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Efficiency and Benefits of Implementing Digital Technologies in the Process of Documenting Traffic Accidents in the Conditions of the Slovak Republic

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Abstract

Today, we live in an ever-faster world, when time at work, work meetings and other daily activities must be completed on time. Therefore, arriving everywhere on time requires consistent time management, which, indeed, can disrupt the unpredictable development of the traffic situation. That is why we try to use various digital technologies and applications that make it easier to plan our activities. For example, when timing your arrival at work, there is a need to have extra time due to an unpredictable traffic accident. The time spent in the columns caused by accident could be markedly reduced if digital technologies were used for documentation. For this reason, the article deals with the implementation of technologies in documenting traffic accidents abroad and their subsequent need for application in the conditions of the Slovak Republic.

Keywords: digitalization, traffic accident, laser scanner, photogrammetry

Introduction

In the world we live in, we find ourselves in a dynamic and constant cycle of responsibilities, business meetings, et cetera. Time plays the most significant role and its management even greater. Time management is ultimately influenced by the current traffic situation on the roads. Depending on the current situation and available information, there is a constant need to actively intervene in the time management of the day. For this reason, it is necessary to pay attention to the given traffic situation and especially monitor the currently available traffic information. And so, from the road user point of view, we now have various applications available, as well as traffic information from radios, websites, et cetera. Their primary task is to monitor the current state of communications based on data from users and use sophisticated algorithms to estimate the time of arrival at the selected destination. The content of the information created by the so-called Open data is usually parameters of traffic flow, congestion, traffic restrictions, traffic accidents (TA), traffic patrols (or other enforcement), deadlines, additional information (fuel prices). However, the applications make this planning easier for us, but the only detail they don't know is to predict driver behavior. This phenomenon is random and mainly depends not only on the nature of the driver himself but also on the setting of his daily schedule. We often encounter cases where a person assumes more responsibilities than he can handle during the day. Therefore, traffic participants try to reduce the time to move between meetings or time spent behind the wheel. And so, there are several road traffic offences. Based on these causes and aspects, subsequently, traffic accidents are created. According to the WHO [1], 1.35 million people die each year on the road. A significant part is made up of pedestrians and cyclists, 26%, 28% are people on scooters and tricycles, and 29% are motorists. And the remaining 17% are based on inaccurate country statistics. The statistics show that the maturity of the road infrastructure and the way of life has a significant share in the causes of traffic accidents. In the case of Slovakia in 2020 [2], there were 11,875 traffic accidents, which is 1,866 fewer accidents compared to 2019. The most common causes, even in 46%, were violations of the driver's duty, 14% speeding. In the remaining cases, it was a failure to obey the traffic lights or traffic signs. Also, in the neighboring Czech Republic [3], the most common cause of traffic accidents was the wrong way of driving, up to 67.4% and speed limit 16%. In other cases, it was a failure to give way and incorrect overtaking.

From the Traffic Index ranking statistics [4], it is possible to show on the example in Bratislava that work and school arrivals or other duties significantly affect the traffic situation. Rush hour traffic is the time when it is most moving to work and school. On the contrary, in the afternoon it is due to the home from work journey, or for shopping reason, picking up children from schools, et cetera. The total time spent in rush hour traffic beyond the travel time represents the morning or afternoon peak on average 22 min. The statistics show that the entire time spent driving at peak times was approximately 167 hours per year. However, in 2020 the pandemic brought some reductions in transport as well. As a result, people restricted their movements and began working from home. And, the statistics show that congestions have been reduced at the time of the anti-pandemic actions. Despite this fact and measures, the time spent at peak times was reduced to an average of 15 minutes. Compared to 2019, the total time spent on congestions has decreased to 112 hours per year.

