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3D MODELING OF THE CAMPUS OF THE UNIVERSITY OF AGRICULTURAL SCIENCES AND VETERINARY MEDICINE CLUJ-NAPOCA USING ARCGIS PRO

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Abstract

The 3D modeling process consists of a three-dimensional representation of an object or a surface using certain specialized software. The 3D modeling was done by using a point cloud resulting from a drone flight. GIS applications enable the analysis of spatial locations by creating and layering information through maps or 3D scenes. In order to create a 3D model of the land, the ortophotomap resulting from a photogrammetric drone flight was used. The generation of the orthophotomap and the dense point cloud offers the possibility of making digital measurements, exporting and creating a database for making applications and drawing up interactive maps according to the user's wishes. The purpose of this work is to use the latest methods of obtaining photogrammetric data with the help of drones, but also to create interactive maps that allow studies and spatial analysis to be carried out. The case study was carried out on the campus of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca using the photogrammetric method and GIS analysis. To obtain the orthophotomap and photogrammetric data, it was decided to fly with the DJI Phantom 4 RTK drone. The analysis of the orthophotomap of the campus and the dense point clouds allowed the graphical representation of the cartographic elements in the ArcGIS PRO application, respectively ArcGIS Online, offering the possibility of accessing them in real time, which represents an up-to-date process and to be considered for conducting studies and spatial analyses. The maps created, both in 2D and 3D format, as well as the WEB applications have the purpose of providing users with data regarding the shape, location, character and arrangement within the campus of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca of the most important component buildings, taking into account their character.

***Key words**: 3D modeling, databases, GIS, Photogrammetry, Web map.*

INTRODUCTION

The main goal is to create a 3D model of the University of Agricultural Sciences and Veterinary Medicine campus in Cluj-Napoca using photogrammetry and GIS techniques. The analysis of the ortophotomaps of the campus and the point cloud data enabled the digitization of campus features within the ArcGIS PRO application and ArcGIS Online. This process resulted in the development of interactive real-time maps, ensuring that the data remains current.

The University of Agricultural Sciences and Veterinary Medicine is located within the Cluj-Napoca municipality, which is situated in the northwestern region of Romania, specifically in the central part of Transylvania, covering an approximate area of 23,000 square meters (Figure 1).

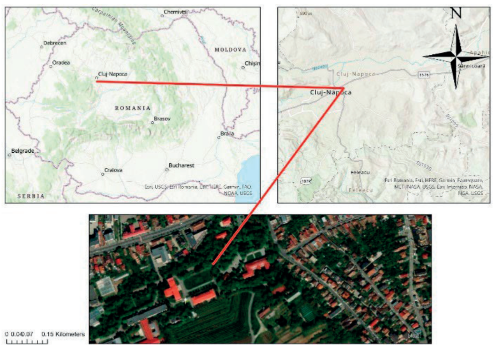

Figure 1. Location of USAMV in Romanian and Cluj-Napoca

MATERIALS AND METHODS

To achieve the desired results, logistical and technical support was necessary, included the use of two drones, one for making the flight for the ortophotomap and the second for capturing aerial photographs of the building facades. Also, a suite of software applications in the field of photogrammetry and geographic information systems played a crucial role. These applications were used in processing the raw images, generating the ortophotomap, creating the database, and georeferencing the campus buildings in 3D format.

To conduct the planned study, a photogrammetric flight was executed using the DJI Phantom 4 RTK drone. This drone is a popular choice for photogrammetric flights due to its high-quality camera and the assistance of various sensors, which together deliver excellent performance and superior image quality.

The technology incorporated in this drone enables data acquisition with centimeter-level accuracy, eliminating the requirement for additional ground control points. The drone is equipped with an integrated RTK module that offers real-time positioning data, ensuring the absolute geotagging for the images.

