

## IMPLEMENTING U.A.V. TECHNIQUES IN MODELLING HYDROAMELIORATIVE WORKS - A CASE STUDY

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### Abstract

*The scientific and technological progress recorded in the last years in the field of geodesy, cartography and land surveying allows the use of some modern techniques and methods towards realizing some complex objectives. This evolution of techniques allows for high level accuracy data to be obtained in short period of time, on large surfaces. U.A.V. photogrammetry serves a wide variety of domains. The present study follows an interdisciplinary research, and modern concepts from land improvement field are approached. For the photogrammetric flight a DJI Phantom 4 Pro drone was used. The photos were taken after a manual flight conducted with the DJI GO application. The generated dense point cloud consists of 82191720 points, having both spatial coordinates and an RGB code. The resulting orthophoto map has a ground resolution of 1.37 cm/pixel. Also, within the project, the Digital Elevation Model (DEM) was obtained which has a resolution of 2.74 cm/pixel, the point density being 1335.85 points/m<sup>2</sup>. The obtained products can be exported, thus allowing them to be integrated into specialized software for further analysis.*

**Key words:** drone, flight, land improvement, U.A.V. photogrammetry.

### INTRODUCTION

Photogrammetry is a technical science that studies the Earth's surface based on the land photographic image processing in order to obtain informative data for the preparation of plans, maps and topographic and thematic studies.

According to Anurogo et al. (2017), aerial photogrammetry is one of the alternative technologies for obtaining data in a relatively short time.

Applications made with the help of drones in the geospatial field are in full development and demand, due to the relatively affordable costs compared to satellite systems (high resolution satellite images) (Colomina and Molina, 2014).

Authors like Toderas (2007) recall the development of techniques and technologies and also the extension of the scope of photogrammetry and implicitly with it the subclasses: aerial photogrammetry, cosmic photogrammetry, extra-terrestrial photogrammetry, terrestrial photogrammetry, analogue photogrammetry, digital photogrammetry, analytical photogrammetry architectural photogrammetry and topographic photogrammetry.

Hidayat and Widartono (2014) cited by Anurogo et al. (2017) presents as a benefit obtained by using drones obtaining aerial photographs, which are then processed so that they are used to support spatial data acquisition. This modern method has many areas in which it can be applied, especially agriculture, forestry, topographic and thematic mapping.

Drones can also be used in the field of hydrological processes, studies being carried out by authors such as Caroloo et al. (2015).

Based on the aerial images taken and subsequently used in the specific geo-information programs, models with centimetres accuracy can be obtained.

### MATERIALS AND METHODS

The area targeted in the study is represented by the upstream part of a slope located in the area of Feleacu, Cluj County, slope arranged with hydro ameliorative works. The targeted area is the one in which we find the channel with concrete falls, realized in order to reduce the slope and limit the drainage speed under the non-erosion speed (Figure 1).

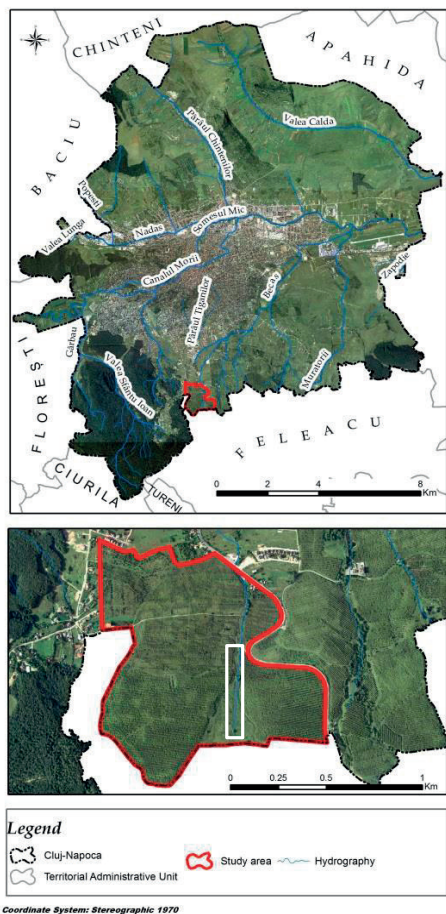


Figure 1. The geographical location of the study area, Cluj-Napoca

Regarding the planning and conduct of the flight activities, a notice was requested from the Civil Romanian Aeronautic Authority, being registered the flight with reference number 44 with the drone having the identifier YRD 0760.

In order to model the terrain using U.A.V. (Unmanned Aerial Vehicle) photogrammetric methods, a DJI Phantom 4 Pro drone was used (Figure 2). The photos were taken after a flight conducted with the DJI GO application.

Taking the aerial photos was done by performing a manual flight. A predetermined flight was not chosen, due to the high altitude differences between the upstream and downstream part of the studied area.

