Proc. 29th National Conference with International Participation "Telecom 2021", October 28 - 29, 2021, Sofia, Bulgaria

Pasture research using aerial photography and photogrammetry

Kalin Dimitrov
Department of Radiocommunications and Videotechnologies
Technical University of Sofia
Sofia, Bulgaria
kld@tu-sofia.bg

Durhan Saliev
Department of Combustion Engines, Automobile Engineering and Transport
Technical University of Sofia
Sofia, Bulgaria
durhan_saliev@tu-sofia.bg

Iliyan Damyanov
Department of Combustion Engines, Automobile Engineering and Transport
Technical University of Sofia
Sofia, Bulgaria
idamyanov@tu-sofia.bg

Tsvetan Valkovski
Department of Radiocommunications and Videotechnologies
Technical University of Sofia
Sofia, Bulgaria
cvalkovski@tu-sofia.bg

***Abstract* — This article focuses on the topic of using unmanned aerial vehicles and modern software solutions and systems in the study of pastures, using aerial photography and aerial photogrammetry.**

Keywords* — *unmanned aerial vehicle, aerial photography, aerial photogrammetry, image analysis, pastures.

I. Introduction

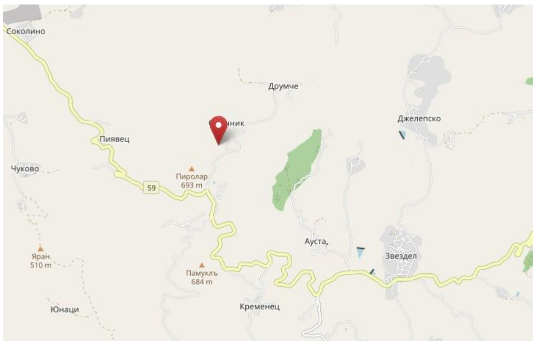
One of the approaches to solving the problems related to the conservation of biodiversity and pasture livestock is the introduction of modern methods and systems for monitoring, management and optimization of pasture areas. The method based on aerial photography is increasingly used in determining the main characteristics of grazing areas [1-5]. The use of unmanned aerial vehicles allows obtaining spatial data, high performance in the study of large areas, flexible and continuous process of data collection without significant influence of weather conditions. This, in turn, allows large and remote grazing areas to be studied and explored in order to take the necessary concrete measures to improve their natural biological environment.

II. System Description

Photogrammetry is a science that uses images to obtain reliable information about physical objects and the environment, through the process of capturing, measuring and interpreting photographic images and models for mapping, measuring distances and other phenomena [6-8]. The minimalist definition of photogrammetry would be: using photos to take measurements. The term "photogrammetry" itself has Greek origins and consists of 3 words: photos - light, gramma - recording and metreo - measurements.

The process uses a sufficient number of captured two-dimensional (2D) photographic images, which after processing by various software packages are used to create three-dimensional (3D) digital models, topographic images or simulations of meteorological models [6-9]. The hardware for software integration in new technologies is so advanced that most photogrammetry operations occur automatically. Photogrammetry is most often associated with the production of topographic maps in general from conventional aerial two-dimensional photographs, although digital and satellite images are increasingly used. Photogrammetry using images obtained from aircraft and satellites is used to create maps at various scales [10-13].

Experimental study, using UAVs and software for three-dimensional photogrammetry, to determine some parameters of a specific pasture zone was performed on 25.06.2021 in the land of the town of Kardzhali in the Republic of Bulgaria with geographical coordinates 41°29'39.7"N and 25°28'44.8 "E (Figure 1) [14].



a

b

Fig. 1. Location 41°29'39.7"N and 25°28'44.8 "E (**a**) and view of the studied pastures (**b**).

The work is done in connection and with the financial support of the project DO1-62/18/03/2021, WP4.

For the purposes of the study, a PHANTOM aircraft, model 4 PRO (Fig. 2) was used, equipped with a specialized high-resolution camera providing excellent characteristics for performing aerial photogrammetry.

a

b

Fig. 2. Photo of the unmanned aerial vehicle used for the research in one of the laboratories of the Technical University (**a**) and during the flight (**b**).

When using UAVs for photogrammetry purposes, it is necessary to capture the images sequentially, because even if only one image is not captured sequentially, the model we want to create through software processing will be incorrect. Camera settings are also crucial for creating a smooth and legible image.