In the context of the above, there is not enough emphasis today on safe driving and consideration with the vehicle on the roads. The traffic situation depends not only on the participants themselves but also on traffic police officers, forensic experts, ambulances and towing services. In the case of traffic police officers, this is mainly the time aspect of documenting the place of traffic accidents. Accident documentation is a complex process, where the output is the basis for a forensic expert and criminal proceedings. So there are legitimate demands for detailed and, above all, precise targeting of the accident site. Currently, in Slovak Republic conditions, classic measuring methods are used. Among the best-known approach to targeting a local accident is the rectangular method, where a sketch and a tape measure are used in this process. This technique requires the complete concentration of a traffic cop. If modern technologies were used at the scene of an accident, this would greatly simplify the process.

Traffic accident documentation technologies

Upon arrival at the accident scene, the police officer must take urgent action to provide information about the accident. During these operations, extra care is taken not to damage or destroy the tracks and not even change them. In this process, it is necessary to ensure that they are carried out in a fixed hierarchy so that the documentation of the traffic accidents lasts as little as possible and the traffic restriction is as short as possible. However, this is challenging with the currently available means and equipment of traffic police officers. Consequently, the whole process is impossible to optimize in terms of time. Therefore, advanced technologies, such as 3D laser scanners, DSLR and UAV, could be used for partial optimization in terms of traffic accident scene documentation.

Laser scanning equipment

The principle of functioning is based on the spatial polar method, which does not determine the spatial position of the characteristic object points, but where a large number of points is focused on the object, distributed in a regular angular grid. The measurement result is the so-called point cloud that captures the scanned object with great detail. The measurement works by sending an infrared beam from a scanner, which bounces off a rotating mirror located inside the device. It then deviates perpendicularly from the axis of the rotating mirror. As from the known values and dimensions of infrared waves and their difference, the length from the object is calculated. And then, the X, Y, Z coordinates of every point are calculated from the vertical and horizontal angles.

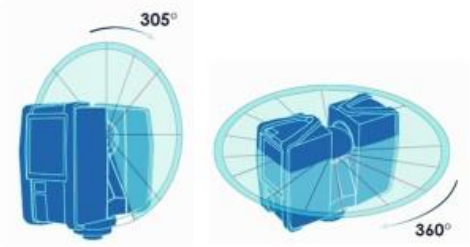

Figure 1 – Data acquisition process [5]

All points are in the Cartesian coordinate system, and their origin is identical to the scanner coordinate system origin. When scanning two or more positions, each position has its particular coordinate system. These systems must be registered with each other through reference balls, that they form a scan subject in a result. Other features that individual scanners dispose of are the measurement of reflectivity and integrated camera built into the device. In the case of the integrated camera, this is to capture the RGB environment. Today's devices can be combined with a 360-degree camera, through which we can obtain a virtual environment or scenery for better orientation.

Ground photogrammetry

It is one of the most accurate photographic methods [6] [7] [8] for the spatial determination of objects. The principle of convergent imaging is based on creating multiple images of an object. The axes of the individual camera shots point to the given object

to create sufficient object overlap on the particular snap-shots. It follows that the same points need to be displayed on at least three images. The content of each image should be as large a proportion of the digitized object as possible. So mainly, accuracy and time are influenced by the photogrammetric points in the form of targets and reference points accuracy of measurement is directly proportional to the number of measurement images. The hard work of the method rests in the need for manual measuring of the object breakpoints.

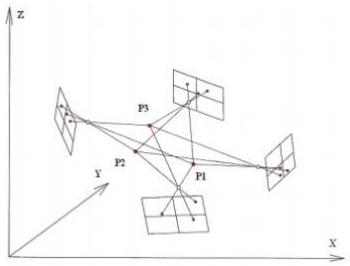

Figure. 2 Convergent imaging [7]

Aerial Photogrammetry

At present, unmanned aerial vehicles (UAVs) are used to collect information form of photographs from the airspace. Unlike terrestrial photogrammetry, UAVs can capture large areas or hard-to-reach places. The principle of UAV modelling is approximately the same as for terrestrial photogrammetry. In this case, it is also necessary to capture the object of digitization from all possible perspectives. It can be performed in the form of an orbit around the item or the so-called grid with the camera oriented perpendicular to the surface. There must be sufficient overlap between the photographs to determine the spatial orientation of the points. Furthermore, the condition must be complied with, where every individual point in the photo must be on at least three images.