The manual mode allowed the altitude change during the flight and tracking the natural terrain, however, in the case of a predetermined flight, the altitude of the drone will remain constant compared to the average altitude of the flight plan, at the value set at the time of flight planning and take-off.

The flight followed the path of the channel with concrete falls, at the return we tried maintaining a line relative parallel with the channel (Figure 3).



Figure 2. DJI Phantom 4 Pro drone

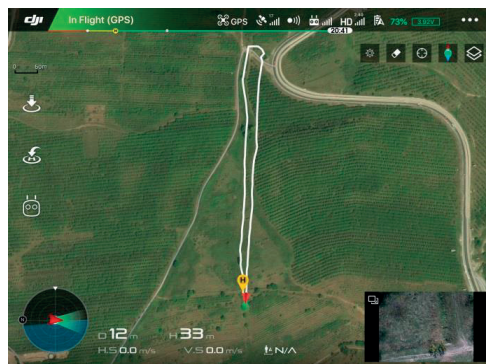


Figure 3. The photogrammetric flight path, DJI GO application

For the photogrammetric processing, the specialized software solution Agisoft PhotoScan was used, which allows the generation of the dense point cloud, the digital elevation model (DEM - DTM or DSM) and the orthophoto map.

The data was downloaded and a number of 145 photograms were obtained at an average flight altitude of 54 meters.

## RESULTS AND DISCUSSIONS

With the help of the application Adobe Photoshop Lightroom Classic, the contrast improvement was done by the histogram equalization method. The histogram equalization represents an accentuation operation of the contrast and its main purpose is to obtain a uniform histogram. Improving the photogram contrast was done automatically at the same time for all the taken photograms (Figure 4).



Figure 4. The photogram before and after the histogram equalization process

Once the project was created, the photograms were imported, the coordinate system was selected, and then the coordinates of the photograms from the WGS 84 projection system were converted to the Stereographic 1970 projection system.

The next stage was represented by the alignment of the photograms, a stage in which the accuracy of identifying the connection points, the maximum number of key and connection points, as well as establishing the pair selection variant was set (Figure 5).

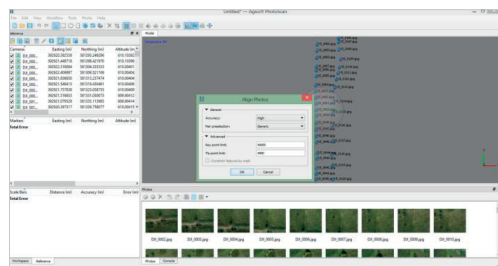


Figure 5. Photograms alignment

In order to georeference the digital model, the coordinates of the ground control points previously determined by GNSS methods (Paunescu et al., 2012) have been uploaded

within the project and will be identified on the photograms (Figure 6).

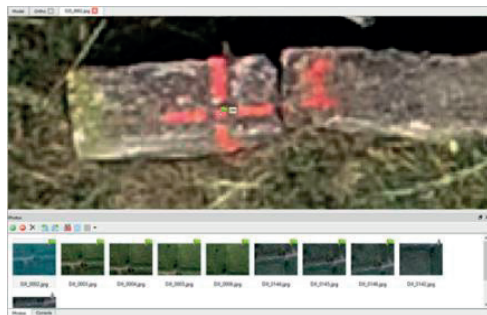


Figure 6. Identifying the ground control points on the photograms

In the model adjustment stage, these ground control points were used, without taking into account the coordinates of the photograms, these being recorded by the internal GPS of drone which does not offer a sufficiently high accuracy. The accuracy of the drone's internal GPS is  $\pm 0.5$  m for the vertical position and  $\pm 1.5$  m for the horizontal position.

After constraining the model, using the bundle adjustment method, based on the ground control points, the dense point cloud was generated. This consists of 82191720 points, which have both spatial coordinates and an RGB code.

Figure 7 shows both the dense point cloud and the camera position.



Figure 7. The dense point cloud and the camera position

In order to obtain the 3D model of the studied area, a MESH was generated, consisting of 5398054 triangles.

The model consists of a network of triangles arranged irregularly based on known elevation points, the dimensions of the triangles varying depending on the terrain. The resulted model is

known as TIN (Triangulated Irregular Network) (Figure 8).

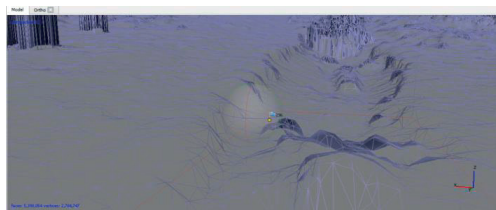


Figure 8. TIN network - detail point of view

If the faces of the triangles are assigned the colours taken from the photograms, the realistic model is obtained.

The digital orthophoto map of the studied area was generated, having as support the obtained 3D model and applying the mosaic method of the photograms (Figure 9). The resulting orthophoto map (Figure 10) has a ground resolution of 1.37 cm/pixel.