The image processing software used is one of the most affordable, for fast and accurate enough primary processing without purchasing a license (free access for 14 days) is DroneDeploy [15]. After starting the application, recognizing and establishing communication with the UAV, all the necessary parameters for performing the flight zone and shooting are determined.

The perimeter of the examined area is determined by entering exact benchmarks (coordinates), the desired altitude for the flight and the shooting, after which the software determines the exact trajectory, the shooting angle and the required minimum number of photos for the studied area.

III. Results

In the primary experimental study, the choice of altitude for UAV flight is 40 meters due to the specific area of the surveyed area. The software used allows the flight to be selected to follow the terrain (Fig. 3), in order to best capture and subsequent mapping.

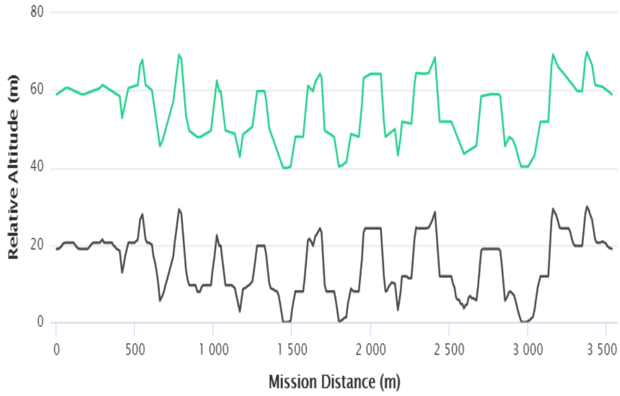
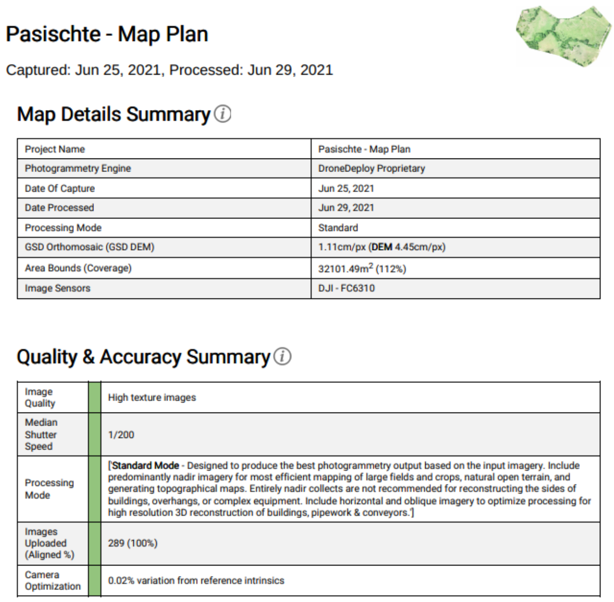


Fig. 3. Altitude data when following the terrain during the flight.

When determining the studied pasture area, the flight plan, sequence and number of images, the required overlap between consecutive images, total area of the shooting area, resolution - the resolution of the processed images presented as the number of centimeters per pixel. After determining the survey area and determining the altitude of the flight by the operator, the software calculates the minimum number of consecutive shots (in our case 289 frames) and the total time required to perform the flight (16:58 minutes). The state of charge of the drone battery is checked and if it is sufficient, the flight is performed. When exploring larger areas, the flight time and trajectory increase, if the capacity of the drone's battery is insufficient to perform the entire shooting, the drone lands at a location specified by the software, after replacing the UAV battery, the shooting continues. The camera settings during shooting can be in automatic or manual mode, it is provided and it is possible to use the setting through the main software of the drone. After the flight and shooting, the images are processed by the software. Figure 4 shows the report of the processed images, which contains all the necessary information for further processing and research. Information is provided for automatic alignment of the map with an existing previous map in the same place, as well as information about the average GPS error of the captured images.



