Comparison of Utilization of Conventional and Advanced Methods for Traffic Accidents Scene Documentation in the Czech Republic

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Abstract

Documentation of the traffic accidents scene is one of the main assumptions and input facts for subsequent accident process analysis. This contribution points out major deficiencies (especially lower accuracy and efficiency) of currently used conventional methods (triangular method, rectangular measurement) and means (surveying wheel, steel tapeline) for the documentation of serious accidents scenes. The article presents an advanced method of localization and traffic accidents scene documentation using geodetic total station (or GNSS) and photographic documentation of traces with selected points for subsequent rectification, possibly using an image from UAV. Indisputable advantages (particularly significant time savings), significantly more accurate traffic accidents scenes documentation results for police in the Czech Republic are evident from performed comparison of these methods at the real road accidents.

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1. Introduction

For use in forensic – engineering practice within the analysis of road accidents, the traffic accidents scene documentation is one of the most important materials. The basic resources providing comprehensive information

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about the traffic accident scene in the Czech Republic are the road traffic accident report, photographic and topographical documentation provided by the police. The accident is analysed on the basis of these data, they are therefore crucial for the reconstruction of the accident course and possibly subsequent determination of the degree of culpability of involved in a traffic accident. Mainly for this reason, a strong emphasis must be put on accuracy of topographic orientation in the traffic accidents scene documentation. Traffic accidents are also associated with considerable direct and indirect costs. Indirect costs arise usually in connection with traffic complications or road closures caused by documentation in scene and cleaning of the accident scene.

Therefore, emphasis must be placed on efficiency, hence on time-consuming inspection of the traffic accidents scenes. The importance of this issue is confirmed by recent research. Laser 3D scanners e.g. in [1, 2] are frequently used for the traffic accidents scene documentation in recent years. Although the site documentation using 3D scanner gives a reliable picture, expansion of this technology into the routine police work in the Czech Republic is impeded particularly for its financial performance. The difficulty of subsequent processing and storage of large data obtained and also some limitations in achieving the road surface shape and surroundings (e.g. grown grassland) is a significant drawback.

Current researches often describe the use of multi-image photogrammetry [3–5]. It’s a technique that allows object measurement from images. The big advantage of this method is to accelerate the work on the traffic accident scene. However, the time required for subsequent processing is longer than using conventional methods. The main disadvantage is the difficulty in documenting of scenes with significant height profile and especially of the very large traffic accidents sites [2].

The aim of this article is to assess the effectiveness of advanced methods of traffic accidents scenes documentation by geodetic total station (alternatively GNSS – Global Navigation Satellite System) and photographic documentation of traces with selected points for subsequent rectification, possibly a unmanned aerial vehicle (hereinafter UAV) imaging and comparison of advanced methods with conventional ways of traffic accidents scenes documentation. Advanced method entails considerable efficiency and accuracy improvement of traffic accidents scenes documentation not only within the scene, but also during subsequent processing of the data collected.

2. Methods

All conventional methods used for the traffic accidents scenes documentation as well as documentation using of the geodetic total station and photogrammetry are described in [6]. Below is a brief description of used advanced documentation methods.

2.1. Geodetic total station

Geodetic total stations is an electronic and optical instrument. It is an electronic theodolite equipped with electro-optical rangefinder (nowadays pulse rangefinder or its combination with frequency range finder is often used). It functions to measure or stakeout horizontal and vertical angles, distances and to register these values. Lengths can be measured using either a prism or in non-prism mode – by direct reflection from the surface of the object being measured. Modern instruments allow one person operation, which is a great advantage in terms of staffing. GNSS measuring instruments can be included into this category, using satellite navigation systems (GPS, GLONAS, etc.) for accurate determination of the geographic location. The condition of using this method for the traffic accidents scenes documentation is a sufficient coverage of the space satellite signal, ongoing refinement is based on reference stations.

