COMPLEX MODEL BASED ON UAV TECHNOLOGY FOR INVESTIGATING PASTORAL SPACE

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Abstract. Data from the specialized literature show that in the last decade there has been a rapid development in the use of unmanned aerial vehicles (UAV) for obtaining spatial information from the pastoral environment. The idea of investigating grassland surfaces with the help of drones was based on the following practical considerations: the size and complexity of pastoral space and the need for data acquisition in hard-to-reach areas and in a short time. In this context, the purpose of the research is to integrate UAV technology and GIS applications into pratological research, the results obtained having both practical and methodological character. For the efficient research of the pastoral space with UAV equipment, a working model was developed, complex from a technical point of view, consisting of several stages: identifying the areas of interest, planning and setting the flight parameters, "photographing" the area, downloading and image processing, and then processing the results in the GIS environment. From each stage, geospatial products can be extracted, and the final products can be used in various ways, both in the pastoral space and in other segments of the geographical environment. Following the application of the working algorithm results the orthophotoplan and the point clouds, from which can be extracted topo-cadastral information (related to the "physical" surface of grasslands), pratological information (related to vegetation and mode of use) or useful information in territorial planning (risk phenomena, relief aspects), with high precision and spatial location. Compared with the classical research methods, the use of the working model based on geomatic technologies, has the effect of reducing the working time and the number of operators, the possibility of tracking time and space of the investigated territory, but also the formation of graphic and descriptive databases that they can be used in other subsequent projects.

1. INTRODUCTION

Due to its size and complexity, the pastoral space is one of the components of the environment in which the UAV equipment and the related GIS techniques have

brought an extra in terms of: investigating the grassland surfaces (Simon et al, 2018); vegetation analysis (Cohen et al, 2018; Sona et al, 2016); biodiversity (Sun et al, 2018; Cojocariu et al, 2018); evaluation and prediction (Sanches et al, 2018; Kyriacos, 2017), etc.

The increased interest in the field of unmanned aerial vehicles (UAV) by the scientific research community, software developers, and those with experience in the field of geomatics has in recent years determined the use of these systems in the most varied models and forms, in different fields of engineering and architecture (Ezequiel et al, 2014). This is due to their flexibility of use, as well as reduced costs compared to traditional photogrammetric flights, which use expensive metric digital cameras or LiDAR sensors (Samad et al, 2013).

UAV systems are nowadays a valuable source of data for 3D mapping, surveillance, inspection and modeling (Remondino et al, 2011). Since drones can be considered as a low-cost alternative to classical aerial photogrammetry, new applications have been introduced in the short and near field. UAV systems are capable of capturing photogrammetric data with digital cameras, they can fly either in manual, semi-automatic or automatic modes.

The measurements by the UAV technology are made in a non-invasive manner, the drones leaving no traces or emissions of any kind, during or after the measurements. The measurements are made in a short period of time and with a high temporal resolution.

Following a typical photogrammetric workflow, 3D results can be produced such as: digital surface or terrain models, contours, textured 3D models, vector information, etc., on small and medium surfaces (Casian et al, 2019).

A UAV system can be used to study pastoral space, when national regulation permits, for various applications. These images have a very high resolution if the flights are made at a height of 100-120 m above the ground (Simon et al, 2018). Very large overlays of 70-75% are recommended to reduce the isolated areas and to obtain a complete and detailed image. A sufficient number of photogrammetric landmarks (GCP - Ground Control Point) is required to make geographical references of the images processed within the point cloud adjustment; the number of GCPs varies depending on the size of the investigated area and its complexity. The accuracy of the obtained point cloud is usually very high (up to a few centimeters), and these data can thus be used for further analysis and for extracting the features from the investigated area (Rusnák et al, 2017).

Currently, many photogrammetric mapping methods have used drones to retrieve and record data and phenomena on the Earth's surface (Maza et al, 2011). This is because the use of a drone equipped with GNSS system (Global Navigation Satellite System) and IMU system (Inertial Measurement Unit) for air measurements is very efficient and cheaper as compared to chartering a plane, it

also allows flying over difficult areas. accessible and significantly reduces the execution time of the work (Zhang and Kovacs, 2012).

