

VIEWING DATA SETS PRODUCED BY PHOTOGRAMMETRY IN WEB BROWSERS. APPLICATIONS ON GRASSLANDS IN ARAD COUNTY

M. SIMON¹, Loredana COPĂCEAN¹, Luminița COJOCARIU^{1,2}

¹*Banat's University of Agricultural Sciences and Veterinary Medicine "King Mihai I of Romania" from Timisoara, 300645, 119, Calea Aradului, Timisoara, Romania*

²*Centre for Mountain Economics, "Costin C. Kiritescu" National Institute for Economic Research, Romanian Academy, Academy House, Calea 13 Septembrie Nr. 13, Sector 5, București, Romania*

e-mail: mihai_simon91@yahoo.com

Abstract

In the last decades, the development of the technique, technology and programs for data and information processing have had a positive impact through the progress in many fields of activity, including the UAV technology. The results of using UAVs equipped with high-performance digital cameras are spectacular, materializing in the first phase in orthophotoplanes that can be exploited for obtaining spatial information with high accuracy and then in three-dimensional models. Because for the processing of digital images, the preparation of orthophotoplanes as well as the three-dimensional models requires specialized operators and "powerful" technical resources, the purpose of these works is to present two alternatives for viewing the data sets in the online environment using a web browser. These alternatives are open-source and allow users to view millions of data sets from sources such as LiDAR or real-time photogrammetry in standard web browsers. In this context, the research presented in this paper was conducted in the western area of Romania, on the administrative territory of Arad county, in the village of Odvoș, the commune of Conop. As a case study, a pasture surface, but also the surrounding area, was selected in order to obtain the orthophotoplan and its three-dimensional model which were subsequently uploaded to web applications and thus available to users for extracting spatial and descriptive information. The GNSS positioning technique was used to determine the coordinates of the photogrammetric landmarks, the measurements were made with a Leica GS08 Plus GNSS receiver, which allows the determination of the spatial position of an interest point using the RTK method. To take aerial images, a DJI Phantom 4 Pro unmanned aerial vehicle was used, equipped with positioning sensors and mapping sensors. One of the main benefits of point cloud visualization in the browser is that it allows users to share their data sets with the public without having to install third-party applications or transfer huge amounts of data. The data set collected by photogrammetry for this study was shared on the two platforms, Potree and Sketchfab and users can view the mapped grassland using the drone, in 3D, but they can also extract important data such as: inventory of trees as well as their height, measurement of fixed elements such as roads and canals, surface calculation, transverse or longitudinal profiles.

Cuvinte cheie: UAV, 3D point cloud, grassland, Potree, Sketchfab

INTRODUCTION

The development of the technique, technology and processing programs in the last decades has positively influenced the progress in many fields of activity, including the UAV (Unmanned Aerial Vehicle) technology, which has made a special leap. The results of using UAVs equipped with high-performance digital cameras are spectacular, materializing in the first stage in orthophotoplanes that can be exploited to obtain cadastral plans with high accuracy. Thus, the use of the two technologies, UAV and digital photogrammetry, can support users in various fields (GHIMBASAN A-C, 2019).

UAV mapping is done using photogrammetry techniques. In general, photogrammetry refers to the measurement of images, these images being captured by drones, airplanes or satellites.

UAV platforms are currently a valuable source of data for inspection, surveillance, mapping and 3D modeling. Starting from the 3D results generated by photogrammetric techniques, products such as Digital Surface Models (DSM)/Digital Terrain Models (DTM), contour lines, textured 3D models, vector data, etc. can be obtained in an automated way (REMONDINO, F, 2011).

Therefore, UAV photogrammetry can be understood as a new photogrammetric measuring instrument. UAV photogrammetry opens various new applications combining aerial and terrestrial photogrammetry, but also introduces low-cost alternatives to aerial photogrammetry with classic equipment (EISENBEISS, H., 2009).

Following the overflowing of space through photogrammetric techniques or laser scanning results point clouds, consider three-dimensional models. In many use cases, point clouds are treated as raw data, which are then refined by transforming them into triangular models or two-dimensional images. 3D scanning technologies such as laser scanners or photogrammetry produce enormous amounts of data, often exceeding hundreds of millions or billions of points. Due to the nature of the data, a large number of points is needed to accurately represent even simple models (HÄMMERLE, M. ET AL. 2014).

