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Use of modern software solutions and systems for analysis and reconstruction of road accidents

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Abstract. This study examines the possibilities of investigating a road accident and provides initial data for the reconstruction of road accidents using photogrammetric techniques. Compared to the conventional practice of road accident reconstruction, photogrammetry saves time, money and is an effective method for investigating road accidents. The use of unmanned aerial vehicles - UAVs and mapping software enables the collection of collecting the data needed to investigate, analyze and reconstruct road accidents. The measurement results can be considered as initial information for a technique for repairing damage analysis. The study shows that photogrammetry has an increasing potential for application in the investigation and recovery of road accidents.

1. Introduction

"Road safety is a problem that is not paid enough attention to - but it is true that it is one of our great opportunities to save lives around the world," Michael Bloomberg, WHO Global Ambassador for Non-communicable Diseases and Injuries. The 2018 Global Road Safety Report states that road accidents take more than 1.35 million lives annually worldwide [1]. That's 3750 lives every day. In addition, road accidents are already the main cause of death for people between the ages of 5 and 29.

Blocked or closed lanes and congestion are an inconvenience for both drivers and officials responsible for the organization and management of road traffic. By using drones, improving traffic safety and improving the organization is present, but on-site reconstruction and subsequent analysis of road accidents is necessary. Investigating officers should disclose evidence and find out the cause and mechanism of the crash, especially when it comes to physical injuries, death or serious material damage.

Distracted drivers in an emergency situation, delayed or stopped traffic, failing to properly orient themselves, provide a perfect opportunity for secondary road traffic accidents. This issue from the point of view of traffic safety is one of the most important in the investigation and reconstruction of a road accident [2].

The demand for these secondary crashes is that most individuals and employees are quickest to gather evidence and begin to participate in the results of road transport produced [3], but conventional mapping of a fatal accident can be inferred over time. at the time of the severity of the accident.

2. Prerequisites and ways to solve the problem

The actual situation of an accident is only clarified by restoring the actual movement of the objects involved in the incident - vehicles, cyclists and pedestrians [3,4]. The prepared auto-technical expertise is the main source of evidence in the investigation of road accidents [5,6,7]. Conventional data collection techniques required for the analysis and reconstruction of road accidents present risks and problems, the most common of which are:

- the need for a sufficiently large number of highly qualified specialists and employees in the analysis and reconstruction of road accidents to cover the entire road network of the country;

- a long period of time for the operations to collect all the necessary data for the subsequent analysis and reconstruction of the road accident, with the site of the accident completely or partially closed during most of the time;
- high risk of danger for employees involved in the collection of data for the analysis and reconstruction of a road accident;
- the need for inspection of the bodies and staff for the temporary organization of the emergency traffic and the controlled recovery of the overall traffic;
- high risk of danger for people involved in a road traffic accident and all staff involved in its elimination, as well as for all road users in the area of the accident.

Photogrammetry is the science of using images to obtain reliable information about physical objects and the environment through the process of capturing, measuring and interpreting photographic images and models for mapping, measuring distances and other phenomena [8,9]. The minimalist definition of photogrammetry would be: use of photographs to make measurements. The term photogrammetry was first used by the Prussian architect Albrecht Meidenbauer in 1867, however, some of the analysis and study of images is relatively new [10,11]. The term "photogrammetry" itself is Greek by origin and consists of 3 words: photos - light, gramma - recording and metreo - measurements.

The use of unmanned aerial vehicles - UAVs and mapping software for the collecting the data needed to investigate, analyze and reconstruct road accidents will drastically reduce the waste of time and resources [12]. In many cases, even in large road sections, a scene of a car accident takes less than 10 minutes with a drone. The use of UAVs technologies for incident investigations will increase the safety of investigating officers. Once aerial photography is complete, investigating authorities can review office data, reducing the time it takes to stop traffic, which in turn increases the safety of other traffic users and control officers. It also eliminates the need for re-travel in order to collect additional data such as road marking distances, etc. The software programs automatically create a scaled three-dimensional model of the pictures, which allows all measurements to be made by simply rotating the model and by marking two or more points, the measurement can be done with very high accuracy.