Figure. 3 Aerial photogrammetry [9]

According to authors [10], the result of each image is a central projection, in which we must know the beam of the camera rays and their properties. For the processing, therefore, it is necessary to know the internal and external elements of the orientation of cameras and photographs. UAV technology does not have accurate measuring cameras that ensure high accuracy terrain rendering. The replacement consists of better quality camera sensors, and also GPS modules are installed in the devices to know the elements of orientation. Aligned points are located in the terrain. The inner alignment of the camera can be performed in a laboratory environment or a software environment with an integrated function.

Theoretical benefits of selected technologies

When using laser scanning, that is an effective mass data collection technology. Mainly, it is about the speed of collection with high accuracy emphasis. The benefit is capturing a large part of the scene, as today's devices can digitize up to a distance of 330m. Subsequently, in such a large scene, it is possible to identify various objects and to measure distances. The main advantage of 3D laser scanning devices is the accuracy of recorded measurements. This type of equipment operation is performed by only one person and is entirely sufficient to ensure all operating requirements. Dangerous situations do not arise in the lives of police officers when documenting traffic accidents. An integral benefit of laser scanning is the ability to return to the accident location in the software environment and further analyze it without the need to go to the accident area again. The benefits of terrestrial photogrammetry include obtaining high-quality textures under the conditions of DSLR device use. In the case of cramped conditions and hardly accessible terrain, it is also in great demand, mainly because of the operation and dimensions of this technology. During criminal proceedings based on a request, it is possible to generate different views from the driver's position. These are mainly prospective conditions, i.e. what he saw at the time of the creation of traffic accidents. From a financial point of view, this is already a very affordable technology. The use of aerial photogrammetry in documenting traffic accidents has the advantage of fast data collection and the ability to capture a wider scene. The benefit in the case of the previous technologies is the capture of space even through obstacles in the horizontal direction. These are mainly places where shadows are created, and there is a need to bypass the object.

Examples of use of selected technologies abroad

In the United Kingdom [11], two types of 3D laser scanners are used. Traditional tripod-based 3D laser scanner and handheld 3D laser scanner. A tripod-mounted laser scanner is used to survey large areas, including collision scenes, and a handheld 3D laser scanner is used to focus on smaller objects, including the interior. The created 3D models are used to make individual cross-sections. Subsequently, these sections from 3D damaged vehicles are compared with 3D models of undamaged motor vehicles. Then to facilitate visualization, it is possible to overlap the cross-sections, where the changes resulting from the collision are better demonstrated.

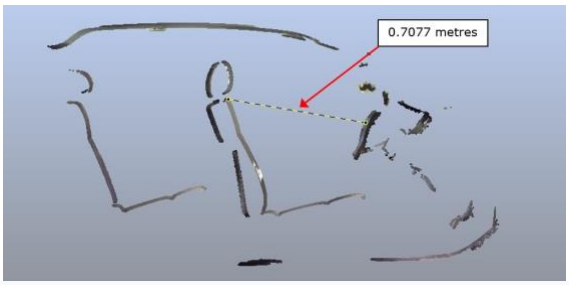

Figure 4. Longitudinal section of an undamaged vehicle [10]

From their experience, they state that the use of this technology type brings enormous benefits to forensic analysis. With the models created in this way, there is no longer a need for the insurance companies to pay for the long-term storage of damaged vehicles because potentially useful information about the dimensions have been captured and digitally stored after the scanning.

In Slovenia [12], a case analysis was carried out comparing the traditional method of documenting traffic accidents with the technique of using modern technologies. The comparison was performed individually among themselves, where the same criteria were taken into account, for example, road width, small tracks and the like. Moreover, the outputs between the individual scanners and the aeronautical drone were compared concerning time, scanner positions and level of detail.

