HIGH-RESOLUTION TECHNOLOGIES AND IMAGES FOR TOPO-CADASTRAL ACTIVITIES

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Abstract: *The present paper aims to present modern topographic measurement technologies and evolution towards a new method, that of measurements made with the help of Unmanned Aerial Vehicle (UAV). The photogrammetric measurements were carried out with the help of Drona DJI Phantom 4 Pro, which made it possible to know a new way of working, much faster and more efficient, compared to traditional topographic measurements. The research presented in this paper was conducted in the western part of Romania, on the administrative territory of Timis County, on the campus of the University of Life Sciences" King Mihai I" from Timisoara. The use of Drona in the field of geodesy is currently in great demand due to its relatively easy operation and relatively affordable cost compared to satellite systems, especially high-resolution images. Over the past decade, the use of unmanned aerial vehicles as remote sensing platforms has become increasingly popular for a wide range of scientific disciplines and applications. Currently, many photogrammetric mapping methods use this technology to retrieve and record data on objects on earth. This is due to the fact that the use of a Dorne equipped with GNSS technology (Global Navigation Satellite System) for aerial measurements is very efficient and cheap and allows overflying hard-to-reach areas, significantly reducing the execution time of the work.*

Keywords: *UAV, DJI Phantom 4 Pro, GNSS, AgiSoft, Pix4D*

INTRODUCTION

Angular measuring instruments evolved over time from rudimentary shapes used in antiquity to the azimuthal quadrant around 1500. The improvement of the telescope by Galileo Galilei [Molesini et al. 1996], the improvement of the drawing board by the Italian Marioni of Udine, the attachment of the telescope to the drawing board, attributed to the mathematician Johann Pretorius, the invention of the vernier in 1631, of the collimation system in 1669, of the toric level in 1704 led to the realization of the first theodolite of modern conception, built by John Rowley in 1704 and later perfected by Jonathan Sisson in 1720.

Industrial production of geodetic instruments began in the second half of the 19th century with the establishment of firms specializing in optics and fine mechanics. The exponents of this industry are Carl Zeiss companies from Jena, Germany [Altamore et al. 2016], taken over in the 2000s by the American company Trimble, Wild Heerbrugg founded in 1921 [Rueger J.M. 2006] by engineer Heinrich Wild, who had previously worked at Carl Zeiss, this company merging in the 90s with Kern, later being taken over by the Swiss company Leica. Throughout their evolution, theodolites have undergone various improvements, resulting in so-called robotic total stations, or even total stations incorporating GNSS receivers.

The instruments for determining angles and distances have evolved in the last half century from classical theodolites and tachimetras, whose exponents can be Zeiss Theo 010, a high-precision instrument of its time, used in geodetic measurements, Zeiss Theo 020 and Zeiss Theo 030, tachimetre theodolites of medium and low precision, used on construction sites, in construction and industry [Matzka et al. 2019].

The next evolution of total stations was their robotization, which translates into attaching a servo motor that allows the instrument to search and track the prism in the workflow.

An example of such a device is the Leica Nova TM50 total robotic monitoring station, a high-precision instrument with a standard deviation of 0.5" (0.15 mgon), a working radius of up to 3500m on the simple prism and 1000m on other surfaces, with an accuracy of distance determination on the prism of 0.6mm + 1p.p.m. [Yang et al. 2021].

The technology of 3D scanning originated in the 60s of the last century, more precisely since 1968, based on the research between 1968 and 1978 of Dr. J. Riegl, at Vienna University of Technology, Austria. The first functional laser was developed in May 1960 by Theodore Maiman in the laboratories of Hughes Research Laboratories [Edl et al. 2018]. Lasers are commonly found in contemporary devices, especially optical storage devices such as compact disc drives or DVD players, in which the laser scans the surface of the disc to collect information. Other common applications of lasers are barcode readers and laser pointers. In industry, lasers are used to cut steel and other metals and to etch various patterns, such as letters on a computer keyboard. 3D laser scanning has applicability in the industrial field, civil engineering, mining, design, entertainment, event investigation-reconstruction, architecture, cultural heritage, real estate [Mita et al. 2020].

