SMART SCANNING WITH UAV TECHNOLOGY

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***Abstract*: *This paper presents a case study about smart scanning with UAV Technologies. The case study was carried out at the Metropolitan Cathedral of Timisoara, which is located near the city center, adjacent to the Bega Canal. The scope of this study was to take part of the cathedral's renovation by helping pinpoint the optimimum location for placing its new illuminating system. Since the cathedral is also a hystorical monument, by law, we first needed to scan the bulding and compare the new values we have with the old ones in order to determine if some areas needed to be repaired/restored first. Once there, all scannings and surveys were made using: GPS Leica G08, DJI Phantom 4, Leica 3D ScanStation C10. To process all data gathered, we used AgiSoft FotoScan and CloudCompare. The method used was georeferencing using Ground Control Points. A total of 18 GCP were taken, all of which were placed strategically inside the area of survey of 19,1 acres for the drone to easily see them. The total flight time was 4 minutes and it flew to an altitude of 84m with an result of 130 images. Using all data points gathered we obtained our point cloud. In order to execute this project, several criteria must be taken into consideration, for exampleThe Metropolitan Cathedral of Timisoara (Figure.1) is one of the most expensive buildings in the city and one of the most famous architectural monuments in our country. The Catedral impresses by its significant dimensions, by the architectural specificity and by the enameled tiles. The additional work consists in adding illumination of the Cathedral's façade to highlight the enameled tiles which shine beautifully when light is reflected on them. Due to the growing interest in updating geodata - mainly 3D data and cadastral data as basis for GIS and mapping applications - there is a demand for a fast and efficient surveying method that combines data acquisition with additional information such as images, orthoimages, 3D-models of buildings and infrastructure, and elevation models. One possibility for such a fast and efficient capture of georeferenced data is the use of UAV systems (Unmanned Aerial Vehicles). Second possibility is 3D scanning because it allows detailed analysis of a building no matter how complex the architecture, no matter what form it would have and no matter how unconventional it would be. Using the scanned data, any intervention on the building can be planned. We can perform 3D laser scanning for buildings, monuments, heritage buildings, archaeological sites, civil constructions, industrial constructions and installations, volume monitoring. For the project mentioned above we used both 3D scanning and UAV technology.*

Keywords: *UAVs, Surveying, Measurement, Mapping, Planning, Modelling, High Resolution, Sustainable, 3D Scanning*

INTRODUCTION

For this project to be executed, we need to take some things in consideration first. For example, we can say that The Metropolitan Cathedral of Timisoara is the biggest and the most expensive edifice in our city and a significant monuments our country has. The Catedral impresses by its significant dimensions, by its architecture and by its enameled tiles. It was raised between 1936 and 1942.(Anders, N, 2013). The contruction was very difficult to finish because of World War II. The surface on which it was built has 1,542 m2. The chatedral has 11 towers, and the most highest one has 90.5m. Because of this, an additional contract for extra work to the ongoing site was signed. The additional work consists in adding illumination of the Cathedral's façade to highlight the enameled tiles which shine beautifully when light is reflected on them. Due to the growing interest in updating geodata - mainly 3D data and cadastral data as basis for GIS and mapping applications - there is a demand for a fast and efficient surveying method that combines data acquisition with additional information such as images, orthoimages, 3D-models of buildings and infrastructure, and elevation models. One possibility for such a fast and efficient capture of georeferenced data is the use of UAV systems (Unmanned Aerial Vehicles).

Second possibility is 3D scanning because it allows detailed analysis of a building, it doesn't matter how complex the architecture is, what form it would have and how unconventional it would be. Using the scanned data, any intervention on the building can be planned.(Dragomir et al., 2012). We can perform 3D laser scanning for buildings, monuments, heritage buildings, archaeological sites, civil constructions, industrial constructions and installations, volume monitoring. For the project mentioned above we used both 3D scanning and UAV technology.

