data, time and cost advantages, it is evaluated that the UAV-Based Photogrammetry can meet all kinds of mapping needs of such projects.

It is seen in this study, although UAV photogrammetry has many advantages relative to field surveying. Highly overlapped vertical aerial images of UAV photogrammetry are capable to make higher dense and more reliable spatial products (Saadatseresht, M. 2015).

UAV photogrammetry is a faster method for making higher quality, more reliable, and more diversity of products with legal validity, it costs several times less than field surveying due to its process automation without any huge field workings. Major advantages of UAVs compared to manned aircraft systems are that UAVs can be used in high risk situations without endangering a human life and inaccessible areas, at low altitude and at flight profiles close to the objects where manned systems cannot be flown (Eisenbeiss, H., 2009). Sauerbier et al. (2010) conducted documentation works in three different archaeological field using two different UAVs. Accuracy of the data obtained have been examined and as a result of the tests it has been confirmed that UAV can be used in the archaeological and cultural heritage works.

Similarly, Turner et al. (2011), they obtained high-resolution images by using UAV, in Frogmore Creek vineyards of South Tazmany. Utilizing these images obtained through the UAV's, it has been shown that information such as the development of grapes, whether or not the area is diseased can be obtained much more easily and much more quickly. Niethammer et al. (2010), using the photos taken by the UAV in Super-Sauza France, he has created the digital terrain model of that risky area which it is active since 1970. Ying-Cheng et al. (2011), they produced a high-precision topographic map of an island in China using images being obtained from UAV. Rokhmana (2017) obtained geoinformation data needed to evaluate the impact area of Indonesia by using UAV, which are various kinds of natural disasters happen.

As can be seen, the accuracy and advantages of the data obtained through the UAVs make the UAVs a serious alternative to conventional surveying planes in topographic map production.

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REFERENCES

BERNI J.A., SUAREZ L, DUGO G., FERERES E., (2013): Remote Sensing of Vegetation From UAV Platforms Using Lightweight Multispectral and Thermal Imaging Sensors, Inter-Commission WG I/V.

COMERT, R., AYDAN U., SENKAL E. (2012): Unmanned Aerial Vehicles Usage Areas and Future Expectations, 4.GIS Symposium ,16-19 October 2012, Zonguldak .

COLOMINA, I., and MOLINA, P, (2014): Unmanned Aerial Systems for Photogrammetry and Remote Sensing: a Review, ISPRS Journal of Photogrammetry and Remote Sensing, 92:82–95.

DEMIREL A.S., AKDENIZ H., AKSU O.,(2007): Two Functional Software for Internal use; Flight Planning and Presenting of Digital Orthophotos, Harita Genel Komutanlığı, 06100 Cebeci Ankara, Turkey - (sdemirel, hakdeniz, oaksu)@hgk.mil.tr Commission IV, WG IV/5.

EISENBEISS, H., LAMBERS, K., SAUERBIER, M., (2005): Photogrammetric recording of the archaeological site of Pinchango Alto (Palpa, Peru) using a mini helicopter (UAV). In: Proc. of the 33rd CAA Conference, Tomar, Portugal.

EISENBEISS, H.,(2009): Doctoral Thesis "UAV photogrammetry" Permanent Link: <https://doi.org/10.3929/ethz-a-005939264>.

HONGO, D., KAJIWARA, K., and HONDA, Y.,(2001): Developing ground truth measurement system using rc helicopter and brdf model in forest area. In: 22nd Asian Conference on Remote Sensing, Vol. 5, Sigapore, p. 9.

KRZYSZEK, P.,(1991): Fully Automatic Measurement of Digital Elevation Models with MATCH-T. In: 43rd Photogrammetric Week. Institut für Photogrammetrie, Universität Stuttgart, Stuttgart, Germany, pp. 205–211.

PRZYBILLA, H.-J. and WESTER-EBBINGHAUS, W.,(1979): Bildflug mit ferngelenktem Kleinflugzeug. Bildmessung und Luftbildwesen, Zeitschrift fuer Photogrammetrie und Fernerkundung, 47(5), pp. 135-140.

ROKHMANA C.A., ANDARU R.,(2017): AIP Conference Proceedings 1857, 100009 <https://doi.org/10.1063/1.4987115>.

SAADATSERESHT, M. , A.H. HASHEMPOURB , M. HASANLOUA, (2015): UAV Photogrammetry: A Practical Solution For Mapping Projects, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-1/W5, 2015 International Conference on Sensors & Models in Remote Sensing & Photogrammetry, 23–25 Nov 2015, Kish Island, Iran.

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SAUERBIER, M. And H. EISENBEISS, (2010): UAVs For The Documentation of Archaeological Excavations, International Archives Of Photogrammetry, Remote Sensing And Spatial Information Sciences 38(Part 5).

QIN, R., GRUN, A.,HUANG,X.,(2013):UAV Project–Building a Reality-Based 3D Model.Coordinates 9,19–25.

RANGO, A., LALIBERTE, A., STEELE, C., HERRICK J. E., BESTELMEYER B., SCHMUGGE T., ROANHORSE A., JENKINS V., (2006).Using Unmanned Aerial Vehicles for Rangelands: Current Applications and Future Potentials. Environmental Practice 8(3): 159.

PODOBNIKAR T.,(2005): Production of Integrated Digital Terrain Model From Multiple Datasets of Different Quality, IJGIS, 19/1, 71–86.

NIETHAMMER, U., ROTHMUND, S., JAMES, M. R., TRAVELLETTI, J., & Joswig, M. , (2010): UAV-based remote sensing of landslides. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 38(Part 5), 496-501.

TANG, L., BRAUN, J., DEBITSCH, R.,(1997): Automatic Aerotriangulation - Concept, Realization and Results. ISPRS Journal of Photogrammetry & Remote Sensing 52, 120- 130.

TURNER, D., A. LUCIEER,(2011): Development Of An Unmanned Aerial Vehicle (UAV) For Hyper-Resolution Vineyard Mapping Based On Visible, Multispectral And Thermal Imagery.

VERGOUW B., NAGEL H., BONDT G., and CUSTERS B.,(2006): Drone Technology: Types, Payloads, Applications, Frequency Spectrum Issues and Future Developments www.springer.com/cda/9789462651319-c2.pdf.

YING-CHENG,L., DONG-MEI.Y., (2011): Aerial Photograpy Technology in Island Topografic Mapping, International Symposium on Image and Data Fusion (ISIDF),pp,11-4.

BIOGRAPHICAL NOTES

B.Sc. Sinan ALTINISIK

1988 – 1992 Yildiz Technical University, Geodesy and Photogrammetry Eng., ISTANBUL, Professional Experience - Pioneered Areas

– UAV Based on Photogrammetry Technologies Specialist : Through the latest state of the his owned UAV with high technology, having great experience in the ongoing delivery of services to its users about all kinds of applications.

– Airborne Lidar (Light Detection and Ranging) Survey and Mobile Laser Scanning Technologies Specialist : To have a great experience at all phases of fastly, accurately and cost effectively production with LIDAR Technologies.

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– 3D Modelling via Oblique Photogrammetry Specialist: Being a pioneer and to have great experience at all phases in 3D Modelling Production through Oblique Cameras mounted to his owned UAV system

M.Sc. Semih Seckin KAVLAK

Kocatepe University, Geodesy and Photogrammetry Faculty, AFYON (2009-2013)

Professional Experience

– UAV Based on Photogrammetry Technologies Specialist

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