In addition to ensure optimized flight safety and precise data collection, the DJI Phantom 4 RTK also stores satellite observation data that can be Post Processed (PPK). The DJI Mavic Air 2S drone is an ideal choice for capturing high-quality imagery. Despite its compact size, the drone is equipped with a 20-megapixel camera capable of producing professional-grade photos and videos, making it well-suited for content creators, but also for photogrammetric missions. It comes equipped with a 1-inch sensor and can record videos at 5.4K/30 fps and 4K/60 fps.

The photogrammetric data was processed with Agisoft MetaShape software. This supposed processing the previously captured images, resulting in the generation of a dense point cloud. To conduct the planned study, the orthophotomap was overlaid with the point cloud data using Global Mapper. Subsequently, measurements were taken, and the coordinates of the buildings within the campus were obtained.

For the georeferencing and 3D construction of the main campus buildings, the ArcGIS Pro software was used. This software enables the creation of a geographic information system that includes a database, a data set, and various layers of different types, such as point, line, polygon, 3D objects, and others.

ArcGIS Online platform facilitates the viewing of interactive maps in an online environment, enabling users to customize the maps based on their specific needs and analyses. Additionally, ArcGIS Online enables the creation of applications using various widgets with multiple functionalities, offering real-time creation, visualization, and analysis of data both in office and field. For optimal drone performance, a camera calibration is preconfigured at start-up, ensuring that all the equipped sensors are functional and ready to execute their tasks during the mission.

Following this, the specific area of interest, the flight path, and the band overlap were chosen, with the software providing estimates for the flight duration, optimal drone altitude, speed, and the number of captured images.

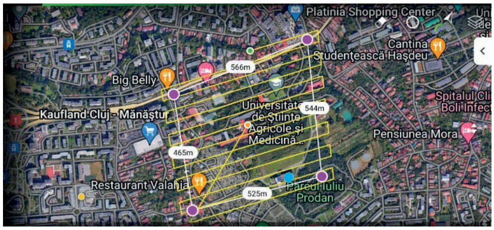

Figure 2. UAV Mission planning

Post-flight, the software automatically generates a comprehensive mission report, detailing all technical settings, including camera calibration and parameters used, along with a mission summary. During the mission, a total of 413 photos were captured at a medium altitude of 97.6 meters. The photogrammetric flight, aimed at mapping the designated area of interest, was conducted from within the university campus and lasted approximately 20 minutes.

RESULTS AND DISCUSSIONS

The processing report indicates, as shown in the blue-coloured image above, the optimal alignment of the images captured during the flight, represented by points denoting the camera positions at the time of shooting (Figure 3). Additionally, subsequent to the flight, a digital elevation model is created, illustrating the variations in elevation across the surveyed region.

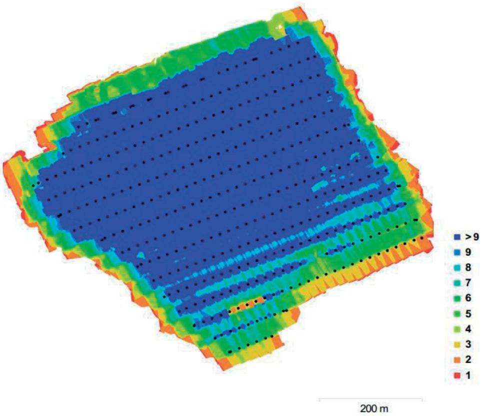

Figure 3. Camera Locations and image overlap

The higher altitude section of the campus is represented in red, the lower portion of the campus is blue, while the green-coloured area represents the middle heights zone. Lastly, the red-tinted lower section of the image represents the ICHAT area, the highest altitude points of the campus, situated at an approximate altitude of 427 meters (Figure 4).

