UAV TECHNOLOGY USED FOR MONITORING A MINING SITE

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***Abstract**: Surveying technology currently offers us a multitude of benefits and can be used in many fields of activity to create a more efficient way of working for people. This project aims to describe the process of 3D reconstruction of a mining site with UAV technology. The first step means performing the actual flight in the targeted perimeter with a drone (or UAV – unmanned aerial vehicle) equipped with a camera to capture images of a site from different vantage points. Out of these images, a photogrammetry software can recreate geo-referenced 3D maps of the mining site. The processing of the cloud of points collected with the help of the drone is an important step of this project. Mining operators can also easily extract the precise volume of stockpiles or areas to be excavated. By providing thousands of data points for one stockpile, drone surveys are far more accurate than surveying with total stations.*

***Keywords:** mining site, drone flight, point clouds, ground control points, digital elevation model*

1. Introduction

The drones in mining improve the overall efficiency of large mine site and quarry management by providing accurate and comprehensive data detailing site conditions in a very short time. They also support better coordination among teams onsite and internationally, offering dynamic oversight of all operations. Above all, this data can be safely produced by on-site workers who have minimal surveying experience at a fraction of the cost of traditional survey methods. [1], [2]

Drone-generated data is a series of overlapping images containing geospatial information, which are stitched together through a process called photogrammetry. Each pixel of each image contains its own georeferenced location in space. [2], [3]

Beyond this, artificial intelligence in the software can automatically highlight those that do not comply with standards or constitutes a potential threat to the workers' safety. [2]

This paperwork aims to present the 3D reconstruction of a mining site, more precisely a limestone quarry (Fig. 1). Using the necessary materials and following correctly the working methodology, photogrammetric products will result as digital elevation model in 2D and 3D, an overlapping report and the 3D model with a textured visualization.

Fig. 1 – The location of the mining site, a limestone quarry from Roscani village, Hunedoara county.

2. Materials and Methods

The traditional methods of monitoring and measuring mining sites have consisted of measuring points using the total station. The using of drones has brought a multitude of advantages in the field of mining, being a much more advanced and precise technology. With the help of images captured by the digital camera attached to the drone and their processing into appropriate software programs, millions of points are obtained that render more accurately the 3D model of the mining site. [4]

In order to perform the flight for this project the drone used was a DJI Phantom 4 RTK model (Fig. 2). This drone model has an implemented RTK (Real-Time Kinematic) system that provides high accuracy and helps to correct errors in real time. [5]

Fig. 2 – The drone used for flight (DJI Phantom 4 RTK)

In order to obtain correct and precise results, the working methodology must be followed correctly and the simplest way to follow this methodology is to divide the work into a few steps.

The first step in performing this project is to recognize the terrain, set objectives and establish the flight perimeter for the drone. It is required to identify the terrain to be measured using UAV technology, as well as to identify obstacles that could prevent data collection during the flight (forest vegetation, high electricity poles, buildings, etc.). [1]

The second step represents preparing the drone for the flight in favourable weather conditions and respecting the perimeter of interest. The actual flight and the related measurements are performed, as well as the marking in the field of the ground control points and their measurement with GPS. Ground control points (or GCPs) are points on the ground with known coordinates. In an aerial mapping survey, GCPs are points which the surveyor can precisely pinpoint: with a handful of known coordinates, it's possible to accurately map large areas. [2], [3]

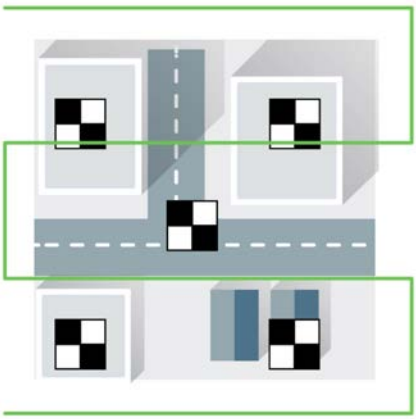

Fig. 3 – Illustration of the GCPs (ground control points)

The third step represents downloading and processing data from drone and GPS using specialized software. The processing of the obtained point cloud will be performed with Global Mapper or PIX4D program which allows us to view, edit and analyse this multitude of points so as to obtain a finite result as faithful as possible to the reality on the ground. Point cloud processing and creating the 3D model as accurately as possible. [5]