In recent years, more and more applications of U.A.V. systems in photogrammetry have become common. This evolution can be explained by the spread of the low-cost combination of GPS/INS systems, which are necessary to navigate a helicopter with high precision to predicted acquisition points [Simon et al. 2020; Șmuleac et al. 2017]. Some systems are used without GPS/INS systems, especially for capturing roofs for combination with terrestrial measurements [Casian et al. 2019]. For applications using only UAVs and to reduce the number of checkpoints, GPS positioning should reach decimetric accuracy.

Currently, many photogrammetric mapping methods have used drones to retrieve and record data on objects on earth [Simon et al. 2022]. This is due to the fact that using a drone equipped with GPS (Global Positioning System) for air measurements is very efficient and cheaper compared to renting an airplane, it also allows overflying hard-to-reach areas and significantly reduces the execution time of the work.

The development of U.A.V. technology in Romania is still in its infancy, and the legislative framework is extremely restrictive, even for small drones, which significantly affects the expansion potential of this field [Gherga et al. 2020]. U.A.V. equipment must be registered and a fee must be paid that sometimes exceeds the value of the equipment [Haloiu et al. 2019]. Thus, in order to use the aircraft, you need approval from the Civil Aviation Authority of Romania. Flights are limited in distance, altitude and area, and applications must be submitted at least 45 days prior to the flight [Smuleac et al. 2014, 2016, 2019; Roxana et al. 2020]. In short, flying an aircraft must be approved by the same institution that monitors flights [Pop et al. 2015; Pascalau et al. 2021]. In another aspect, the "ground pilot" requires advanced training, both for the use of the equipment and especially for the processing of recorded data.

MATERIALS AND METHODS

Smarter, more flexible, faster, stronger? These are the promises that the new DJI Phantom 4 Pro drone offers. The body of the drone is made of revolutionary materials and has an aerodynamic design that adds more precision to your controls, increases agility and respects coordinates even in strong wind conditions [Peppa et al. 2019].

The Phantom 4 is flexible enough to meet different flight requirements. Thus, sport mode adds extra agility and speed to the drone. The top speed increases by 25%, while all positioning systems are preserved for safer, better controlled flight.

High-efficiency engines and high-capacity battery specially designed for the DJI Phantom 4 (figure 1) give the drone a flight time of 28 minutes [Silva et al. 2018]. The DJI

Phantom 4 is one of the few drones equipped with an obstacle detection sensor (TapFly and ActiveTrack function).

Figure 1. DJI Phantom 4

It has five cameras on board that help it in orientation, so that up to the range of 15 meters it recognizes obstacles to be avoided. The DJI Phantom 4 comes with two cameras in front and below plus the main 4K camera. Thanks to the camera system it has, it can establish a three-dimensional image of the terrain. The Obstacle Sensing System mode ("automatically tracking objects and people") enables a safer flight and the Smart Return mode makes it easier to return after filming.

Thanks to Active Track mode ("moving tracking") the drone is capable of tracking the objective, so it does not have to support any kind of transmitter – the camera always keeps the target in the composition of the image, but changing the target is also easy. The designers of the drone increased the flight time to about 28 minutes. This gives the initial flight time an extra 25% than previous models. Between the radio control and the drone can be a distance of up to 5 km – a view for the pilot of a 720p resolution image. In Sport mode, the drone is capable of flying up to 70km/h. The "soul" of the Phantom 4 drone, it has a magnesium alloy casing that is strong enough, but with low weight.

Figure 2. DJI Phantom 4 Pro

The battery has a new place in the body of the drone, so the weight distribution has changed a bit. Because of this change, the drone is more agile, lighter and faster so that it is easier to maneuver (figure 2).

The central camera has a resolution of 4K that allows a capture of 30fps, the update frequency. The camera module is mounted on the 3-axis stabilizer, which avoids all vibrations and protects it from unwanted movements.