The idea of developing a technical work scheme that integrates modern, precision means and technologies for analyzing agricultural surfaces and especially those used as pastures and meadows, is based on several practical considerations: the large size and complexity of the investigated space, the need for the rapid acquisition of pratical data, problems related to the accessibility of the territory, etc.

For a complete and complex analysis of the information, the processing of the results can be done later in Geographic Information Systems (Simon et al, 2019).

In this context, the purpose of the research is to develop a study model in the pastoral environment that integrates the UAV technology and the GIS applications, the results obtained having both practical and methodological character.

2. MATERIALS AND METHODS

2.1. Testing areas of the study model

In order to test the applicability of UAV technology in the pastoral space through the proposed working model, six areas (grassland surfaces) were selected and flown in Arad, Suceava, Caras-Severin, Hunedoara and Timis counties (fig. 1).

Figure 1. Test areas with UAV equipment (processing after www.geospatial.org)

2.2. Research methodology

The stages of the research methodology are presented schematically in fig 2.

Figure 2. Research methodology

2.3. Technical equipment used

The field stage:

- DJI Phantom 4 Pro drone - data obtained with DJI GO on manual flights and Pix4Dcapture on automatic flights;
- Leica Geosystems GNSS equipment, the GS08 Plus model - for determining the coordinates of the ground control points located on the investigated areas
- data obtained with the Leica SmartWorx application.

The office stage:

- Leica Infinity, for processing the observations obtained with the GNSS equipment;
- Agisoft PhotoScan Professional or Pix4Dmapper for aerial image processing;
- Global Mapper and Leica Cyclone for "modeling" the results obtained;
- Autodesk AutoCAD and ArcGIS for extracting the necessary information and integrating the results in the CAD environment, respectively GIS.

3. RESULTS AND DISCUSSIONS

In the last years, the automation, in all the theoretical and practical fields, is transposed through the high level of autonomous photogrammetric processing. One of the most important advantages of UAV systems is the ability to quickly provide high temporal and spatial resolution information, but also to enable rapid response in required situations (Simon et al, 2018; Raparelli and Bajocco, 2019). Another major advantage is that drones can be used in risky situations, inaccessible areas or with some political, military, social, etc. limitations (Wall and Monahan, 2011).

As the vast majority of the grassland surfaces in Romania are arranged in hill and mountain areas, which are difficult to reach, UAV techniques can facilitate the

identification and monitoring of remote grassland surfaces. In this context, we propose to go through several stages.

3.1. Flight mission planning and proper photography

In the first phase, a terrain reconnaissance is carried out and the flight plan is established together with the ground control points. The flight plan depending on the size and complexity of the investigated area and can be made using the Pix4Dcapture application so that the entire area is flown over from a single flight or a manual flight can be made through the DJI GO application. In the case of automatic flight, in the Pix4Dcapture application, the route to be followed by the drone together with the flight parameters, the height at which it will be performed, the degree of image overlap, etc. is established. If we do not use an established flight plan, all these parameters are set in real time during the flight from the DJI GO application.

The planning of GNSS determinations involves, in the first phase, establishing the approximate position of the points that will serve as photogrammetric landmarks and then of the working mode, of the sessions for realizing the observations and the stationary times. These photogrammetric landmarks whose coordinates were determined in the national Stereographic 1970 projection system realize the connection between terrain and image (fig. 3).

Figure 3. Flight mission planning

Because the battery life is about 20-25 minutes depending on the weather conditions, the route is set in such a way that it respects this time. In the event of battery depletion, the device has the ability to return to the take-off point. After replacing the battery, the drone will continue its mission exactly from where it

remained. Their own research has shown that as a flight with a battery can cover up to 40 hectares. The possibility of successive use of several accumulators allows the overgrowth of large areas of grasslands, of the order of hundreds of hectares, which, in other situations, could be crossed in a long time and with considerable effort.