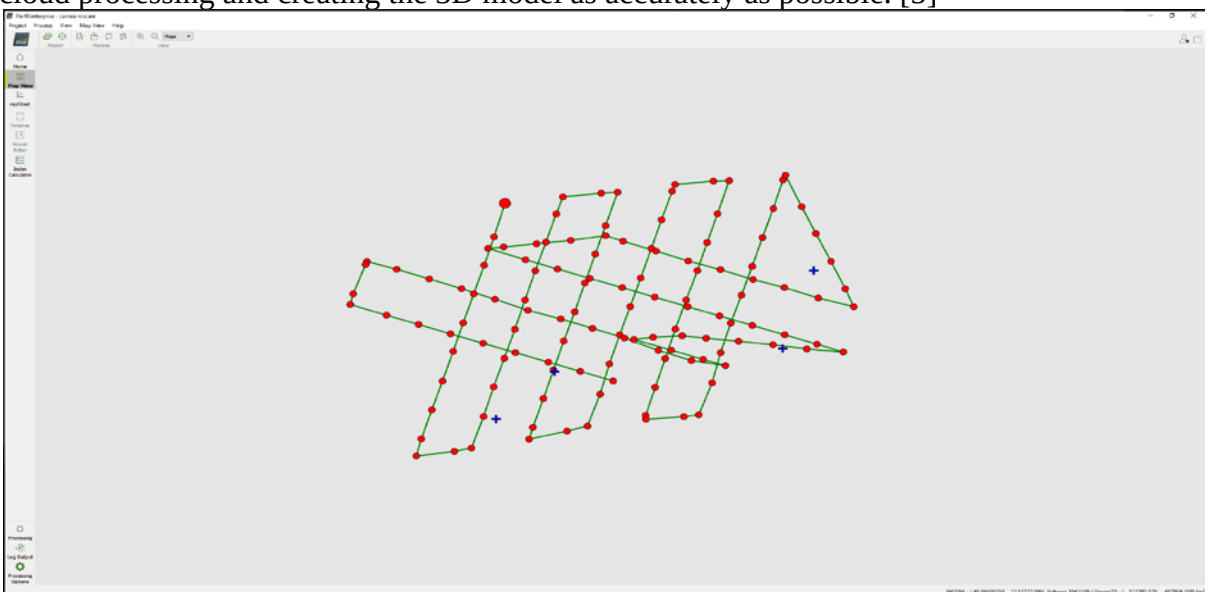

Fig. 4 - Top view of the initial image position.

Using the PIX4D software program the top view of the initial image position has been obtained (Fig. 4). The green line follows the position of the images in time starting from the large red dot and the 4 points illustrated with the “+” sign in blue represent the 4 ground control points. [5]