The greatest joy is that Phantom 4 has a Full HD resolution of 120 fps. Still images can be 12 MP which can be saved in DNG, RAW formats. Of course, there is D-Log and Cine-D profile for video. The combination of GPS and GLONASS gives you constant information about the drone's position. With the new updates for GLONASS, it offers support from a minimum of 36 satellites anywhere in the world.

Agisoft Photoscan Professional

AgiSoft PhotoScan is an advanced image-based 3D modelling software used to create professional and quality 3D content [Jebur et al. 2018]. Based on state-of-the-art 3D multi-image reconstruction technology, this product uses images taken in different positions and is effective in both user-controlled and unguided conditions.

Photos can be taken from any position, provided that the object to be reconstructed is visible in at least 2 of them, the processes of image alignment and reconstruction of 3D models being fully automated. This specialized 3D modelling program supports imports of images that have extensions such as JPEG, TIFF, PNG, BMP, JPEG Multi-Picture Format (MPO), and, as exported files, they can be of the type: Wavefront OBJ, 3DS Max, PLY, VRML, COLLADA, Universal 3D, FBX, PDF.

This is a commercial software application that integrates the entire data processing flow, from image sets to exporting digital models and textures in various formats. Going through the processing flow can be done, in Agisoft Photoscan, step by step or, based on a fully automated script (batch processing)

A comparison between the two image processing solutions shows that an integrated application such as Agisoft Photoscan offers, first of all, convenience in use. The ability to handle large projects and the speed of data processing are very good, but the quality of the hardware platform is essential. The application makes heavy use not only of process and memory, but also of the graphics process/processors. For this reason, it is recommended to use the most powerful graphics stations available.

To reduce costs, the use of platforms designed for gaming can be considered. Flexibility and parameterization possibilities can be considered good, covering most of the basic needs and numerous other exotic options. For example, the generated areas can be optimized by reducing ("decimation") and finally equalizing the number of nodes and faces. Even more, it is possible to export surfaces to be further finished and retouched in other computer graphics applications, with Agisoft Photoscan accepting the reimport of corrected surfaces and using them as a basis for texturing (and generating orthophotography).

There is, however, a limit to the flexibility available in AgiSoft Photoscan, for example, an important limitation is the lack of total control in the texturing process, the application automatically choosing the areas of the images to be assembled into the final texture (or orthophotography). For special applications at the forefront of research or for processing images recorded under difficult (or altered post-recording) conditions, the use of a fully integrated solution may no longer be a way to recommend.

RESULTS AND DISCUSSIONS

The use of drones in geospatial science, at present, is in great demand due to its relatively easy operation and relatively affordable cost compared to satellite systems, especially high-resolution images. One of the advantages gained by using drones is to take aerial photographs or photographs that are then processed for mapping so that they can be used to support the acquisition of space data.

The campus of the University of Life Sciences" King Mihai I" from Timisoara is located in the built-up area of Timisoara, on Calea Aradului. On the land there are built a number of 27 buildings, in which 6 faculties function, as well as the university campus served by canteen, library, dormitories and a sports base.

1. *Fieldwork*

Following the exact determination of the objective to be measured, in the first stage a reconnaissance of the terrain was made and ground control points were established. These points were materialized in the field through targets with a size of 1m/1m (figure 3).

Figure 3. Targets with DJI drone

Figure 4. Leica Viva GS08 Plus

The targets have a role in georeferencing in the national stereographic projection system 1970 of photogrammetric images, images that resulted from drone flight. For this study we used three targets located on the area we surfed with the drone. Thus, the coordinates of the 3 ground marker targets were determined based on GNSS technology using the Leica Viva GS08 Plus GNSS system (figure 4) by connecting with the ROMPOS permanent station system. The data that was determined with GPS was downloaded and processed with Leica Geo Office Combined v. 8.4 software.