The process uses a sufficient number of captured two-dimensional (2D) photographic images, which, after being processed through various softwares, are used to create three-dimensional (3D) digital models, topographic representations or simulations of meteorological models. The hardware to software integration in new technologies is so sophisticated that most photogrammetry operations happen automatically. Photogrammetry is most commonly associated with the production of topographic maps generally than conventional aerial two-dimensional photographs, although digital and satellite images are increasingly used. Photogrammetry using images obtained from aircraft and satellites has been used to create maps at various scales [13]. Recent improvements in the design of cameras and photogrammetric devices have led to an increase in accuracy, allowing mapping at scales up to 1: 200. The photogrammetrically derived 3D information obtained from the images is used to create maps and plans and provide input for terrestrial modeling packages, orthophoto and geographic information systems. Photogrammetry is used to provide national mapping and map review on a small and medium scale. On a larger scale, photogrammetric data form the basis for 3D modeling in a wide variety of applications, including highway design, meteorological anomaly studies, pipeline routing, and more. Photogrammetry is aerial, terrestrial and close-range. Increasingly, UAVs are using sophisticated positioning and control technologies to meet the stability and specific position of the camera during photogrammetry. Aerial photogrammetry requires multiple overlapping images, often up to 80% of the previous image, to produce an accurate, ultra-high resolution large format image. The main difference in terrestrial photogrammetry is that it is usually non-topographical because it is quite difficult to capture and plot large areas of varying height when shooting from the ground. Ground modeling focuses on measuring buildings, engineering structures, film kits, mines, and more.

The mapping process relies on image clarity. When using drones, shooting is best done at around noon when the sun is upright and light shadows are minimal. Depending on the location, noon and vertical sunlight will cause the least visual obstruction [14].

Photogrammetric recordings are made at an angle determined at the angle of the camera of the UAVs, depending on the purpose and object of the study - the camera is perpendicular to the ground or it is necessary to capture the investigated object at an angle. The flight management and position of the drone camera, through modern software products performance are captured from all perspectives as the software uses combined technology for accurate modeling in three dimensions.

3. Results and discussion

An experimental study using an UAVs and three-dimensional photogrammetry software to determine some parameters was carried out in the territory of the Technical University of Sofia, namely the courtyard of block 9. The image processing software used is one of the most widely used and accessible [15], for fast and sufficiently accurate primary processing without the purchase of a license (free access for 14 days). After launching the application, recognizing and establishing communication with the UAVs, all the necessary parameters for the flight area and shooting are determined (Flight Logs Fig. 1). The perimeter of the study area is determined by entering the exact benchmarks (coordinates), the desired altitude for the flight and the shooting, after which the software determines the exact trajectory, the shooting angle and the required minimum number of pictures for the studied area. In the initial experimental study, the choice of altitude for the flight of the UAVs was 50 meters due to the specifics of the surveyed area and the presence of buildings (Fig. 1).