MATERIALS AND METHODS

The Metropolitan Cathedral of Timisoara is located in the historical Banat region, in western Romania. It is built in the center of the city, at the crossroads of the most important arteries of circulation and it has the following coordinates:

- DMS: 45° 45′ 2.48″ N, 21° 13′ 26.83″ E
- Decimal: 45.75069, 21.22412

Figure 2 – Localization of Metropolitan Cathedral

2.1. Materials used

For the study area, we used:

- **GPS Leica 08** (Figure 3) The RTK network rover has been designed to be the perfect system to operate with Leica Vivia CS10 3.5 G field controllers. This controller has an integrated high-speed 3.5 G modem that connects to the RTK reference networks and enables broadband internet connectivity for data transfer via your mobile connection so you can connect and measure once the unit is turned on.(Herbei et al., 2016).

Figure 3 - Leica GS058 together with the UAV Phantom4

- **DJI Phantom 4 Drone** (I Figure 4) is DJI's smartest flying device. It is eqiuipped with an camera stabilizer, a compass module and IMU system which increases high performance.

Figure 4 - UAV Phantom4 Pro together with the Leica GS058

- **Leica 3D ScanStation C10** (Figure 5) features a high-precision / long-range scanner, beveld sensor, batteries, a controller, data storage, and a video camera that is auto-adjustable with laser plummet. This features come in one small and portable device.

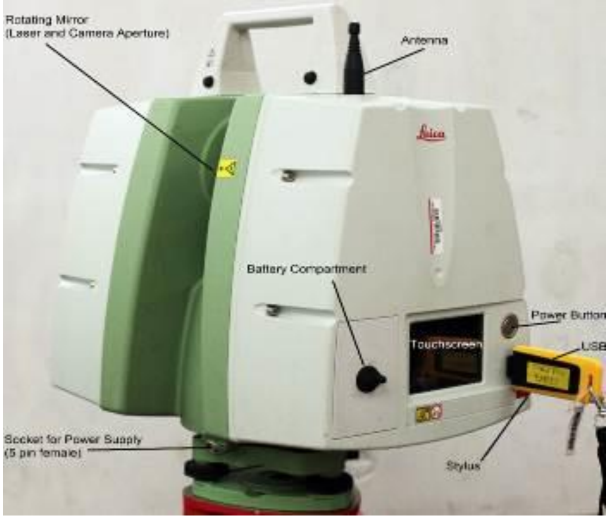

Figure 5 - Leica 3D ScanStation C10

2.2. Methods used

The chosen method is Georeferencing using GCP (Ground Control Points).

GCPs are large distinct bullseyes placed on the ground, strategically placed across the area of interest.(Jim, Crume., 2018). Before you start, RTK GPS coordinates must be first measured from the center of each GCP.

Figure 6 – Position of Metropolitan Cathedral

They establish that any point on your chart correctly matches the latitude and longitude with the real GPS coordinates. It is important in your aerial imagery that the GCP be easily spotted . (Figure 7)

Figure 7 - Ground points used for georeference

This is accomplished by using high contrast colors and ensuring that the GCPs is sufficiently large to be seen from your particular flight height.

Usually, when using ground control points, it is recommended to fly at 90 m with a frontlap and sidelap of 70/75, but this may change depending on the area you map. (Herbei et al. 2016.). (Figure 7)

RESULTS AND DISCUSSION

3.1.Flight Planning and Flight Execution

The software used is the SkyCatch iOS app. While keeping things easy for operators, you can plan missions at any time without having the drone connected.

First we need to plan our flight. To do so, access Flight Planning:

- Drag a box over the area you want to cover.
- Move the corners of the boxes to make the desired area bigger or smaller.
- You can also select the desired ground resolution and altitude.
- When you're ready to go fly, just plug your device into the DJI remote controller.
- The flight app will automatically detect the drone and camera, run a series of system checks, and let you know when everything looks ready for takeoff.