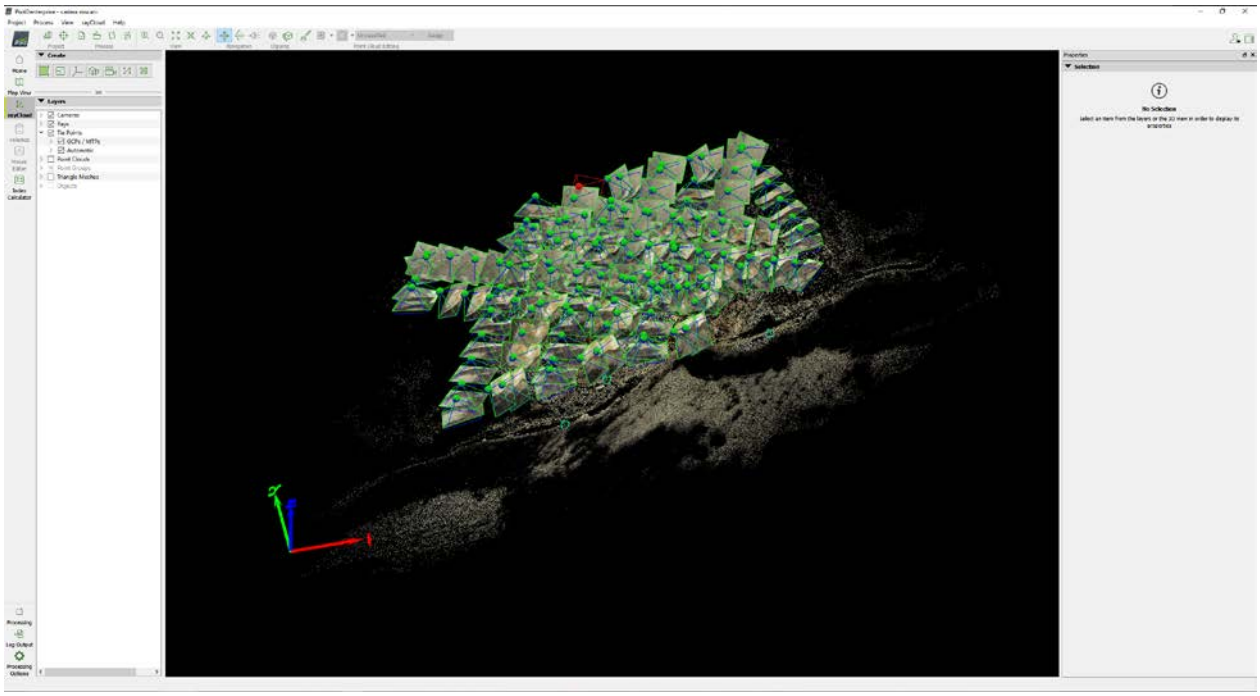

Fig. 5 - Representation of the images collected by the drone and the millions of points obtained from them

In order to obtain the point cloud which will be processed, all the images captured with the drone are geo-referenced (Fig. 5, Fig. 6). These geo-referenced images correspond to the points of interest.

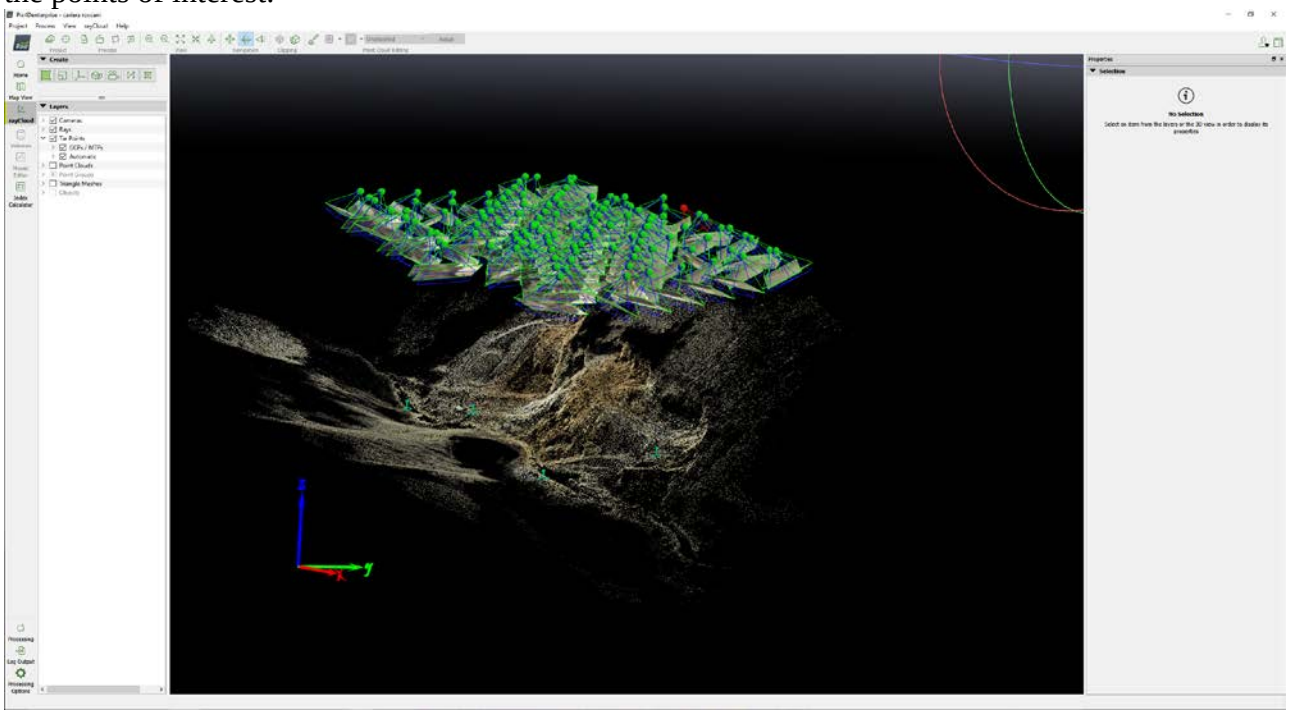

Fig. 6 – Geo-referenced images and the point cloud formed on them

3. Results and Discussion

After the process of editing and densifying the point cloud, the data obtained using UAV technology is thus transformed into a final product, as a 3D model of the mining site (Fig.7).