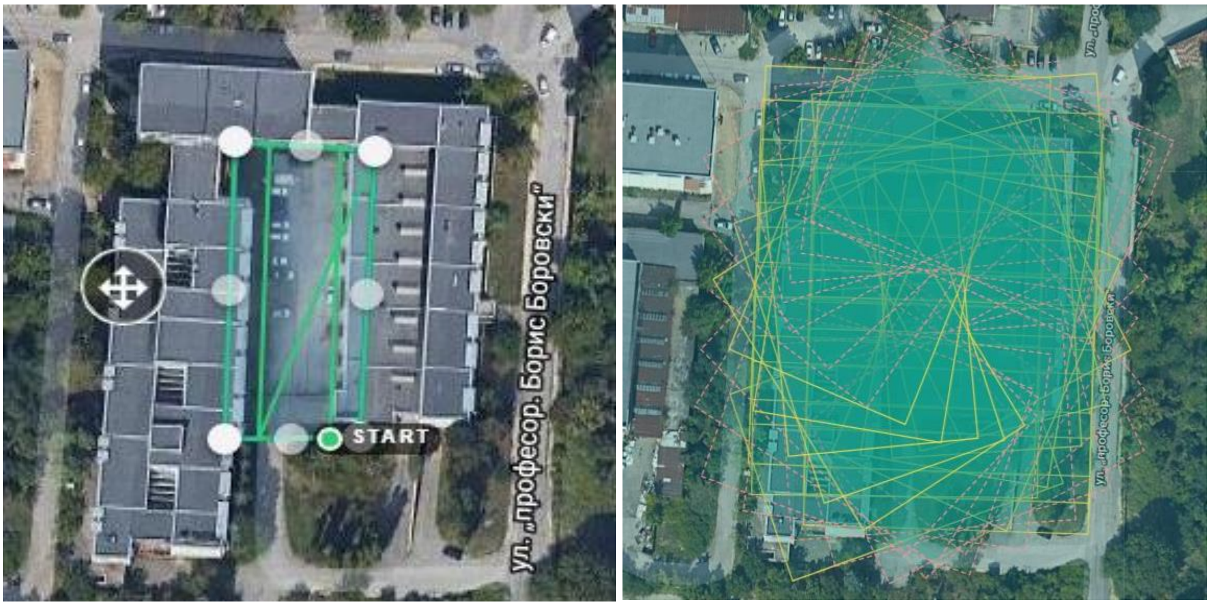

Figure. 1. Location of the study area and pilot image sequence plan.

The figure shows the flight plan, sequence and number of images, the required overlap between consecutive images, the total area of the captured area, the resolution - the resolution of the processed images, represented as the number of centimeters per pixel. After determining the study area and determining the altitude of the operator, the software calculates a minimum number of consecutive shots (in our case 45 frames) and the total time required to complete the flight (2:48 minutes). The status of the battery of the drone battery is checked and, if sufficient, the fields are executed. When exploring larger areas, flight time and trajectory are increased, if the drone's battery capacity is insufficient to perform all of the shooting, the drone lands at a location determined by the software, after replacing the battery by the UAVs recording continues from the moment of interruption. The camera settings during shooting can be in automatic or manual mode, it is provided and it is possible to use the setup through the basic drone software.

After completion of the flight and shooting, images are processed by software. Figure 2 presents image processing information that contains the necessary information for post-processing and downloading. Providing information about the use of the subject to be moved requires a previous site map, which also gives information about the average GPS error of the captured images.

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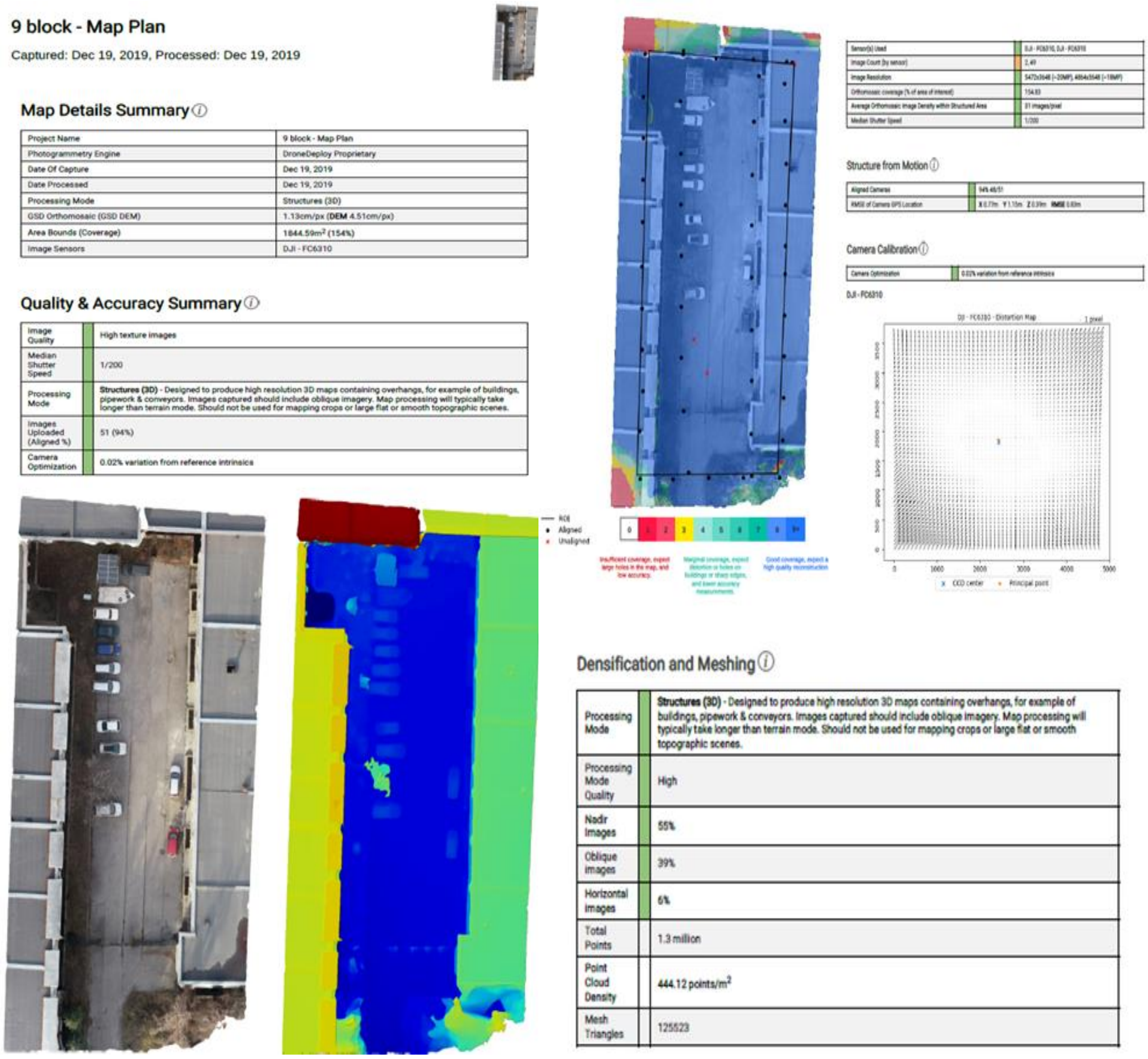