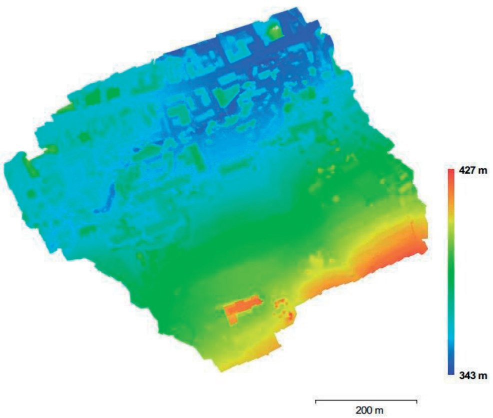

Figure 4. Digital Elevation Model

After the drone flight, a series of crucial steps were taken to obtain the ortophotomap and the dense point cloud. These steps should be executed chronologically and in a systematic manner to achieve the best quality results. The steps include creating the project, importing the raw images, generating tie points using a specific method, adjusting tie points, compensating the block aerial triangulation, conducting precise aerial triangulation, generating and selecting the digital elevation model, and obtaining the ortophotomap. Ground control points (Figure 5) are used in georeferencing the model both from planimetric and altimetric point of view.

Figure 5. Ground Control points locations

The accuracy of the aerotriangulation is determined as mean squared error, which is calculated based on the disparities between the control points and the actual model. The drone flight and processing in Agisoft MetaShape contributed to the creation of a dense point cloud enabling the identification of points even in challenging areas, such as buildings near trees (Figure 6).

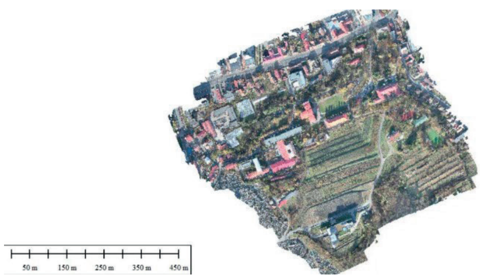

Figure 6. Dense point Cloud

Figure 7 displays the digital elevation model, illustrating the variations in elevation across the surveyed area (Sălăgean et al., 2018). After completing all the requisite procedures, the resulting orthophotomap (Figure 7) is suitable for mapping, conducting analyses, and performing complex measurements.

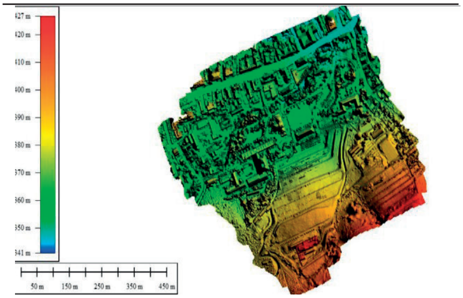

Figure 7. Digital Elevation Model in Global Mapper

After completing all the requisite procedures, the resulting orthophotomap (Figure 8) is suitable for mapping, conducting analyses, and performing digital measurements. We accomplished significant progress using Global Mapper software, especially in implementing key steps to achieve our intended objectives, such as integrating the point cloud over the orthophotomap (Jayaraj et al., 2018).

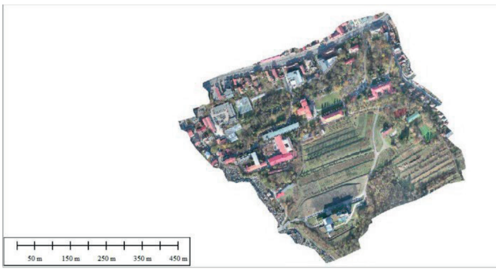

Figure 8. The USAMV Cluj-Napoca Campus Ortophotomap

Through the imported data, the coordinates of both the base of the buildings and the top of the buildings were extracted. Creating area features for each facade of the buildings is an essential step for a detailed and comprehensive analysis of the structures. The use of the Create Area Feature function to delineate the shapes of the buildings on the point cloud ensures accuracy and facilitates the creation of polygons. With the polygons generated for the Rectorate building, the Faculty of Horticulture building, and the Aula Magna building, we can conduct a more thorough study as intended. The most important aspect for the data processing part in ArcGIS PRO is the creation of the database (Figure 9). Raster data and vector data such as line, point and polygon were inserted into the project, which were used to fulfill the problem addressed.

