RECONSTRUCTION OF A MULTI VEHICLE COLLISION ON A HIGHWAY: COMBINING FORENSIC EVIDENCE EXAMINATION, 3D-SCANNING AND 3D-PHOTOGRAMMETRY WITH NUMERICAL ACCIDENT RECONSTRUCTION METHODS

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ABSTRACT

Accident reconstruction is a complex task – especially in cases where more than two vehicles were involved and where more than one collision occurred. It is important for the police to know the needs and possibilities of the accident investigator and to understand the basic reconstruction principles.
It is essential to record the damage on the involved vehicles for a detailed evaluation. The contact areas and/or damages have a very high importance in complex accidents for the reconstruction of what happened.
The combination of classical forensic methods (micro trace examination) to prove physical contacts and the numerical methods of up to date accident reconstruction with accurate 3D-data allows an efficient approach in accident analysis.

Keywords: accident reconstruction, 3D-scanning, 3D-photogrammetry, trace evidence, micro traces

INTRODUCTION

Swiss rescue forces 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 confiscated by the public prosecutor. Most police forces in Switzerland use stereo-photogrammetry and/or modern multi picture photogrammetry on site.
In Switzerland two Police Corps (Zurich City Police and State Police Berne) operate 3D-LASER-scanners to record 3D-data at accident sites and at crime sites.
In addition the new developments in computing and in 3D-CAD, combined with optical methods, the so called **f**orensic 3D-CAD-supported **ph**oto**g**rammetry (FPHG) allow a detailed evaluation of the morphological properties of such contact areas.
The "bodies" in the virtual space of a computer are checked for morphological matches of "stamp" and "print". It is possible to evaluate a "match" in the three spatial dimensions with high accuracy.
The combination of photogrammetry and 3D-LASER-scanners for the record of the accident area and of optical 3D-scanning of the "bodies" and/or vehicles is the basis of an accurate accident reconstruction. On this basis, even a reconstruction of the timeline of an accident is possible.

ACCIDENT RECONSTRUCTION NEEDS

The reconstruction of complex traffic accidents includes complex movements and collisions of the involved vehicles and/or persons in time and space. These movements and collisions obey the laws of classical physics (conservation of momentum, rotational momentum and energy).
The accurate spatial situation of the accident site with the found marks and physical evidence, all collision areas and the final positions of the involved vehicles and/or persons must be known to scale.

THE ACCIDENT SITE AS A 3D-DATA SET

Many accident sites can be examined in 2 spatial dimensions – often the relevant properties of the accident site are located on one single plane. The evaluation of multi vehicle collisions involves a large accident area with a lot of spatial 3D-information that is relevant for the accident reconstruction.

Of special interest are contact areas where involved vehicles collided e.g. obstacles, guard rails or the highway slope.
A scale 3D-model of the entire accident site is essential for an accurate accident reconstruction.
It includes as many of the found accident traces as possible. The 3D-model can be superimposed with true colour photo-graphs for visualisation purposes and to document the relevant trace evidence.
Tire marks, final positions of vehicles and/or persons and the position of debris can be evaluated to scale.
We use a HDS6000 3D-LASER-scanner (LEICA) that covers a range of up to 50 m in one scan.
The spatial resolution and the accuracy of the recorded point cloud are excellent. Due to the very narrow frequency range of the used LASER source, the influence of the daylight is almost inexistent.