Pasischte - Map Plan

Captured: Jun 25, 2021, Processed: Jun 29, 2021

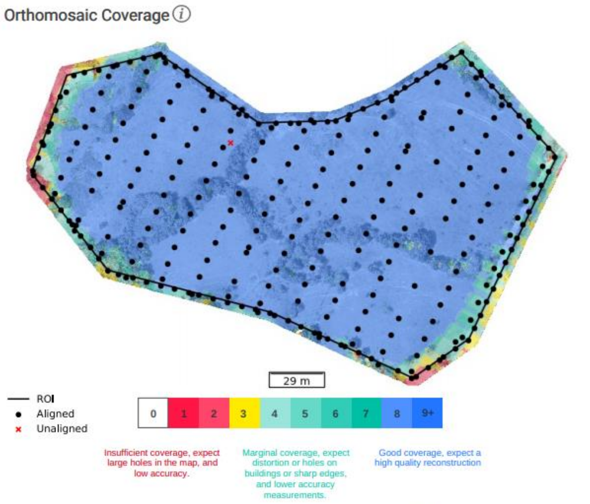
Map Details Summary

Project Name	Pasischte - Map Plan
Photogrammetry Engine	DroneDeploy Proprietary
Date Of Capture	Jun 25, 2021
Date Processed	Jun 29, 2021
Processing Mode	Standard
GSD Orthomosaic (GSD DEM)	1.11cm/px (**DEM** 4.45cm/px)
Area Bounds (Coverage)	32101.49m^2 (112%)
Image Sensors	DJI - FC6310

Quality & Accuracy Summary

Image Quality	High texture images
Median Shutter Speed	1/200
Processing Mode	['**Standard Mode** - Designed to produce the best photogrammetry output based on the input imagery. Include predominantly nadir imagery for most efficient mapping of large fields and crops, natural open terrain, and generating topographical maps. Entirely nadir collects are not recommended for reconstructing the sides of buildings, overhangs, or complex equipment. Include horizontal and oblique imagery to optimize processing for high resolution 3D reconstruction of buildings, pipework & conveyors.']
Images Uploaded (Aligned %)	289 (100%)
Camera Optimization	0.02% variation from reference intrinsics

a



Sensor(s) Used	DJI - FC6310
Image Count (by sensor)	289
Image Resolution	4864x3648 (~18MP)
Orthomosaic coverage (% of area of interest)	112.14
Average Orthomosaic Image Density within Structured Area	32 images/pixel
Median Shutter Speed	1/200

b

Fig. 4. Information about the captured area (**a**) and the images taken and processed (**b**).

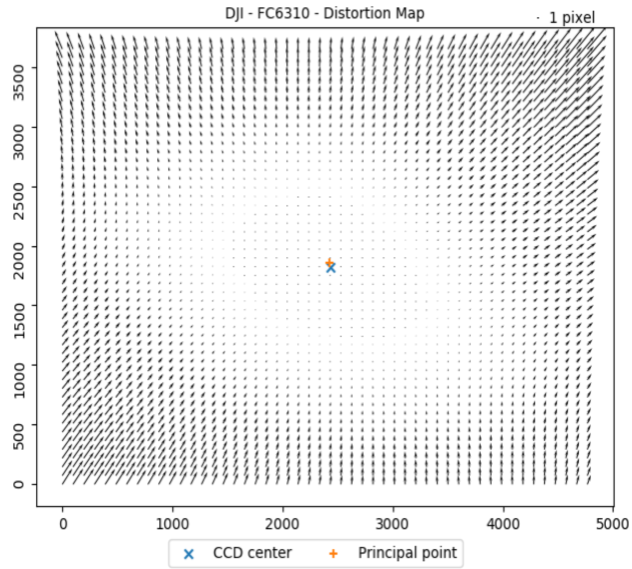
The processed images of the studied area provide an opportunity to determine all the necessary parameters - terrain, slopes, determine the geographical coordinates of each point for the studied area, determine the exact volume characteristic of selected elements, determine the exact area of a study area. It is possible to determine several zones simultaneously, measure the distances between individual points in the horizontal and vertical planes, and measurements in all planes are possible. The processed images for the studied terrain are detailed and allow to determine visually many specific elements with sufficient accuracy. Figure 5 and table 1 shows the three grazing areas of the studied terrain.

Fig. 5. Information on all necessary areas for the studied pasture.

The calibration of the camera is shown in Figure 6. In an ideal workflow, the calibration diagram of the camera would be symmetrical and the blue / red cross dots are close to each other or overlap.

TABLE I. AREAS OF THE STUDIED TERRAIN

Label	Title	Area
2	Pasture 1	0.58 ha
3	Pasture 2	0.85 ha
4	Pasture 3	1.09 ha
5	Study area	3.21 ha



	Fx	Cx	Cy	k1	k2	k3	p1	p2
Value	3667.23	2427.19	1855.32	0.00583579	-0.0165782	0.0182504	0.00306909	0.00105123
Error	0.153786	0.0857263	0.101882	0.507642	1.75812	1.82647	0.0284517	0.0347994

Fig. 6. Camera calibration.