Figure 9. Geodatabaze of the USAMV Cluj-Napoca Campus in Arcgis Pro

To create the 3D model of the buildings on the USAMV Cluj-Napoca campus, the coordinates of the points at the base of the main buildings were determined, namely the Rectorate building, the Faculty of Horticulture building and the Mihai Șerban Magna Hall building.(Figure 10).

Figure 10. Geodatabase with the buildings

GIS applications find use in various fields related to the processing of spatial information, including urban planning, cadastral management, and cartography. In urban planning, GIS tools optimize urban transport, aid in locating housing space, establish zoning based on diverse criteria, support urban planning studies, facilitate the issuance of construction and demolition permits, and enable the inventory of land uses. In the realm of cadastral management, GIS applications are employed for the comprehensive integration of the entire cadastral process, from land measurements to the editing of plans and cadastral records. Moreover, in cartography, GIS applications are instrumental in the creation and maintenance of maps and topographic plans. They also integrate terrain, photogrammetric, and satellite data into map content to generate thematic maps. (https://www.academia.edu/19674635/Curs_Sisteme_Informationale_Geografice).

As shown in Figure 11 in the created application, a part of the points at the base of the campus component buildings are represented, together with a selection of the green space.

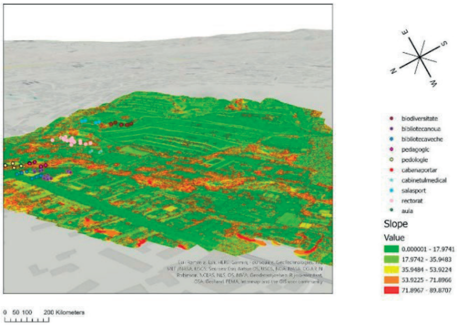

Figure 11. The ArcGIS PRO Aplication

As can be seen in Figure 12, a 3D map of the area of interest was generated, taking into account the location and shape of the buildings, and also taking into account the differences in height and the Ground area (Song, et al., 2018).

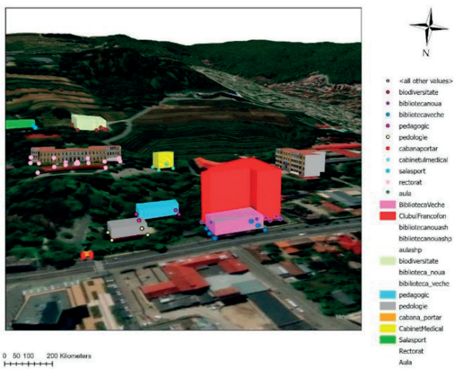

Figure 12. 3D Visualization of the USAMV Cluj-Napoca Campus

In Figure 13 the contour lines across the USAMV Cluj-Napoca Campus are represented. To render the contours, the digital elevation model was inserted as an input file and an interval of 8 contours were added.

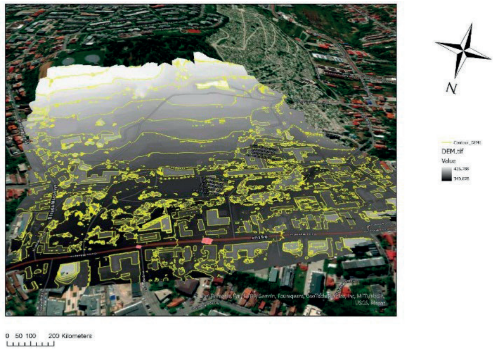

Figure 13. Contour lines în ArcGIS PRO

In the last part of the study, several online applications were made using the Arcgis Online platform. Within the interactive map in Figure 14, buildings of interest are included, each with an individual color. Also, two layers that form the database have been inserted within the map. The first layer, titled 3D buildings, is the actual representation of the buildings, and the halls layer is a symbolic representation of the location of several halls where student, administrative and festive activities are carried out.