2.3. Photographic rectification

Application of digital rectification of images for traffic accidents documentation consists of transforming obliquely photographed areas of the road to the planar image of the traffic accident site in plane view, which is relatively accurate and allows to display in specific scale all distances and positions of each track and to create an objective map of the traffic accidents scene in a relatively short time. A big advantage of this method lies in the
possibility of additional measuring of distance or length of tracks directly on the rectified image. As mentioned in [7], it is also possible to determine the radius of the trajectory tracks from the rectified image, which can subsequently serve for the speed limit calculation.

2.4. Unmanned aerial vehicles

Usage of remote-controlled unmanned aerial vehicles – mostly UAVs – becomes another option for the traffic accident scene documentation with the development of new technologies. UAVs can be directly fitted with different types of cameras and camcorders or carry these devices as an accessory. With these unmanned devices it is possible to get photographic images or video recordings of the traffic accident scene immediately after the accident, or you can get this documentation even with a time interval after removal of the main consequences of the accident in case the traces of the accident site and the vehicles final positions were appropriately highlighted.

3. Case studies

In this chapter, there are mentioned two case studies which demonstrate the advantages of the utilized methods.

3.1. Case studies no. 1

This case study deals with a traffic accident of two vehicles on a four-arm intersection with tragic consequences, in which death of three people and one serious injury occurred. Due to the higher collision speed of both vehicles, their final position was at a considerable distance from the scene of the collision off the road in a field of grown grain. Consequently, the location of the scene by using conventional methods (triangular method or rectangular measurement method) and means (surveying wheel, steel tapeline) would have been very time consuming. Also, the vastitude of the traffic accident scene and the shape of the intersection (Figs 1 and 2) impaired the use of conventional surveying methods. For this reason, the scene was localized by the geodetic total station. An area of the vehicle conflict contained the largest number of tracks needed for the accident analysis and was thoroughly photographically documented with marked points for subsequent rectification. The whole traffic accident scene has also been documented using UAV.

Time expenditure of scene localization using surveying geodetic total station was about 60 minutes, including the instrument set up. The advantage of this localization compared with simple rectified image or image from UAV is the possibility to create 3D profile of the traffic accident scene including its surroundings for subsequent accident process analysis and view conditions involved in the traffic accident.
Combination of localization by surveying using a geodetic total station with rectified image or an image from a UAV, mostly enable better orientation in measured polygon, which is advantageous in case of complicated tracks and also tracks that overlap. An advantage of image taken by a UAV compared to a rectified image can be seen in the possibility of the larger accident scenes imaging, when individual images can be placed one over the other. Although the rectified image allows connection of several shots through two common points, within larger traffic accidents scenes it can be lengthy process. Usage of the rectified image at scenes with very variable relief or in otherwise difficult terrain (fields of grain, bushes, trees) is also very limited. In this case, rectified image could be enough for view of the collision scene and its closest surroundings; usage of the UAV imaging is preferable for outlook at the whole traffic accident scene.

3.2. Case studies no. 2

The following example is a typical example of a traffic accident with ambiguous cause, because there occurred so called competition in breaching of a legal obligation to observe the speed limit and yield. The driver of a passenger vehicle pulled out from a location outside the road and did not yield to a vehicle coming from the right at speed higher than a speed limit. The localization of this site by using the conventional methods was difficult and time-consuming, mainly because of the nature and number of tracks (Fig. 3) and also due to the structural and technical conditions of the road, which did not allow an unambiguous choice of metrical lines (absence of horizontal road markings, irregular unpaved road edge, etc.).
The scene localization using the geodetic total station took 40 minutes and is shown in (Fig. 4). Since that part of the braking tracks of one of the vehicles occurred under the railway bridge, usage of the UAV imaging was impossible. Photographic image documentation was carried out of the selected points for subsequent rectification at the scene. During processing, the entire scene was completed from four rectified images. Due to the significant number of tracks in the collision area of both vehicles and their course, a combination of a polygon obtained by using the geodetic total station and rectified images was the most efficient option. Despite the relatively small time-consuming documentation and subsequent traffic accident scene plan processing, this method provides a completely true picture of the traffic accident scene for subsequent analysis of the accident process during the expert examination.