In addition to processing and rendering data sets with huge volumes, making them available to "end users" is another challenge. At present, in more and more fields of activity, huge volumes of data are constantly being collected and stored using specialized software. In this context, the easier the access to this data is, the greater the number of users.

Given that the possibility of effective use of collected data (extracting useful information contained) is an increasing challenge, this study presents a more "accessible" alternative for viewing data and/or extracting information obtained by UAV photogrammetry. In general, 3D data visualization and configuration is not a new topic, but using the latest web technologies, 3D data can now be integrated directly into websites, so they can be accessed anytime, from any computer and from various users, without the need for additional software installation.

More recently, several platforms for publishing, distributing and viewing 3D content have been created. These platforms offer a viewer based on WebGL and WebVR technologies that allow users to view 3D models on the web, for viewing on any mobile browser or desktop browser (SCHUETZ, M., 2016).

Platforms such as Potree or Sketchfab allow users to view billions of data sets from sources such as LIDAR or photogrammetry, in real-time in standard web browsers. One of the main benefits of point cloud visualization in the web browser is that it allows users to share their data sets with other users without the need to install third-party applications and transfer huge amounts of data.

MATERIALS AND METHODS

The researches presented in this paper - a case study - were carried out in the western area of Romania, on the administrative territory of Arad county, in the commune of Conop, the village of Odvoş situated at the border between the historical regions Banat and Crişana, at the southern foot of the Zarand Mountains, on Mureş (Figure 1), area included in previous researches (SIMON, M., 2017, 2018).

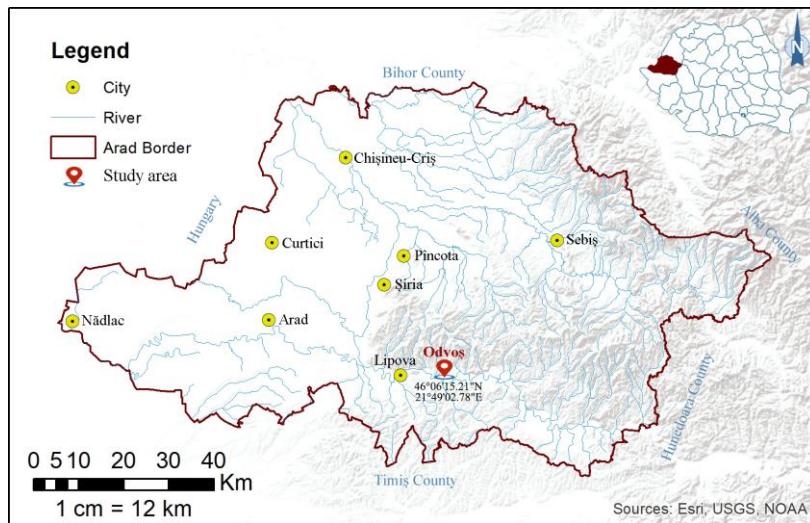


Figure 1 Location of the study area

The working methodology underlying this study was divided into several stages and is summarized in Figure 2. Ground measurements were made to determine the photogrammetric landmarks using the GNSS technique, then aerial images were taken using the UAV technique. The result of the two techniques after data processing is a point cloud that was later uploaded to the WEB platform.