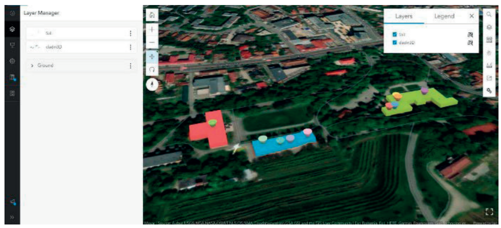

Figure 14. Interactive map of the USAMV Cluj-Napoca campus in ArcGIS Online

Figure 15 shows an innovative concept of the ArcGIS platform, namely allowing real-time localization of the user. The interactive map was accessed and by allowing the use of location and the phone's built-in GPS module, real-time positioning was possible. Thus, the position of the user in the center of the lawn can be observed.

This applicability can beexploited for example by any user who wants to reach a certain building within the campus. Within the scene of the interactive map represented in Figure 16, some information is presented in a succinct way (Sugiantoa et al., 2023).

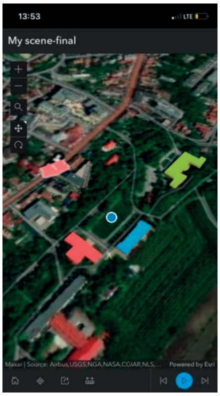

Figure 15. Accessing the interactive map from the mobile version of ArcGIS Online

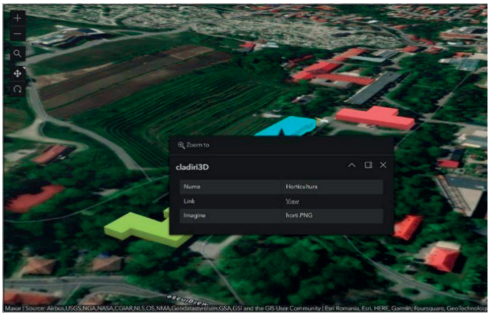

Figure 16. Accessing informations regarding the inserted buildings

By simply pressing the cursor on the surface of any represented building, a table is displayed that includes some information about the building of interest, such as the name, a link that redirects the user to the official website, namely to the Faculty website of Horticulture, and a representative picture of the objective in question (Xu et al., 2012).

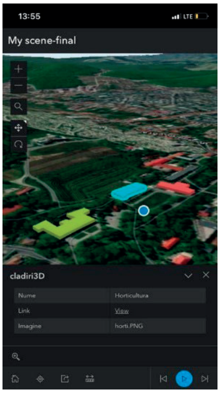

Figure 17. Accessing information from the phone

Similarly, the interactive map allows access for information in the phone version of the program as well (Figure 17), being important or the user to know where they need to go within the campus.

Figure 18. Path lenght measurement function

As can be seen in Figure 18, the length measurement function has been introduced within the interactive map. On the right side of the image, all the available functionalities are displayed, and for the measurement function, both the measurement of lengths and the measurement of the area of the desired polygon have been added. Thus, according to the figure, it can be seen that the length from the entrance point to the campus of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca to the front of the Faculty of Horticulture building is approximately 245.85 meters.

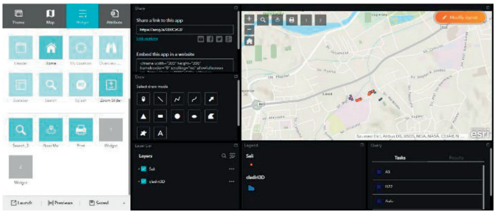

Figure 19. Editing the interactive map

Figure 19 shows all the elements that can be added to the display of an interactive map. Applications are in the form of widgets and can be added according to the user's desire. All the available widgets are presented on the left side, and on the right side are those inserted in the map composition.

Thus, in the presented map (Figure 20) widgets such as:

- The Share function that offers the possibility of distributing the interactive map to any user.