2. *Preparation of the flight plan*

The drone used was DJI Phantom 4 Pro (figure 5), whose composition includes the camera (with a 4K shooting capacity and images of 12 megapixels), the GNSS, GPS and GLONASS positioning system (which allows image acquisition in the WGS 1984 system), propellers, intelligent battery, obstacle detection system.

Figure 5. DJI Phantom 4 Pro

The maximum flight altitude of the drone is up to 3 km, our flight being made at an altitude of 120 m. The flight was carried out at this altitude, because the lower the flight height, the better the sharpness of the images. At this altitude, a total of 54 shots were taken, all of which passed the quality test.

The aerophotography was done when the angle of elevation of the sun was greater than 25 degrees, i.e. approximately 12 PM. The flight took place in conditions of maximum visibility that did not affect the rendering on orthophoto plane of the natural colors existing on the ground. These relevant details have not been omitted so that the map obtained does not show clouds or accentuated shadows.

The drone is manoeuvred using the remote control. A mobile phone or tablet is attached to it, connecting them via a USB cable. Once the mobile phone was attached and connected, the Pix4Dcapture app (figure 6) was used to make the flight plan and accurately track the drone's flight in real time.

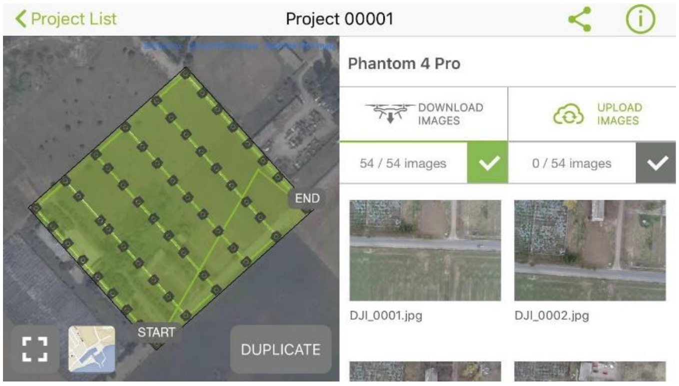


Figure 6. Making your flight plan with Pix4Dcapture

Figure 7. Pictures taken during the flight

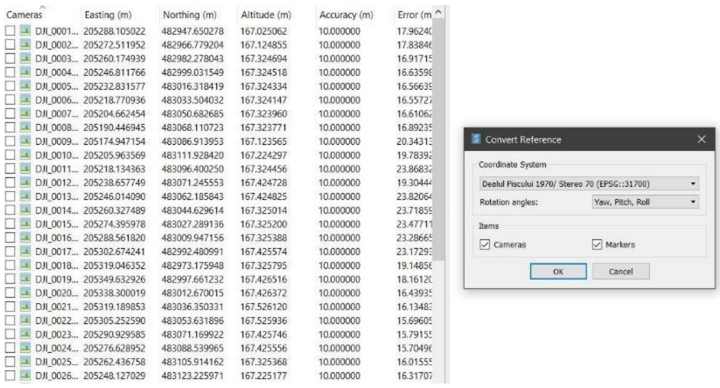
The route that the drone follows was planned and established in advance, not deviating from the route established by the operator. The drone went in straight lines for the acquisition of photogrammetric images, which overlap longitudinally in a proportion of 70% and transversely in a proportion of 75% to ensure increased accuracy and to create the 3D model.

During the flyby, the drone captured all three targets marked on the ground which were then useful for georeferencing aero photogrammetric images (figure 7). We calculated the flight height according to the scale at which the ortho photo plane had to be made. The height must be constant, that is, once set it must be kept until the end of the flight, otherwise errors will occur in data processing and ortho photo plane realization. After the entire surface was engulfed and the flight was completed, the drone returned exactly to where it left off at the start of the flight.

3. Office work

The first office stage is the download of raw GPS data, namely the ASCII file with the coordinates of the three control points that we will use for georeferencing the ortho photo plane from the WGS '84 projection system to the '70 stereographic system.