Figure. 2. Area information, sequence of capture, compaction and networking.

The processed images provide an opportunity to determine additional parameters of the study area (terrain, buildings, etc.). The study area includes a building stock, several cars and one trailer, a photovoltaic charging station and one tree. The following figures show some of the data that can be obtained from the processed images. It is possible to determine the coordinates of each selected point in the study area, and can determine slopes and displacements between points of reference. Figure 3 shows the possibility of determining the area of several selected elements (vehicles) from the study area. Several zones have been identified at the same time, with the interior yard of Unit 9 of the Technical University of Sofia being 777 m^2 in the study area, and the area of one of the vehicles that are parked in the study area is defined and shown in the Figure. The figure also shows the possibility of measuring distances between points in a horizontal plane, and measurements in all planes are possible.

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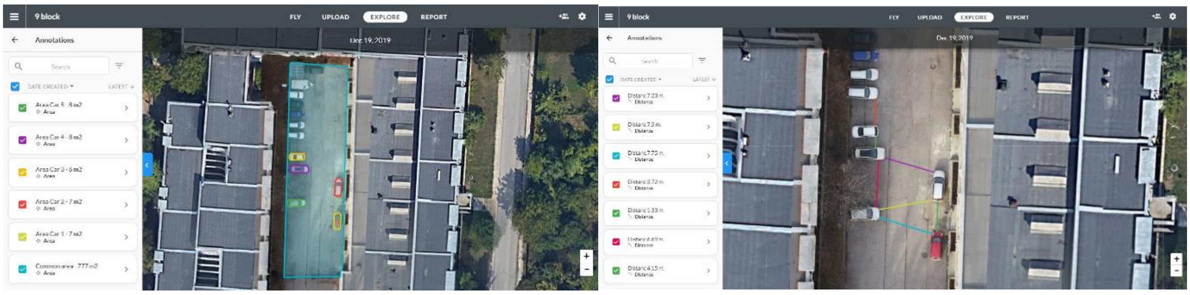

Figure. 3. Location of the study area and pilot image sequence plan.

Processed by software and provided three-dimensional images of the research area, these images are in high definition and allow sufficient accuracy to determine visually and calculate many details.

In order to get a more detailed picture of a particular car using photogrammetric photography, additional shots were taken from a UAV lift height of 10 meters. One on the territory of the 9th building of the Technical University of Sofia (Fig. 4) and the other on the landfill of the Union of the Bulgarian automobilists in Mladost in the city of Sofia (Fig. 5). The software allows accurate and specific shooting of the profile of a car, while calculating its exact area and the volumetric characteristics of the specified car (detail). The quality of the processed images enables accurate road profile capture, unevenness and traces of brake traces, and the listed parameters on the road surface can be determined and measured.