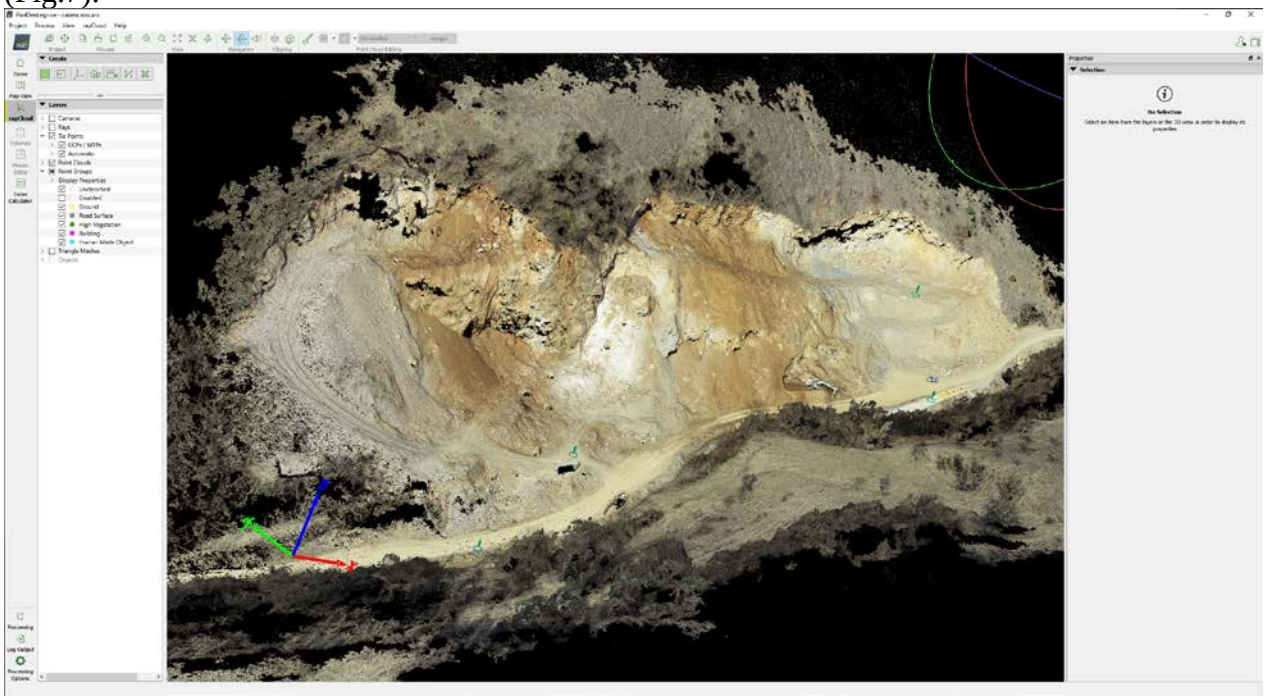

Fig. 7 – 3D model of the mining site

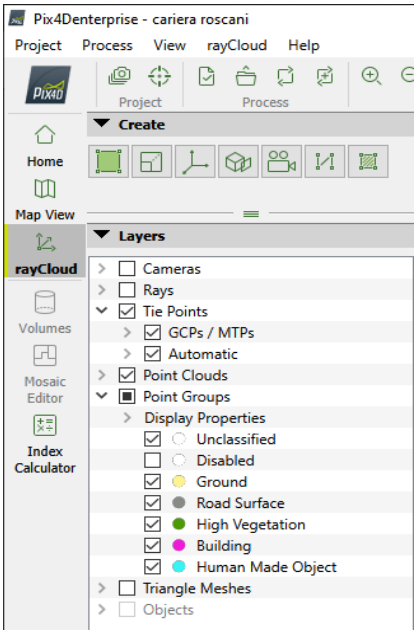

Fig. 8 – Point categories that can be viewed in the 3D model

The PIX4D software program offers the user a point classification and allows the user to choose which category of points wants to edit or view as ground points, high vegetation points, building points, etc (Fig. 8). [5]

The altitude of the terrain in the area of interest is also an important result of the data collected with the drone and using the Global Mapper v22.1 software program are obtained digital elevation model in 2D (Fig. 9) and digital elevation model in 3D (Fig. 10). [5]