In the second stage, data was processed with Agisoft PhotoScan Professional software (figure 8). This data processing is carried out by determining the flight path of the drone. Stereoscopic vision allows us to see an object from two different perspectives, such as aerial photography taken from different camera positions. That is why the result of mapping data by using this drone can produce images with a very high resolution, it also produces a three-dimensional image of the recorded surface



Cameras	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)	Error (m
DJI_0001...	205288.105022	482947.650278	167.025062	10.000000	17.9624
DJI_0002...	205272.511952	482966.779204	167.124855	10.000000	17.8384
DJI_0003...	205260.174939	482982.278043	167.324694	10.000000	16.9171
DJI_0004...	205246.811766	482999.031549	167.324518	10.000000	16.6359
DJI_0005...	205232.831577	483016.318419	167.324334	10.000000	16.5663
DJI_0006...	205218.770936	483033.504032	167.324147	10.000000	16.5572
DJI_0007...	205204.662454	483050.682685	167.323960	10.000000	16.6106
DJI_0008...	205190.446945	483068.110723	167.323771	10.000000	16.8923
DJI_0009...	205174.947154	483086.913953	167.123565	10.000000	20.3431
DJI_0010...	205205.963569	483111.928420	167.224297	10.000000	19.7839
DJI_0011...	205218.134363	483096.400250	167.324456	10.000000	23.8683
DJI_0012...	205238.657749	483071.245553	167.424728	10.000000	19.3044
DJI_0013...	205246.014090	483062.185843	167.424825	10.000000	23.8206
DJI_0014...	205260.327489	483044.629614	167.325014	10.000000	23.7185
DJI_0015...	205274.395978	483027.289136	167.325200	10.000000	23.4771
DJI_0016...	205288.561820	483009.947156	167.325388	10.000000	23.2866
DJI_0017...	205302.674241	482992.480991	167.425574	10.000000	23.1729
DJI_0018...	205319.046352	482973.175948	167.325795	10.000000	19.1485
DJI_0019...	205349.632926	482997.661232	167.426516	10.000000	18.1612
DJI_0020...	205338.300019	483012.670015	167.426372	10.000000	16.4393
DJI_0021...	205319.189853	483036.350331	167.526120	10.000000	16.1348
DJI_0022...	205305.252590	483053.631896	167.525936	10.000000	15.6960
DJI_0023...	205290.929585	483071.169922	167.425746	10.000000	15.7915
DJI_0024...	205276.628952	483088.539965	167.425556	10.000000	15.7049
DJI_0025...	205262.436758	483105.914162	167.325368	10.000000	16.0155
DJI_0026...	205248.127029	483123.225971	167.225177	10.000000	16.3170

Figure 8. Loading images and changing the coordinate system

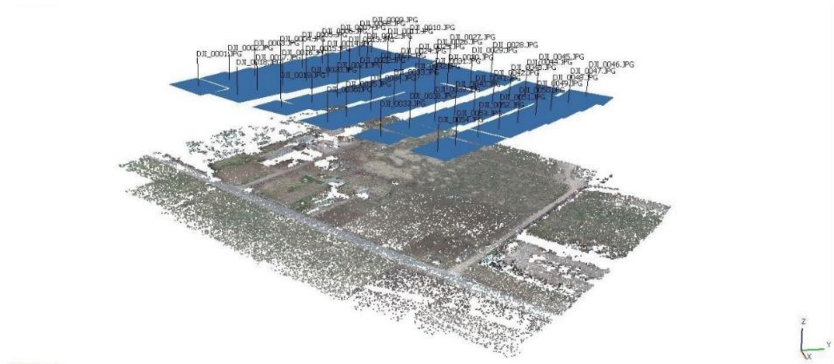


Figure 9. Align images

Photo alignment (figure 9) is done to identify points in each photo and do the same matching process in two or more photos. The photo alignment process will generate the initial 3D model.

After we have achieved the alignment of the images, follows the part of entering the coordinates of the control points (figure 10) and georeferencing the point cloud based on them.