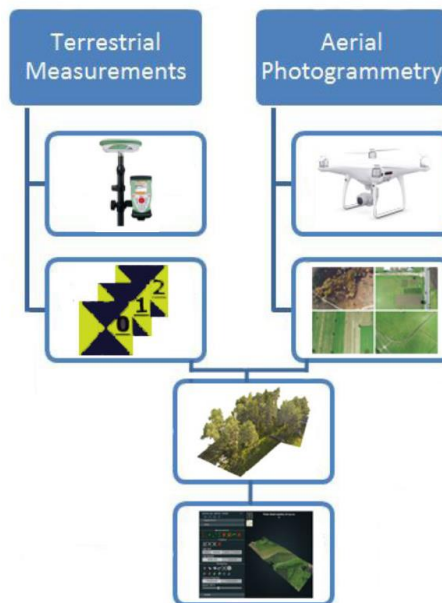


Figure 2 Workflow

✚ Equipment used

➤ ***Instruments used for terrestrial measurements***

The GNSS positioning technique was used to determine the coordinates of the photogrammetric landmarks. The determinations were made with a Leica Viva GS08 Plus GNSS receiver (Figure 3) which allows the determination of the spatial position of a point of interest using the Real Time Kinematic (RTK) method [6]. The system ensures fast positioning with a high accuracy of up to 2 cm depending on the number of visible satellites, the GSM signal and the corrections from the Romanian Position Determination System (ROMPOS). This system is based on Global Navigation Satellite Systems (GNSS) including GPS, GLONASS and GALILEO, providing additional data needed to improve position determination accuracy up to several millimeters.



Figure 3 Leica Viva GS08 (original photo)

All determinations were made in the European Terrestrial Reference System 1989 (ETRS89), introduced in Europe as a geodetic reference system, but were automatically transformed due to the implementation in the receiver used of the eTransDat software in the National Stereographic Reference System 1970 (STEREO 70).

➤ ***UAV technique used for digital image retrieval***

For aerial imaging, a DJI Phantom 4 PRO UAV type device [8] was used (Figure 4), equipped with positioning sensors (GNSS and inertial navigation unit IMU) and with mapping sensors (aerophoto digital camera). This is a quadcopter that has autonomous flight capability, which can be manually controlled at take-off and landing, by radio control; at safety altitude it is automatically controlled by the GNSS system.



Figure 4 DJI Phantom 4 Pro (original photo)

The Phantom 4 PRO is equipped with a GNSS system with the single-frequency code signal (L1) and provides an estimated accuracy of 5-10 m. With the help of the GNSS system, the coordinates of the perspective centers (X, Y, Z) of the aerial images were determined, and with the IMU unit the angles were set on the three axes (ω - the tilt angle on the X axis, ϕ - the angle of inclination on the Y axis and κ - the rotation angle on the Z axis). Thus, after the flight was realized, the positions of the perspective centers of the images and the inclinations of each image from the moment of their acquisition were known.

➤ **Hardware component**

For processing digital images, a Lenovo Legion laptop with a very powerful processor was used, which allowed the processing of the large amount of information contained in the digital images. The main features of the laptop are: Intel® Core™ i7-7700HQ 2.80GHz processor, Kaby Lake™, 8GB, 1TB, nVIDIA GeForce GTX 1060 6GB.

✚ **Software components used**

The use of modern equipment and the retrieval of data from the field has led, implicitly, to the use of the programs with which it was equipped, but also programs for processing. In this regard, considering the operations performed, the following programs were used:

- Downloading data from the Leica Viva GS08 Plus handset was done using the Leica Infinity software;
- Flight planning using the UAV and processing of digital imagery was done with the Pix4Dcapture program;
- Obtaining orthophotoplan based on digital images was achieved with the Agisoft Photoscan program specialized in image processing for obtaining three-dimensional models and orthorectified products. Agisoft Photoscan is a 3D image-based modeling software, used to create professional 3D structures and quality;
- The processing and transformation of products obtained with the help of Agisoft into other products that are easier to handle has been done using the Global Mapper program.

RESULTS AND DISCUSSIONS

The planning of the GNSS determinations involved, in the first phase, the establishment of the approximate position of the points that will serve as photogrammetric landmarks and then of the working mode, the sessions to realize the observations and the stationary times. These photogrammetric landmarks whose coordinates were determined in the national stereographic projection system 1970 realize the connection between terrain and image (Figure 5).



Figure 5 Photogrammetric landmark (original photo)

The GNSS determinations on the 4 photogrammetric landmarks used were performed by the RTK method, for each of the 4 photogrammetric landmarks, a session of determinations corresponding to the observation time of 1 minute was made (Figure 6).

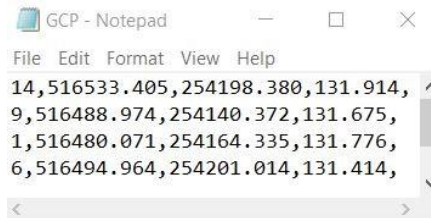


Figure 6 Stereo '70 coordinates - ASCII file

The Pix4Dcapture software compatible with the DJI Phantom 4 PRO UAV was used to determine the flight parameters. The PIX 4D program allowed the direct field planning of the flight path, the setting of the longitudinal and transverse covers between the images, the flight speed, the angle of inclination of the shooting axis and a total autonomous control from take-off to landing of the UAV (Figure 7).