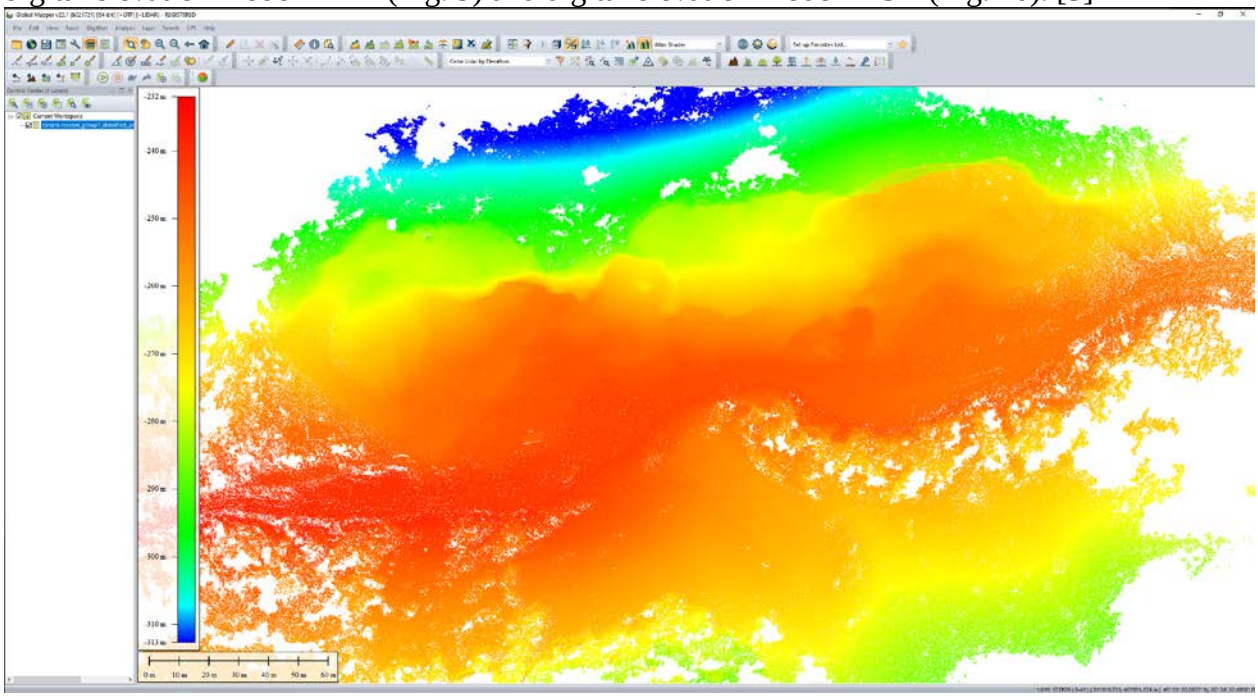

Fig. 9 – Digital elevation model (DEM) in 2D and altitude level scale

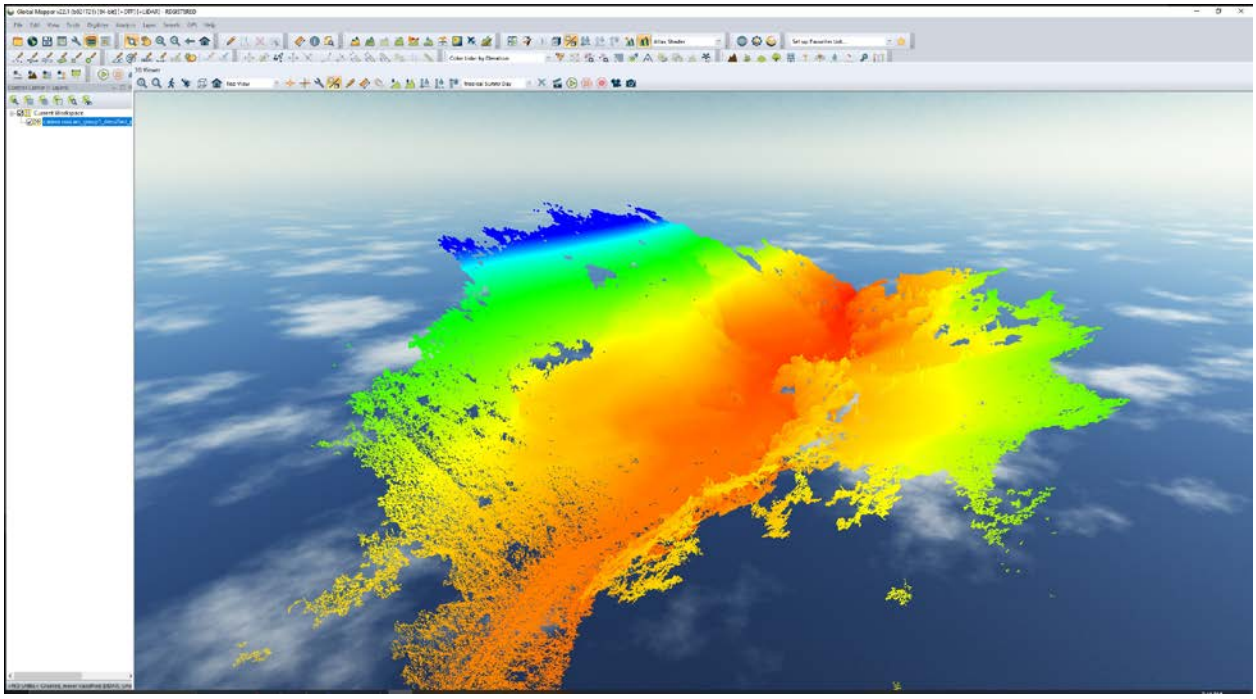

Fig. 10 – Digital elevation model (DEM) in 3D

The software implemented in the DJI Phantom 4 RTK drone automatically generates an overlapping report for a detailed observation of the areas where sufficient data were collected and the accuracy of the points generated. [5]

Number of overlapping images computed for each pixel of the orthomosaic. Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. [5]

Good quality results will be generated as long as the number of keypoint matches is also sufficient for these areas.

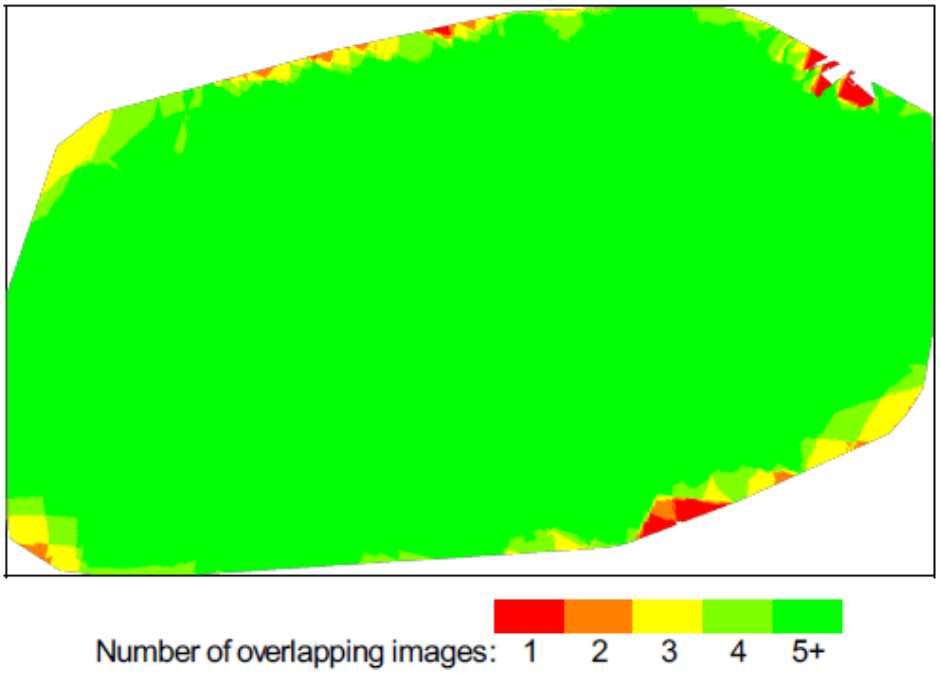

Fig. 11 – The overlapping report

4. Conclusions

Drone aerial images can be used to generate point clouds, digital surface models, digital terrain models and a 3D reconstruction of a mining site, including its stockpiles. [4]

Drones in mining improve the overall efficiency of large mine site and quarry management by providing accurate and comprehensive data detailing site conditions in a very short time. [4]

Benefits of using UAV technology [4]:

- Stockpile management
- Better inventory and financial data
- Accuracy of volumetric calculations
- More and better data for monthly or weekly management
- The risk of injury on-site is low
- During drone survey, mining exploitation benefit from continuity in the site because they have no influence on the efficiency of the drone.

Also many other applications can be made within this project. An extremely beneficial application for high productivity in the mining industry is the volumetric calculation of the excavated material. Volumetric calculations are performed in order to highlight the volume differences of the quantities excavated from one period to another.

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