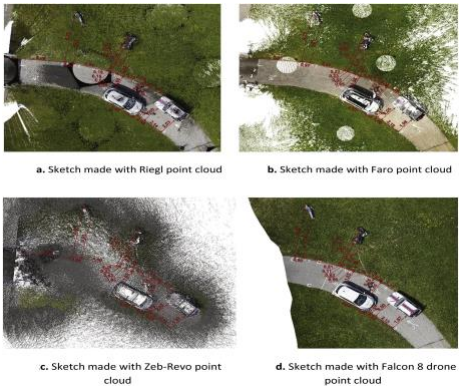

Figure 5. Comparison of outputs from a laser device [12]

The figure shows that it is necessary to choose the right type of equipment and determine the correct way to document the traffic accident. The times compared to classical documentation ranged from 49% to 94.4% in favor of technology. The police officers were wrong in redrawing the final sketch. There was no error in generating the sketching from the data obtained from the devices. The Ljubljana Police Department has owned a 3D scanning device for several years. The amount of information that can be obtained about the traffic accident location, they are constantly being called to the traffic accidents. The degree of credibility of the data gained through scanning devices is acceptable by the relevant laws.

In China, in Shenzhen city [13], traffic police use aerial drones to document accidents. Those within the police methodology, which they have developed the documentation of traffic accidents, can generate a map within 15 minutes upon arrival. The process begins with accident reporting when a patrol is sent to the scene. With the help of applications and the flights are programmed in advance, above the accident location. Upon arrival at the traffic accident site, a police patrol member launches the application and the aerial drone maps out the accident site. After the flight, the data is processed and displayed in the final form on a police officer's tablet computer, who then signs it as part of the accident record.

Figure 6. Accident record signature [13]

In the Czech Republic [14], case studies were carried out to document traffic accidents using the classical method and with the help of modern technologies. These accident sites were of moderate severity as for light traffic accidents there is no need to use these technologies. Collision sites ranged from local roads to highways. In most cases, it was a collision of two or more cars and an overturning of a truck due to a lack of speed adjustment when crossing an intersection.

Figure 7. Drone accident recording [14]

In all studies, in addition to the comparison between the individual methods, also the following parameters were monitored:

- Time required to document the accident by the classical method.
- Length of traffic restriction.
- Time required to document the accident with modern technologies.
- Time required for data conversion and comparison.
- Inaccuracy of individual technologies.

The obtained results of traffic accidents documentation show that there is a very significant difference in the time of accident documentation. While in the classical documentation, the time required to obtain all the necessary information range from 40 minutes up to 180 minutes, when shooting and processing, the time represented a range from 10 minutes up to 14 minutes. For sure, this significant difference will reflect in the duration of the vehicle columns. Compared to the classical method of traffic accident documenting the length of particular congestion, using UAVs would further reduce the car column duration by approximately 65%. In addition, the time saving depends on the severity of the traffic accidents. Since 2015, each traffic inspectorate has been provided with a special-purpose vehicle equipped with a total geodetic station.

Conclusion

Documentation of the track at the traffic accidents site is a fundamental input parameter for analysis of the process by experts. The inaccuracy of the input data during the analysis process increases the tolerance interval of the calculation or makes it impossible to perform the precise analysis itself. Itself. Another factor that affects this process is electromobility, which has its specifics. Therefore, the process of documenting accidents is very demanding and complicated. Upon arrival at the scene, the police officer must take urgent action to secure the area. He must also create an accident record throughout the process, from arrival at the site to the lanes. As already mentioned, if modern technologies were integrated into this process in Slovak Republic conditions, it would significantly contribute to the streamlining of the traffic accident documentation process. Also, if UAVs and laser scanners were included in the traffic police equipment, the result would be a safer and smarter workflow. The streamlining of this process would have an impact, not only on time spent in the columns and the environment (amount of CO2 consumed) but on the road managers themselves. Mainly the reason is the constant acceleration and deceleration of vehicles, which negatively impact the road. In this way, internal combustion engines increase fuel consumption and CO2 production. Finally, implementing modern technologies would contribute to increasing the safety of police officers. It would be a potential explosion of an electro-mobile, which could be a traffic accident participant.

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