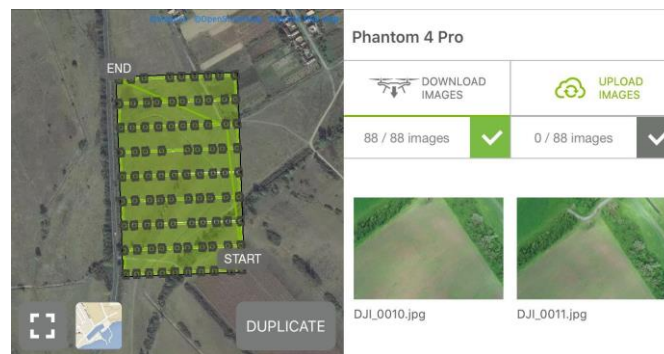


Figure 7 The flight plan with the captured images

In order to obtain almost Nadir images, the aim of the shooting axis was to be as vertical as possible, avoiding the taking of lateral images. Due to the necessity of using the central portions of the images in obtaining the orthophotoplan, where the influence of the level difference is smaller, a longitudinal coverage between images of 75% and a transversal coverage between adjacent bands of 70% was set (Figure 8).

Drone Type	Date	Time	Type
Phantom 4 Pro	28 May 2019	12:03	Grid
Flight Time	Location	Dimensions	Overlap
12min7s	46.103335°, 21.816815°	432m x 268m	75% - 70%
Camera Angle	Look Grid Center	Altitude	Path
90°	No	120m	2753m

Figure 8 Report generated by the application at the end of the flight with the main specifications

The point cloud was obtained using the Agisoft Photoscan software. The data import was done by uploading in the program of processing the 88 images in the .jpg format.

The definition of the coordinate system, by choosing the Point Dealul Piscului 1970, was made in order to use the Stereographic 1970 projection system. This process determines an automatic transcalculation of the coordinates of the perspective centers of the images from the moment of recording, determined in the WGS 89 system, in the Stereographic 1970 system.

The alignment of the images, which practically represents the operation of orienting them from the classical photogrammetry, was carried out in several stages. The merging of the images was important for the reconstruction of the geometry of the image network as well as for the subsequent thickening of the point cloud.

The second stage involved the scaling and georeferencing of the point cloud through photogrammetric landmarks of known coordinates (Figure 9). They were inserted from a previously created .txt file that contains the spatial coordinates X, Y and Z and their name.

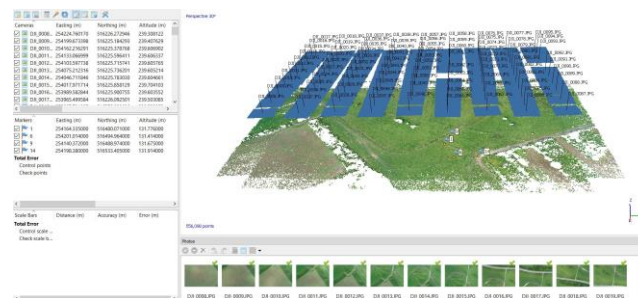


Figure 9 Image alignment, coordinate system definition and georeferencing

After the insertion of the photogrammetric landmarks it was realized the superposition of their position in the space space with that of the image space by placing the symbol in the image on the correspondent of the representation in the field. The process was performed for all digital images in which the photogrammetric landmarks determined in the field phase appear.

Generation and visualization of the dense cloud involved image matching algorithms using MVS applied to the rare point cloud, scaled and georeferenced. In this stage, the camera parameters and the 3D position of the points were used, all adjusted in the previous step. Thus, a point cloud of approximately the same density was obtained, sometimes even higher than the density of points taken using LiDAR systems (Figure 10).