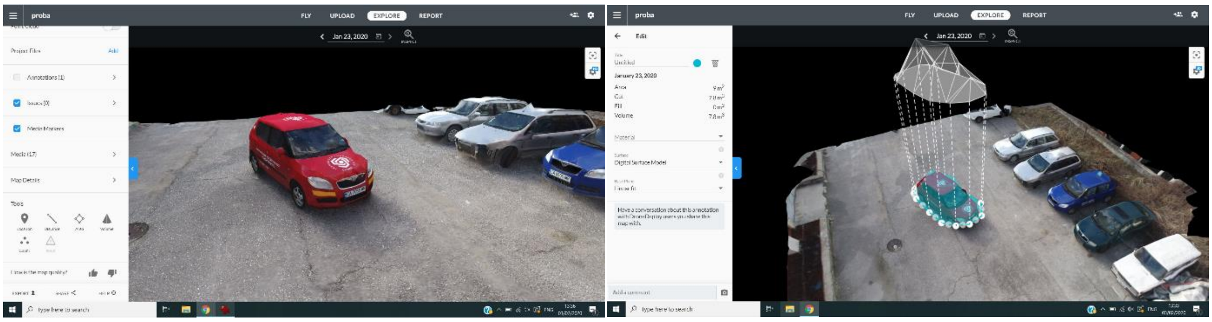

Figure. 4. Three-dimensional detailed image of the examined vehicle.

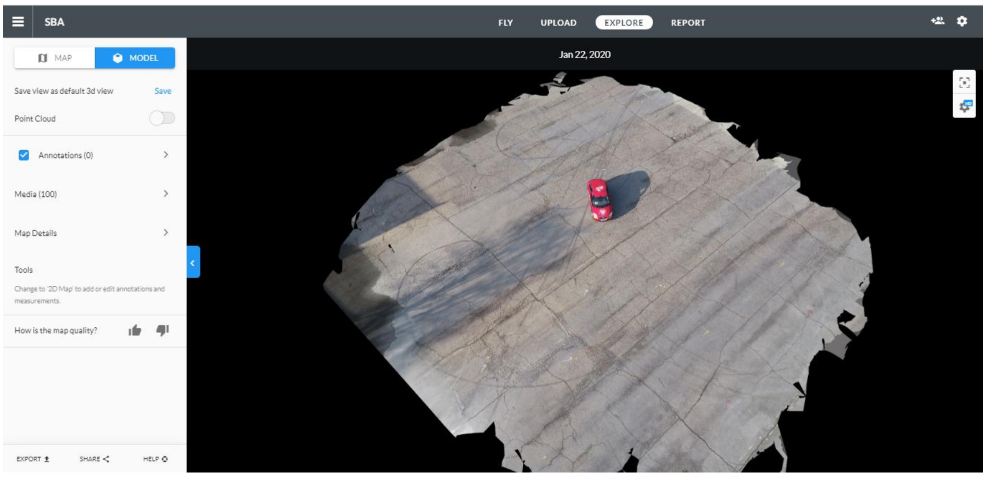

Figure. 5. Three-dimensional detailed image of the examined vehicle.

From the information about the car and the area around it from a lower height (10 meters), it seems that the software processes a two-dimensional image, presented in a three-dimensional picture, presenting a sufficiently accurate, detailed image in scale and a sufficient number of accurate and specific measurements for the vehicle, attack and the space around it.

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4. Conclusion

This study presents the potential for road traffic accident investigation and provides initial data for the reconstruction of road accidents using photogrammetric techniques. Compared to the conventional practice of road accident reconstruction, photogrammetry has proven to be a time-saving and effective method for investigating road traffic accidents. The 2D photogrammetry method and the incident trajectory technique can be applied to actual road accidents. Using a portable control system as a reference system, the 3D photogrammetry method can be used in vehicle deformation testing. Measurement results may be considered as initial information on a technique for repairing damage analysis. The study shows that photogrammetry has an increasing potential for application in the investigation and recovery of road accidents.

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