Cameras	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)	Error (m)	Yaw (°)	Pitch (°)
DJI_0001...	205288.105022	482947.650278	167.025062	10.000000	17.962400		
DJI_0002...	205272.511952	482966.779204	167.124855	10.000000	17.838462		
DJI_0003...	205260.174939	482982.278043	167.324694	10.000000	16.917154		
DJI_0004...	205246.811766	482999.031549	167.324518	10.000000	16.635986		
DJI_0005...	205232.831577	483016.318419	167.324334	10.000000	16.566395		
DJI_0006...	205218.770936	483033.504032	167.324147	10.000000	16.557276		
DJI_0007...	205204.662454	483050.682685	167.323960	10.000000	16.610626		
DJI_0008...	205190.446945	483068.110723	167.323771	10.000000	16.892357		
DJI_0009...	205174.947154	483086.913953	167.123565	10.000000	20.343132		
DJI_0010...	205205.963569	483111.928420	167.224297	10.000000	19.783927		
DJI_0011...	205218.134363	483096.400250	167.324456	10.000000	23.868325		

Markers	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)	Error (m)	Projections	Error (pix)
1	205393.725000	483103.816000	90.515000	0.005000	0.004455	14	0.312
9	205349.736000	483117.435000	90.359000	0.005000	0.004071	13	0.211
14	205366.182000	483084.590000	90.427000	0.005000	0.005523	13	0.382
Total Error							
Control points					0.004723		0.309
Check points							

Figure 10. Entering CGP coordinates

Room locations and error estimates are shown in figure 11. The altimetric error (Z) is represented by the colour of the ellipse, and the planimetric error (X, Y) is represented by the shape of the ellipse.

Count	X error (mm)	Y error (mm)	Z error (mm)	XY error (mm)	Total (mm)
3	3.93297	2.60007	0.04921	4.71472	4.71498

Figure 11. Checkpoint locations and estimated errors

In photogrammetry, the exploitation of the aerial image independently is done by processes: graphic, analogue, analytical or digital, obtaining the planimetric representation (graphic, photographic, numerical or digital) of the details of the object space that are represented on the aerial image. After georeferencing and processing specific to digital photogrammetry based on aerial images, different products can be generated, such as: DEM, DSM, DTM, ortho photo plans, etc.

Obtaining the third dimension (Z) involves exploiting two or more photograms taken from different points and having a double coverage area. This is how the stereogram is obtained, which is, in fact, the set of two successive images taken from different points, with a longitudinal coverage between 70% and 75%.

The next stage is the realization of the 3D model (figure 12) which will be used as the basis for making the Digital Elevation Model (DEM) of both the Digital Surface Model (DSM) and the Digital Terrain Model (DTM).