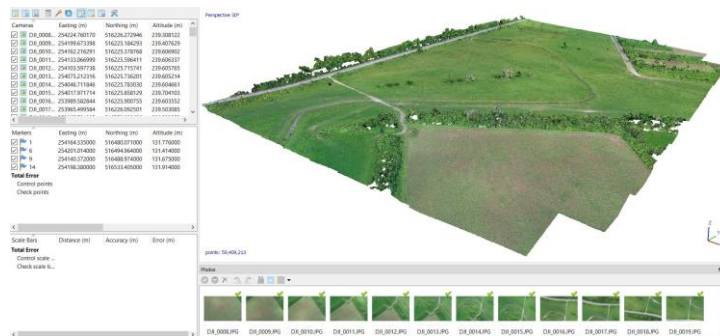


Figure 10 Visualization of the dense cloud point

The point cloud export was made by selecting the .las file in the size of 1.43 GB, which we will upload later on the web platforms. Potree platform allows uploading large files while Sketchfab platform uploads files of up to 50 MB.

Because the Sketchfab platform limits us to small files, we divided the project into several files. Thus, in the first phase, we uploaded separately the 3D model of the channel that crosses the studied passage in order to make different measurements in the respective area (Figure 11 - left). For the second loading option we opted for an area with pasture trees that can be analyzed on the 3D model (Figure 11 - right).

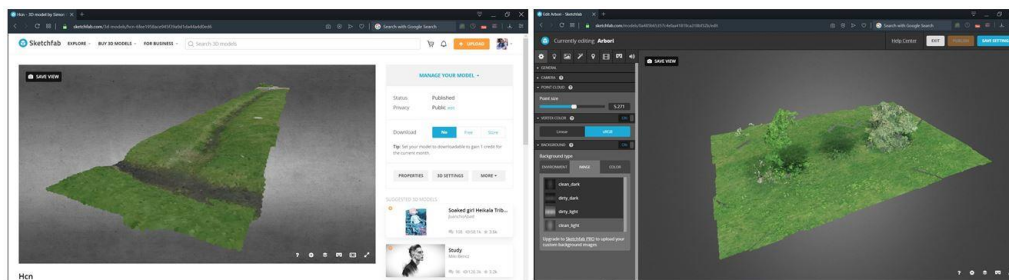


Figure 11 Models uploaded to the Sketchfab platform

Sketchfab is a platform for publishing, distributing, discovering, buying and selling 3D content. Provides a viewer based on WebGL and WebVR technologies that allows users to view 3D models on the web, for viewing on any mobile browser or desktop browser. The disadvantage of these platforms is that it allows uploading only two small files per month in free mode, if we sleep to upload more than two models per month we must create a premium account.

A much more complex platform is Potree, a free, large-point cloud-based WebGL maker developed by the Institute of Computer Graphics and Algorithms, TU Wien. In this platform, we had the opportunity to upload the entire model generated with photogrammetric techniques (Figure 12), in size of 1.43 GB. This platform allows more operations than the Skecthfab platform but creating the server for this platform is much more difficult and requires IT knowledge.

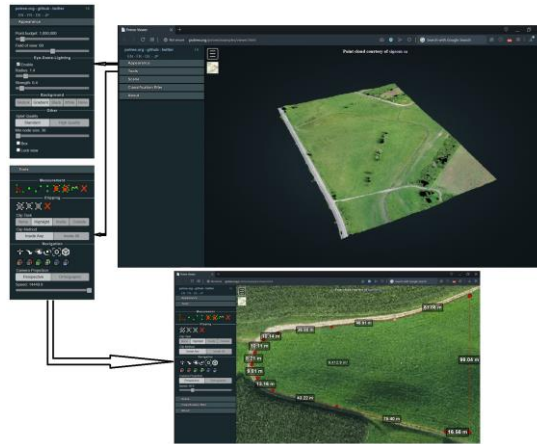


Figure 12 The model loaded in the Potree platform

Once the model has been uploaded to this platform, we can generate a link that we can send further for viewing the model. The platform is very well thought out and offers a variety of applications, from the calculation of areas or perimeters to transverse or longitudinal profiles. Unlike Sketchfab, Potree does not allow the sale or purchase of 3D models.

CONCLUSIONS

In the case of the grassland analyzed in this paper, the visualization of the point cloud and implicitly the images resulted by its processing, through the two presented platforms, allows both exploratory analysis (visualization and thus obtaining information related to shape, neighborhoods, geomorphological aspect, vegetation cover). as well as performing precision measurements (surface, perimeter, boundaries, "isolation" and calculation of useful surface).

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