Most of the missions realized through the Pix4Dcapture application were performed by simple grid flights in polygonal form with an image overlap of 80% transversal and 70% longitudinally, the camera angle was set to 90 °, and the flight altitude was set at 100-120 meters (fig. 4).

Figure 4. Setting the flight parameters

In the case of areas flown by DJI GO, decisions related to altitude, speed of movement or angle of the room are made in real time, depending on the details we want to highlight. Manual flights are recommended for panoramic images, but previous research (Simon et al, 2018) has shown that automatic flight is recommended to obtain a quality 3D point cloud and orthophoto. In the case of small surfaces, this can also be done by manual flight.

In the case of automatic flights, the images are captured automatically depending on the degree of overlap established, whereas in the case of the manual flights, the images are captured classically by pressing the camera button in the application (fig. 5).

Figure 5. Capture images

3.2. Image storage

Images were stored on the Micro SD memory card and downloaded, either through a card reader on a laptop or computer or directly into a Cloud account from which we can download them later (fig. 6).

Figure 6. Download images

3.3. Image processing

In the present study, in most cases, image processing was performed with Agisoft PhotoScan Professional software and with Pix4Dmapper software for several areas. Processing involves determining the flight path of the drone. Stereoscopic view allows viewing of an object from two different perspectives, such as aerial photography taken from different camera positions.

The result of mapping the data using the drone can produce very high resolution images, it also produces a three-dimensional image of the recorded surface. Photo alignment is done to identify the points in each photo and to make the same matching process in two or more photos (fig. 7).

In the case of a complete workflow based on the UAV technology together with the GNSS technology, we can safely say that although the automation has reached a high level of performance for the automatic extraction of the connection points and the generation of the Digital Elevation Model, a high percentage of time is absorbed by the acquisition of images and measurements of photogrammetric landmarks, especially if direct georeferencing cannot be performed.

Francesco Nex and Fabio Remondino (2014) estimated that the time required for feature extraction depends on their typology; most of the time being devoted to the acquisition of images (20%) and their processing to obtain the Digital Surface Model (25%).

Figure 7. Image processing

After completing the processing, Agisoft Photoscan Professional or Pix4Dmapper software allows us to view quality reports of the results and to export these results obtained in different extensions compatible with other applications or programs that we will use to extract the necessary information.

3.4. Data integration in GIS

An efficient and highly complex way to use data acquired with UAV equipment is to integrate it into the GIS environment (Capolupo et al, 2015; Cohen et al, 2018; Herrmann et al, 2020; Mahajan and Bundel, 2017; Simon et al, 2018). In this environment, numerous products can be obtained, useful in both quantitative and qualitative analysis of the pastoral area (table 1).

Table 1. Data integration in GIS

UAV product	GIS product
Point clouds	Digital Elevation Model
	Relief maps
	Climate maps
	3D modeling
	Hydrological analysis
	Volumetric calculations
Orthophotomap	Assisted classification
	Analysis of changes
	Topo-cadastral measurements
	Identification of objectives
	Surface monitoring

The integration of the data obtained in the GIS allows the complex analysis, together with other geospatial data sets.

The images and products obtained by UAV equipment can be used both in the GIS environment, but also in the CAD environment, with numerous applications in agriculture, forestry, spatial planning, urbanism and architecture, topography and cadastre or any activity area that uses geospatial data.

4. CONCLUSIONS

By using the UAV equipment, based on the model designed, we obtain topo-cadastral information, pratical information or information useful in territorial planning, with high accuracy and spatial location, represented cartographically.

Compared with the classical research methods, the use of the working model applicable in the pastoral space, based on geomatic technologies, has the effect of reducing the working time and the number of operators, the possibility of tracking in time and space of the investigated territory, but also the formation of certain bases graphic and descriptive data used to generate cartographic materials, with possibilities for use in other subsequent projects.

The working model applied in the analysis of the pastoral space, technically complex, comprises a logical succession of stages that also have individual results

(from each stage can be extracted geospatial products), and the final products can be used in various ways, both in pastoral space, as well as in other segments of the geographical environment.

The UAV technology can study areas with relatively large grassland areas, found in difficult environmental conditions, in adverse weather conditions.

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