Figure 12. Representation of the 3D model

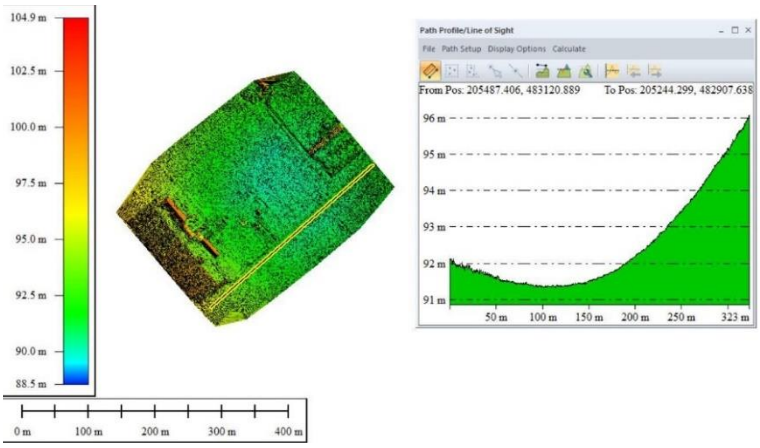


Figure 13. Longitudinal profile on DEM

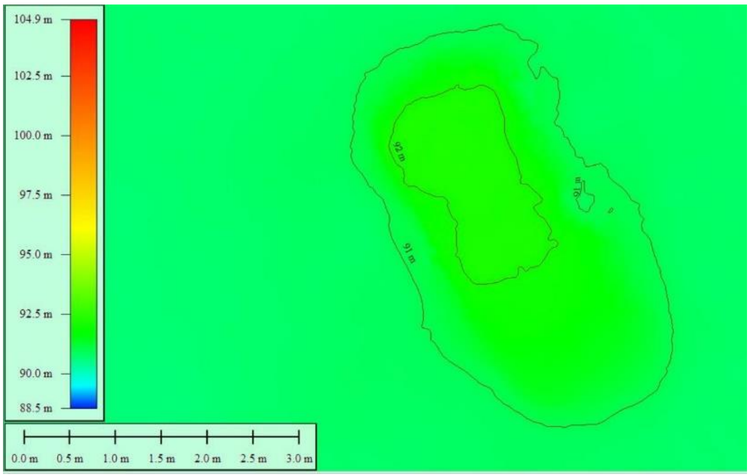


Figure 14. Generation of contour lines

In order to create the digital elevation model (figure 13), certain quantitative and thematic data are required, which constitute the computer basis of the model. These data are obtained from images taken by the aero photogrammetric camera placed on the aircraft.

Based on the DEM we made a longitudinal profile (figure 14) of the road in which a level difference of 4 meters can be observed over a distance of about 350 meters. Also based on the DEM we generated the level curves of the studied area.

4. Technological flow of obtaining orthophoto images

The main stages of work are the measurement of connection points between models and block compensation of photograms, performed by aero triangulation. Air triangulation contains both stages and is necessary for image rectification and orthophoto image obtaining. Linking images through connection points (made manually or automatically) makes the initial orientation of images in relation to each one.

As a support function, a digital elevation model (DEM) is calculated after adjusting images in bulk, and spectral corrections can be applied at different stages of the process. When bulk adjustment has been run and DEM calculated, it is possible to make individual ortho-rectified images.

Points measured on the ground improve the accuracy of the final result, but they are optional if you do not want to perform a coordinate ortho photogram in the national system. The production of final mosaics can be done from ortho-rectified images or from original images.

Figure 15. Image from Google Earth and orthophoto overlay over Google Earth

The final export can be done in *.tiff, *.sdw format or even *.kml format to be directly visible in Google Earth (figure 15). The workflow for obtaining orthophoto images is as follows: entering the orientation parameters of the camera, automatic correlation of images (link points, tie points) or manual, insertion of landmarks and bulk compensation of images (aero triangulation), calculation of the digital elevation model (DEM), individual correction of images and their mosaic to obtain the ortho photo plan of the photographed area.

Being composed of at least one aerial photogram – usually extracted from several that have been assembled and geometrically corrected, the ortho photo plan has very precise quantitative characteristics. These are data of perfect combination of measurements included in the stereographic projection system on which the official mapping of Romania is based – the Stereo 70 system.

For this reason, in the ortho photo plan, surfaces, angles, distances or perimeters can be measured and highlighted with maximum accuracy (figure 16). As a result of Decree No. 305 of September 1971 issued by the State Council of Romania, in the civil sector of the country it was decided to replace the Gauss-Kruger projection with a new projection called Stereographic 1970.

The name has since been simplified to the Stereo 70. The Stereo 70 projection is compliant, does not deform angles, allows geodetic measurements to be processed directly in the projection plane, without calculating geographical coordinates provided that corrections to reduce measurements are applied to the projection plane beforehand. On a piece of the obtained ortho photo plan, we identified a plot and prepared a plot plan for an experimental culture that will have distances of 1m/1m (figure 16).

Figure 16. Tracing plan - experimental culture

The photographic map thus obtained is to scale. An ortho photo plan is a geo-reference, by assigning actual geographic or rectangular coordinates and is saved electronically or printed on an appropriate medium.