Now, we can start Flight Execution on site:

- Once at the site, power the drone on, take your GPS device, and calibrate the compass;
- Start the DJI app to configure camera settings and verify that the drone passes the pre-flight checklist;
- Open the map window and verify that the home position is the actual location of the drone;

- If it’s off, wait for more satellites to connect to improve the location accuracy of the drone.

Figure 8 - The flight corridor

Figure 9 - Definition of flight parameters

Once these steps are completed, open the SkyCatch app to execute the flight. (Figure 8, 9). Note that you want to be closer to the starting point as the drone always needs battery to travel to the starting point. We placed 18 GCPs of an area of 19,1 acres. The total flight time was 4 minutes and it flew to an altitude of 84 m with an result of 130 images.(Lemmens, M. 2011) (Figure 10)

Figure 10 – Obtaining aerial images, Metropolitan Cathedral

3.2 Data processing:

For data processing we used **AgiSoft Fotoscan** and **CloudCompare** softwares.

Agisoft FotoScan is a program that is used for photogrammetry and organizing digital images. It also creates 3D objects. (Figure 11, 12, 13).

CloudCompare is a 3D point could software that can manage limitless scalar fields per point cloud that can be used with different dedicated algorithms, that means that CloudCompare has a precise point density.

The process in **AgiSoft Fotoscan** Software is very simple:

- Upload the images taken in the field in the software;

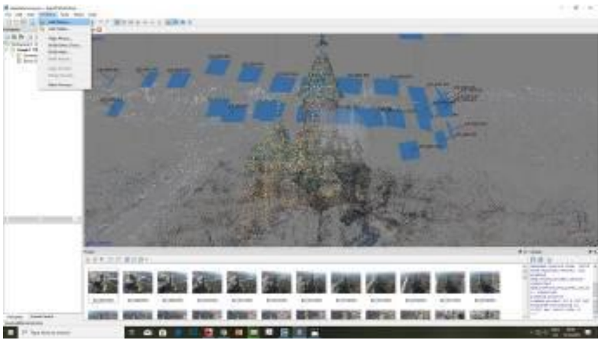

Figure 11 - First alignment of aerial images

- Position the images in the coordinates taken with the UAV technology;

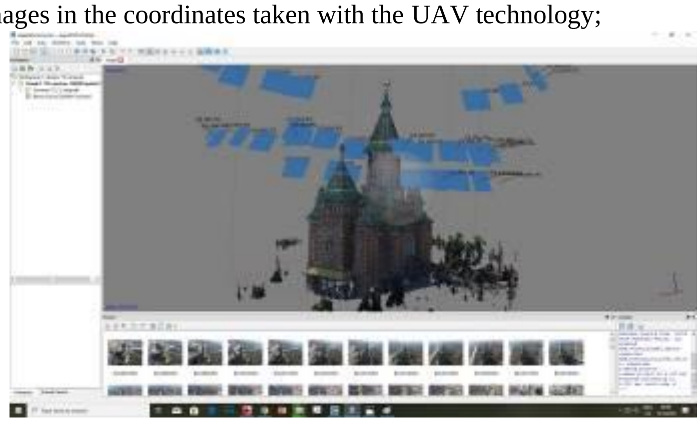

Figure 12 - Point cloud obtained after alignment (colors taken from images taken by the UAV technology)

- As a last step we got a cloud of points.

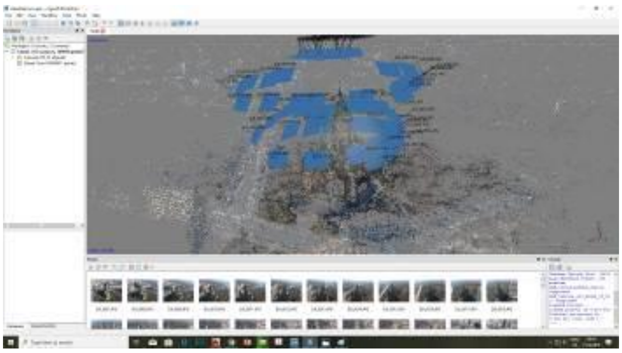

Figure 13 - SmartAlign with AgiSoft

After obtaining the point cloud in **Agisoft**, (Popescu et al., 2016) we will repeat the same procedure as above in **CloudCompare** Software:

- Upload the images taken in the field in the software;

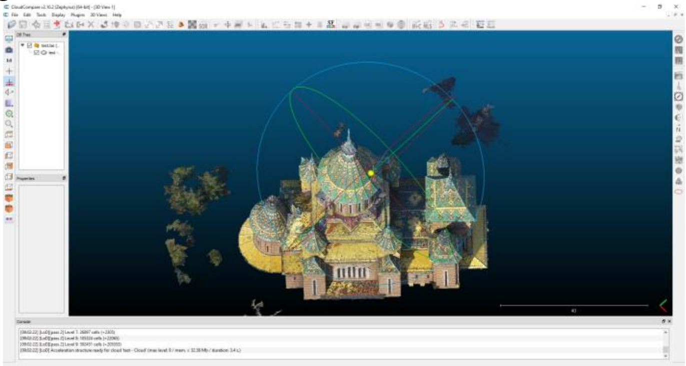

Figure 14 - Point cloud obtained after alignment

- As a last step we got a cloud of points.

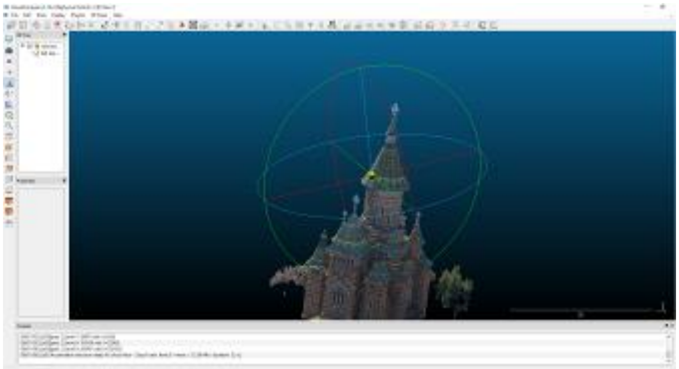

Figure 15 - Point cloud - CloudCompare

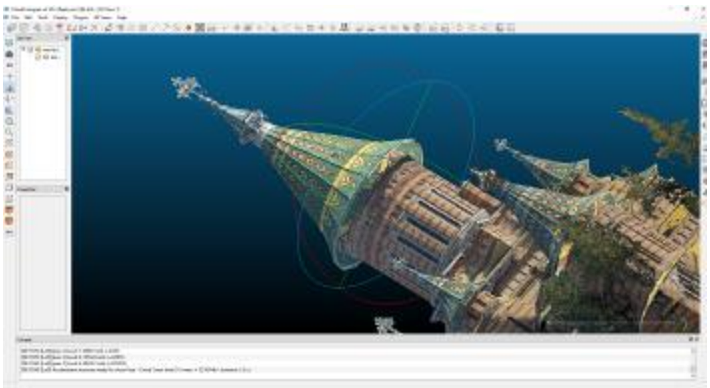

Figure 16 - Point cloud, Metropolitan Cathedral

This comparison between the two softwares is done to observe the pixel resolution, where in CloudCompare the point density is much more visible.

CONCLUSIONS

The advantage of UAV systems is that the survey, where the subject's position and/or dimensions are accurately measured in 2D or 3D, results in an accurate digital representation. To ensure sufficient images are collected in the right configuration, the UAV is used to take overlapping stereo images. These stereo images are then used to produce the initial output which is a point cloud. A point cloud is a set of data points within a three dimensional space. This allows a detailed analysis of a building, itdoesn't matter how complex the architecture is, what form it would have and how unconventional it would be. (Wilfried, Linder., 2016). The scanning had as a defining purpose the reconstruction of some elements and also adding illumination of the Cathedral's façade, to highlight the enameled tiles which shine beautifully when light is reflected on them.

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