Arguments for 3D-Scanning and 3D-Photogrammetry as Basis for Accident Reconstruction

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ABSTRACT

A main problem in accident reconstruction is to record and evaluate the damages on the involved vehicles or aircrafts. Often human beings or obstacles are also involved in such collisions. Therefore the contact areas and/or damages have to be recorded and evaluated. The new developments in computing and in 3D-CAD, combined with optical methods, the so called Forensic 3D-CAD-supported Photogrammetry (FPHG) allow very detailed evaluation of the morphological properties of such contact areas.
Of special interest is the morphological match of “stamp” and “print”. With the use of FPHG, the examination becomes independent of the physical access to the “bodies” and the evaluation can be done in the virtual space of a computer. This allows a thorough examination of the “match” in all three dimensions with high accuracy.
The combination of 3D-photogrammetry (RolleiMetric) for the record of the accident area and of 3D-scanning on the “bodies” and/or vehicles covers almost any situation or incident scenario and is the basis of an accurate accident reconstruction.
Currently we are missing a 3D-scanning tool for big objects or entire accident sites, but the development of 3D-Laser-scanning instrumentation is proceeding very fast, first products are already available.
The combination of classical methods of accident investigation with classical forensic methods and 3D-photogrammetry and 3D-scanning allows a new, efficient and thorough approach in the field of accident analysis.

Key words: 3D-photogrammetry, FPHG, 3D-scanning, accident reconstruction, collision, traces, case report

INTRODUCTION

Rescue and police forces normally take series of standard photographs during the rescue and recovery work after serious and/or fatal traffic accidents. In addition to these photographs, a number of “important” distances are measured at the accident site and a simple sketch of the situation is drawn. Often the involved vehicles are secured by the public prosecutor.

ACCIDENT RECONSTRUCTION NEEDS

The main interest in accident reconstruction is to reconstruct the sometimes very complex movements and collisions of the involved vehicles and/or persons in time and space. To do this work, the accurate spatial situation of the accident site with the found traces, all collision areas and the final positions of the involved vehicles and/or persons must be known “on scale”.

RE-EVALUATION OF THE ACCIDENT SITE WITH 3D-PHOTOGRAMMETRY

At most accident sites we find a large number of so called “reference points” or “reference objects”, that remained unchanged during and especially after the accident. This means we can find even days or weeks after an accident a lot of spatial information at the accident site, that allows an accurate linking between original - but standard - photographs taken immediately after the accident with calibrated photographs of the 3D-photogrammetry system taken later in time. The evaluation of the calibrated photographs results in an “on scale” 3D-model of the entire accident site – whereas the accident traces often are not visible any more. The 3D-model can be superimposed with the calibrated photographs for visualisation purposes or with the non-calibrated standard photographs. The first result of fitting standard photographs into the “on scale” 3D-model is the position of the camera and the parameters of the used optics when the photograph was taken. Then all additional information on the standard photographs like tire marks, final positions of vehicles and/or persons and the position of debris can be evaluated “on scale”. The re-evaluated positions of this additional information can be added into the 3D-model and then be used for the accident reconstruction work.

The opportunity of an inspection at the accident site to take the calibrated photographs can be used to collect additional information such as visibilities or ranges of sight into the 3D-model of the site.
With the use of small stickers as additional "points of reference" on collision areas on side rails, poles or similar objects it is possible to evaluate the height of such contact areas and to show the corresponding geometrical matches.
The available computing and 3D-CAD tools, combined with FPHG allow very detailed evaluation of the morphologic properties of such contact areas.

COLLISION ANALYSIS NEEDS

Of special interest is the morphological match of "stamp" and "print".
For a thorough collision analysis the damages on the involved vehicles must be evaluated to analyse the "match" in all three dimensions with high accuracy. This allows an accurate reconstruction of the collision configuration with respect to positions and angles.
With the use of FPHG, the examination of such questions becomes independent of the physical access to the "bodies" and the evaluation can be done in the virtual space of a computer.

EVALUATION OF THE COLLISION DAMAGES WITH OPTICAL 3D-SCANNING

Optical 3D-scanning on the "bodies" and/or vehicles involved in an accident allows a very detailed recording and evaluation of the contact areas and collision damages.
The scanned contact areas on injured "bodies" allow a detailed and time independent study for legal medicine.
The scanned collision damages on the vehicles in combination with a 3D-scan of the undamaged vehicle allow an accurate calculation of the deformation depths in all three dimensions and thus an accurate estimation of the absorbed deformation energies.

A MULTIPLE COLLISION ACCIDENT: STANDARD PHOTOGRAPHY, 3D-PHOTOGRAMMETRY, OPTICAL 3D-SCANNING AND ANALYSIS OF MICRO TRACES (PAINT, GLASS, FIBRES)

The accident happened during a Saturday night on a Swiss highway.
It began with a typical excess speeding accident: Loss of control, skidding, collisions with side rails. The vehicle #1 came to a stop in the middle of the three lane highway.The two passengers left the car.
In that moment vehicle #2 arrived with more than the allowed speed of 100 km/h, hit the two passengers and collided with the left front corner of vehicle #1. One passenger was thrown towards the left lane, one passenger to the centre lane. Vehicle #1 was violently pushed away as a result of the heavy impact of vehicle #2. The person on the centre lane was subsequently hit by the front of his own car and dragged along.
Some instants later, vehicle #3 arrived on the left lane, did an emergency braking, hit the person lying on the left lane, hit vehicle #1 in a tapered angle into its left side and came to his final position next to vehicle #2.
The police did a detailed recording of the accident site with standard photographs. The examination of the accident site included a number of measured distances and trace complexes and the final positions of the two victims and the three vehicles. Photographs and measured positions of the collision areas on the side rails as well as photographs of the involved vehicles were available.
All vehicles and the clothing of the two victims were secured for further examination.
In that night it was not possible to close the highway completely and to work with photogrammetry equipment on the accident site.
We were called to examine the accident and to do a complete analysis of what had happened. Especially we had to find out which vehicle(s) had killed which person(s).
We collected and preserved micro traces on the involved vehicles, on the side rails of the highway and on the clothing of the two victims as evidence of contact.
Then we recorded the complete accident site with 3D-photogrammetry and linked the 3D-Model of the site with the standard photographs to evaluate the recorded traces. Then we did a 3D-scanning on the damaged areas of the three vehicles and on undamaged cars for comparison purposes.
The combination of these methods and the re-evaluation of the standard photographs allowed finally a detailed analysis of the different accident situations in the virtual space of a computer.
All contacts between vehicles, passengers and side rails could be proved with corresponding micro traces (paint chips, fibres and plastic traces)
This was the basis of an accurate accident reconstruction with PC-Crash for the dynamic part of the accident analysis.