For this study, two different flights were made, the first flight was made in March, and the second flight was made in June. Based on the first flight, experimental cultures were traced and the second flight has the role of analysing the evolution of cultures.

For the second flight, the principle was exactly like for the first, only this time we used four ground checkpoints. The georeferencing of images on the four control points is shown in figure 17.

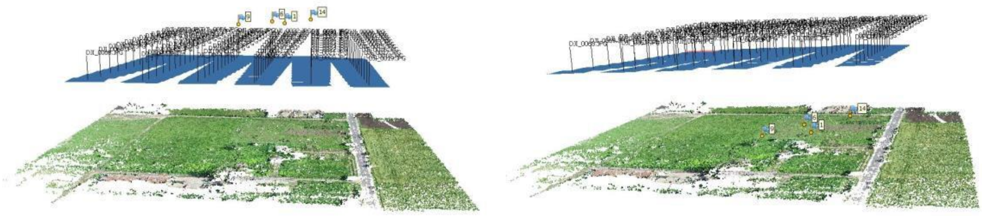


Figure 17. Georeferencing images on GCP

In the image on the left side, we can see that the point cloud is below the control points, meaning that the altimetric error is very large if we process the images without control points. In the image on the right, the point cloud has been georeferenced by checkpoints, now accurate to 2-3 cm.

In conclusion, by comparing the two ortho photo plans (figure 18) the presented paper wants to present the benefits of using UAV technology in topography, cadastre, GIS, etc. This technology supports specialists in various fields of activity, such as: public administration, environmental protection, inspections, agriculture, cadastre, transport, energy, public safety and national security.

Figure 18. Comparison of the two ortho photo plans obtained

CONCLUSIONS

In conclusion, we can say that the use of drones is increasingly practiced both in foreign countries and in our country because it offers the user the possibility to enter inaccessible, difficult or dangerous areas for human operators.

Regarding the safety of personnel, this is ensured by carrying out measurements from a safe distance. The measurements are made in a non-invasive manner, the drones leaving no traces or emissions of any nature, during or after the measurements. Measurements are carried out in a short period of time and with a high temporal resolution.

Thanks to the low flight speed and the possibility of gliding, combined with a programmable flight path, areas of interest covering relatively large areas can be studied. Autopilot, perfectly integrated with the aircraft, can accurately follow the predetermined flight plan, controlling the camera in such a way as to obtain coverage of the entire studied area.

A synthetic presentation of the current stage of development of photogrammetry and remote sensing, based on the achievements known so far, allows a realistic appreciation of the possibilities and limits of this means of investigation.

Flight planning and measurements have shown that this U.A.V. system offers great advantages in recording cultural heritage compared to traditional methods.

Most current so-called U.A.V. mapping systems or mapping systems using drones use autonomous, modern and sophisticated technology for flight; And yet surprisingly they take photogrammetry back 50 years, and more!

However, by properly addressing error issues and implementing fundamentals to achieve true photogrammetric accuracy, we can take a leap forward in accurate photogrammetry using drones!

Recognizing the many potential sources of erosion, and then appropriate treatment to eliminate or at least measure them, will be the most important discriminating factor between drone mapping systems. Resistance and payload information are of little relevance for accurate mapping and photogrammetry. Systems that clearly specify mapping precisions in X and Y, as well as in height, should be the systems of greatest interest for photogrammetric mapping using drones. This precision must be definitively stated, with clear information on the reliability and repeatability of such accuracy.

The project of photographing the entire campus with the help of modern technology (drone) resulted in situation plans that are used by students in the photogrammetry, GIS and remote sensing laboratory, also these plans, which resulted in the Stereographic 70 system, can be used to prepare topo cadastral documentation for notations in the land book of the land and buildings related to the campus. The accuracy of determining plans relative to classical topographic methods is on the order of centimetres.

Also, with the help of plans resulting from drone measurements, the number of levels of construction, the type of roof (terrace or roof structure), as well as the colour and texture of the facades can be established. For land intended for parks, the type of tree, soil vegetation and the application of a GIS for each type of soil can be established.

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