IV. CONCLUSIONS

The present study presents the possibilities for using photogrammetric techniques for research and decision making in the management of large pasture areas. Compared to conventional practice, photogrammetry provides an opportunity to save time in effective large-scale research on large areas. Using a portable management system as a reference system, the 3D photogrammetry method can be used in pasture management. The measurement results can be used to determine the required terrain and areas for pasture management and to determine the available biomass. Pasture management solutions need to cope with the ever-increasing demand, as more different species congregate in pasture areas, there is more food for birds, reptiles, amphibians, and there are more insects.

The study shows that the use of unmanned aerial vehicles and digital photogrammetry software has a growing potential for research and management of large pasture areas.

References

[1] I. Sinde-González, M. Gil-Docampo, M. Arza-García, J. Grefa-Sánchez, D. Yánez-Simba, P. Pérez-Guerrero, V. Abril-Porras, „Biomass estimation of pasture plots with multitemporal UAV-based photogrammetric surveys," International Journal of Applied Earth Observation and Geoinformation, vol. 101, pp. 102355, 2021.

[2] J. Gillan, M. McClaran, T. Swetnam, P. Heilman, "Estimating Forage Utilization with Drone-Based Photogrammetric Point Clouds," Rangeland Ecology & Management, vol. 72 (4), pp.575-585, 2019.

[3] J. Hadfield, B. Waldron, S. Isom, R. Feuz, R. Larsen, J. Creech, M. Rose, J. Long, M. Peel, R. Miller, K. Rood, A. Young, R. Stott, A. Sweat, K. Thornton, "The effects of organic grass and grass-birdsfoot trefoil pastures on Jersey heifer development: Heifer growth, performance, and economic impact," Journal of Dairy Science, vol. 104 (10), pp.10863-10878, 2021.

[4] M. Pecina, T. Bergamo, R. Ward, C. Joyce, K. Sepp, "A novel UAV-based approach for biomass prediction and grassland structure assessment in coastal meadows," Ecological Indicators, vol.122, pp. 107227, 2021.

[5] G. da Silva Vieira, B. Rocha, H. Pedrini, N. Sousa, J. de Lima, R. Costa, F. Soares, "Visual Detection of Productive Crop and Pasture Fields from Aerial Image Analysis," 2020 IEEE Canadian Conference on Electrical and Computer Engineering (CCECE), pp. 1-4, 2020.

[6] W. Linder, Digital Photogrammetry: Theory and Applications. Springer Science & Business Media, 2013.

[7] S. Jones, K. Reinke, Innovations in Remote Sensing and Photogrammetry. Springer Science & Business Media, 2009.

[8] F. Carvajal-Ramírez, F. Agüera-Vega, P. Martínez-Carricondo, UAV Photogrammetry and Remote Sensing. MDPI, 2021.

[9] X. Wang and J. Gao, "Study on Pastures Ecological Footprint of Baotou Region," 2009 International Conference on Environmental Science and Information Application Technology, pp. 60-64, 2009.

[10] F. Sarwar, A. Griffin, S. Rehman, T. Pasang, "Detecting sheep in UAV images," Computers and Electronics in Agriculture, vol. 187, pp. 106219, 2021.

[11] G. Abdulai, M. Sama, J. Jackson, "A preliminary study of the physiological and behavioral response of beef cattle to unmanned aerial vehicles (UAVs)," Applied Animal Behaviour Science, vol. 241, pp.105355, 2021.

[12] J. Wu, G. Zhou and Q. Li, "Calibration of Small and Low-Cost UAV Video System for Real-Time Planimetric Mapping," 2006 IEEE International Symposium on Geoscience and Remote Sensing, pp. 2068-2071, 2006.

[13] M. Nolan, C. Larsen, M. Sturm, "Mapping snow depth from manned aircraft on landscape scales at centimeter resolution using structure-from-motion photogrammetry," The Cryosphere, vol. 9, pp.1445–1463, 2015

[14] https://www.openstreetmap.org/search?query=41°29'39.7"N 25°28'44.8"E

[15] https://www.dronedeploy.com/