Sharing is done via a link and can be sent to social media applications allowed and agreed to by ArcGIS Online developers.

- The drawing function allows the graphic representation of elements such as point, line, polyline, curved line, or geometric elements such as triangles, rectangles, circles and textural elements.
- The Layers function provides the display of all layers included in the interactive map, and allows their selection or de-selection.
- The map legend displays all the elements represented in the map composition
- Query is the function to query the map by displaying the rooms that have been entered into the map database.

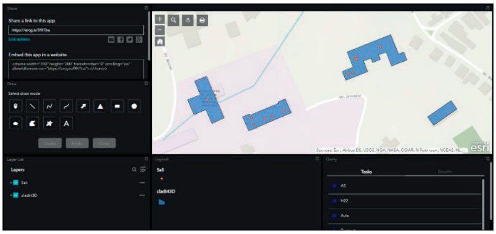

Figure 20. Viewing loaded widgets

Figure 21 shows the result of a query. A query was made within the created map, by accessing a point in the building of the Rectorate of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca.

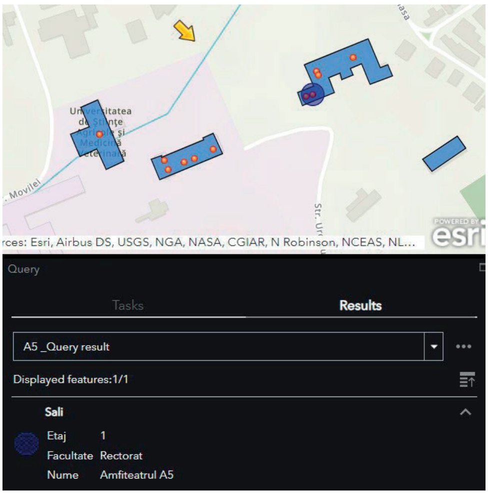

Figure 21. Performing a query

Thus, the performed application immediately rendered the location of the A5 Amphitheater. In the displayed table the A5 Amphitheater is located in the Rectorate building on the 1st floor.

CONCLUSIONS

The advantages of performing photogrammetric flights instead of clasical measurements consists in the speed of mission execution and the high accuracy of the obtained data. For the economic sector, execution costs are significantly reduced compared to classic methods and with the help of drones accessibility is possible in dangerous areas or inaccessible to human operators.

At the same time, the data obtained from the photogrammetric works are accessible for use. They are easy to manage from the storage point of view and can generate many subsequent exports in correlation with the requirements of the project. For processing, certain programs such as Agisoft MetaShape or Global Mapper facilitates the principle of operation or the execution of scanning or cadastral works.

Using the Geographic Information System, through the ArcGIS PRO and ArcGIS Online programs, the functionalities and permeability of the creation of various types of applications, represent an advantage for all users who want to carry out studies or spatial analyses. Also, another advantage of the programs developed by ESRI is the implementation of functions for creating interactive maps in 3D format that are used to reproduce the details of a surface in the highest possible quality.

The advantages of the Geographical Information Systems are its use in fields of activity such as cadastre, through the storage, management and permanent updating of cadastral data. Also, the GIS offers a plus to geography, being possible to represent any surface of land regardless of the current position.

Also, the work addressed is a topical one, in that it presents contemporary procedures and state-of-the-art methods, through these programs and applications that facilitate the principle of operation in the field of photogrammetry and GIS.

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Using the drone to generate digital data was imperially needed to make measurements on the USAMV campus. Through the resulting data, it was possible to create specific maps for the objective proposed in the work.

The maps created, both in 2D and 3D format, as well as the WEB applications have the purpose of providing users with data regarding the shape, location, character and arrangement within the campus of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca of the most important component buildings, taking into account their character.

The generated WEB applications can be accessed from any device which is an important advantage of viewing the campus as well as various functionalities through the user's location.

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