![Polygon measured by a geodetic total station with photographic rectification connected images.](image)

**Fig. 4.** Polygon measured by a geodetic total station with photographic rectification connected images.

### 4. Results and discussion

Selected case studies illustrate the considerable refinement and primarily streamlining of the traffic accident scene inspection using a combination of scene localization using geodetic total station and photographic imaging of traces with selected points for subsequent rectification, possibly an image from a UAV.

Conventionally used surveying wheel seems not only inaccurate, but especially inappropriate with respect of time and accuracy in serious accidents. The use of conventional methods appears to be insufficient especially for accidents involving throwing vehicles off the road with the incidence of inclinations.

Using a combination of the new techniques has been tested in practice in the context of cooperation between the Police of the Czech Republic and the Institute of Forensic Engineering in Brno [8] for several dozen real serious traffic accidents resulting in person’s death and health consequences over 1.5 years. Documentation using a combination of these methods has also been compared with the documentation using conventional methods. Mutual comparison of values measured by different methods within real accidents and deviations of the measured values are shown in the Table 1.

**Table 1.** Comparison of conventional and advanced methods for traffic accidents scene documentation.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Average time of scene inspection and processing by conventional methods [min]</th>
<th>Average time of rectification and processing by advanced methods [min]</th>
<th>Average time savings in collision area [min]</th>
<th>Average measurement error X – coordinate</th>
<th>Average measurement error Y – coordinate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway</td>
<td>277</td>
<td>84</td>
<td>80</td>
<td>0,9%</td>
<td>5%</td>
</tr>
<tr>
<td>Straight roads</td>
<td>210</td>
<td>75</td>
<td>47</td>
<td>0,9%</td>
<td>4%</td>
</tr>
<tr>
<td>Complicated intersections</td>
<td>260</td>
<td>115</td>
<td>33</td>
<td>11%</td>
<td>10%</td>
</tr>
</tbody>
</table>
In terms of precision, a deviation in the order of per cents can occur when using conventional methods, however, this can mean deviation of several meters within the larger traffic accidents scenes. When using geodetic total station or GNSS measuring device, the maximum deviation is in the order of centimetres in the entire measured section. The performed comparison of these two methods within real traffic accidents shows the saving of time during usage of advanced methods of documentation compared with the conventional method in average of 49%. According to [9], the average closure time as a result of the traffic accidents on highways was around 2.5 hours, when the amount of consequential or indirect loss is an average of about 130,000 Euros/hour. On the basis of the performed real highway traffic accidents documentation, the usual average documentation time when using conventional methods was about 80 minutes (during which it is not possible to manipulate with vehicles, with the exception of the work of the Integrated rescue system). When considering the average time savings of 51%, usage of the advanced documentation methods could mean an average savings of about 40 minutes, which corresponds to avoiding of consequential or indirect loss amounting to about 85,800 euros for a single traffic accident on the highway.

5. Conclusions

This research has been motivated by the fact that in the sphere of documentation techniques there has been an instant significant progress. Methods used by the police for documenting the scenes of traffic accidents in the Czech Republic remain practically unchanged for decades. In terms of progress, there is a clear trend these days for searching possible savings. The influence of modern documentation methods on time and consequently financial savings has been researched on real traffic accidents. In comparison with conventional methods, by the use of modern methods of documentation it is possible to reach remarkable savings in terms of teens of percent, which, in global scale, can mean nationwide savings. According to this research, this influence hasn’t been examined and described yet.

The advanced method using total stations, rectification or UAV is gradually expanded for the practical use by police in the investigation of serious traffic accidents for its undeniable advantages and considerably faster and more accurate documentation.

References