Both the obtained orthophoto map as well as the point cloud can be exported, thus allowing them to be integrated into specialized software for further analysis.

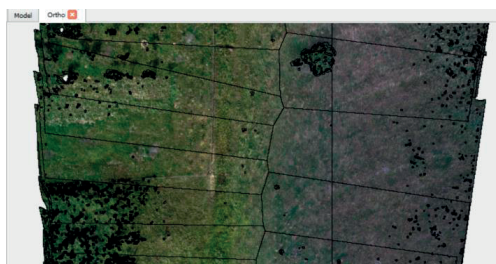


Figure 9. The mosaic method

Also, within the project, the Digital Elevation Model (DEM) was obtained (Figure 11) with a resolution of 2.74 cm/pixel, the point density being 1335.85 points/m<sup>2</sup>.

The DEM is a valuable tool for the topographic parameterization, especially for erosion and drainage analyses, hill-slope hydrology, watersheds, groundwater flow and contaminant transport studies (Walker and Willgoose, 1999; De Vantier and Feldman, 1993; Jensen and Domingue, 1988).

The photogrammetric processing is synthesized in the form of a report, which includes the calibration elements of the camera, details

about the digital elevation model, details about the ground control points, errors, resolutions obtained (Processing Parameters: General - cameras, markers, coordinate system; Point cloud; Alignment parameters - accuracy, alignment time; Optimization parameters; Dense Point Cloud; Model - faces, vertices; Orthomosaic - size, coordinate system, channels, blending mode; Reconstruction parameters).



Figure 10. The orthophoto map of the study area



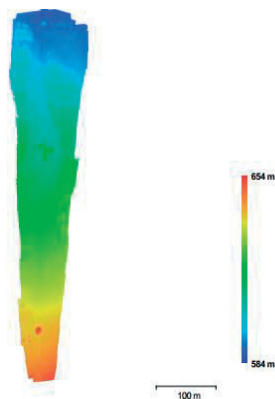


Figure 11. Digital elevation model

The obtained products can be used for various purposes, respectively complex analysis, spatial modelling, and profile creation.

The geo-informational application Global Mapper allows data processing and analysis, having many significant tools. Within the version 18.3 of Global Mapper, the point cloud was loaded (Figure 12) for preview and terrain analysis.

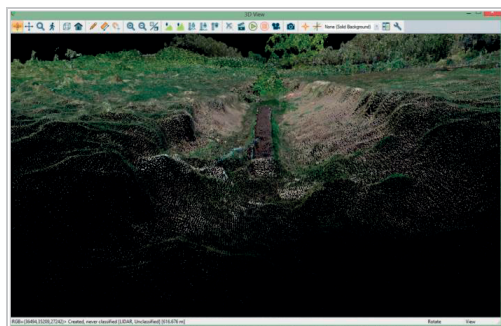


Figure 12. 3D visualisation - point cloud

At the same time cross-sections were generated throughout the point cloud, which rendered the shape of the terrain, of the channel and of the concrete falls from the studied area (Figure 13, Figure 14).

These cross-sections obtained using the application Global Mapper can be exported as x, y, z files or in a CAD format -dxf.

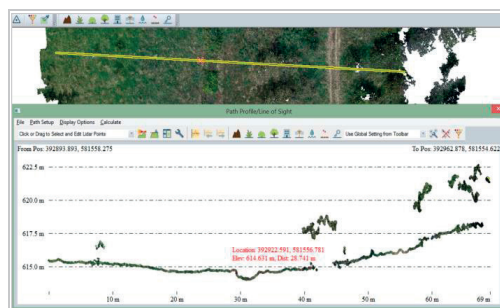


Figure 13. Cross section within the point cloud

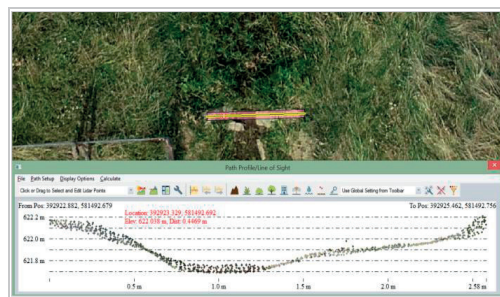


Figure 14. Cross section within the point cloud, fall

## CONCLUSIONS

Modelling the terrain was done throughout U.A.V. photogrammetric methods. The resulting orthophoto map has a ground resolution of 1.37 cm/pixel and the obtained digital elevation model has a resolution of 2.74 cm/pixel. The obtained products can be used for various purposes, respectively complex analysis, spatial modelling.

The photogrammetric techniques carried out can be used to future design works in order to redesign the channel as well as the falls. Cross-sections can be used in modelling hydraulic and hydrological processes.

U.A.V. photogrammetric methods are used with success in the field of land improvements, having as deliverable material the point cloud, the orthophotomap and the digital elevation model with a centimetric accuracy.

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