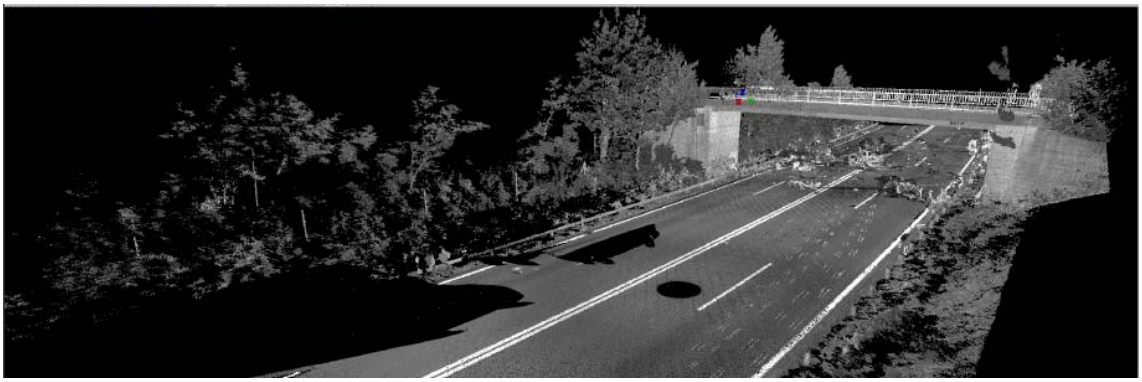

Fig. 1 – 3D-LASER-scan of the accident site, combination of 5 single scans

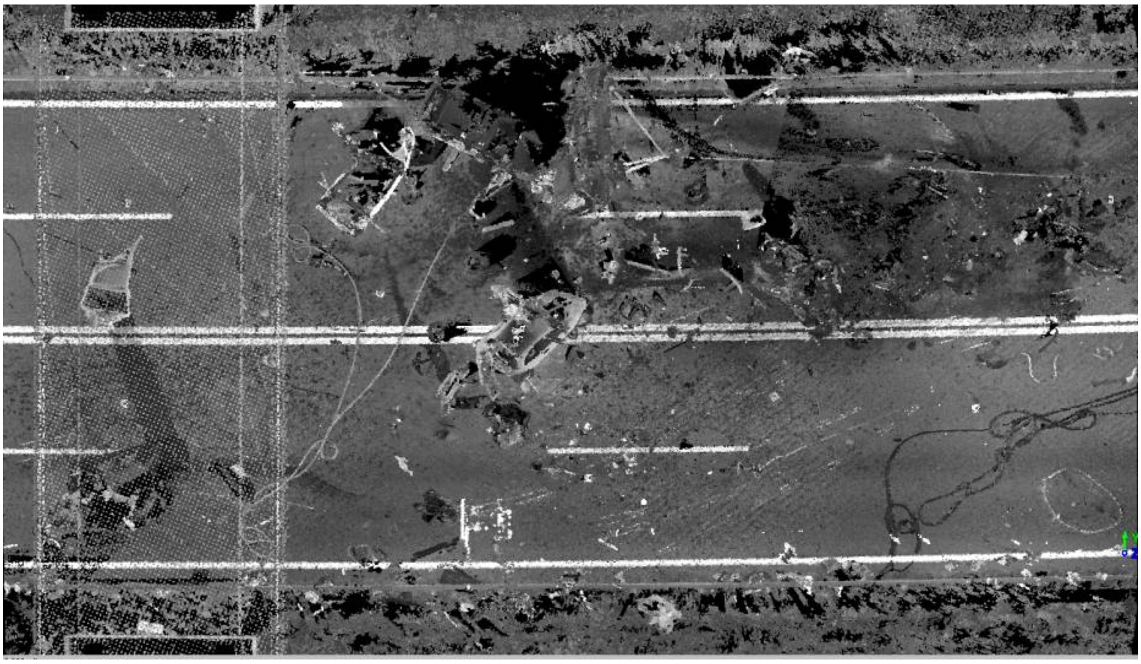

Fig. 2 – 3D-LASER-scan: Debris and trace evidence at the accident site

The 3D-model can be used to answer additional questions such as visibilities or ranges of sight.
The available computing and 3D-CAD tools allow 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 damage to the involved vehicles must be evaluated to analyse the “match” in all three dimensions with maximum accuracy. This allows an accurate reconstruction of the collision configuration with respect to positions and angles.
Thus 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 SUPERIMPOSED COLLISION DAMAGES

Optical 3D-scanning on the bodies and/or vehicles involved in an accident allows a detailed evaluation of the contact areas and collision damage. This is of special importance if contact areas were involved in more than one collision. The final collision damage on such vehicles is the result of superimposed damage of different contacts. The detailed 3D-data of the damaged vehicle allows often an accurate reconstruction of different contact situations.

We use an ATOS III scanner and the TriTop photogrammetry system to collect the 3D-data (GOM).

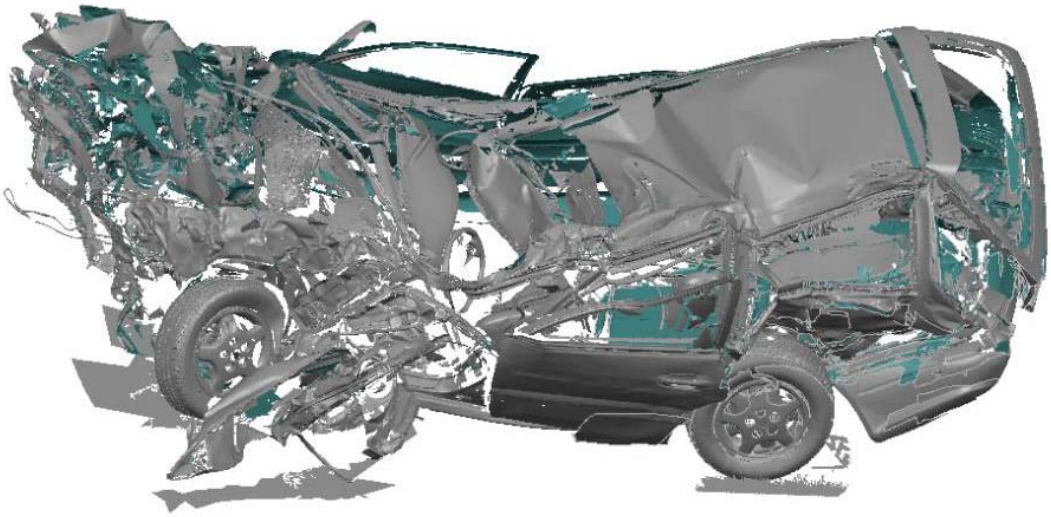

Fig. 3 – Collision damages on the Mitsubishi Sigma, rendered 3D-data set

In most cases the calculation of the single deformation depths and thus an accurate estimation of the different absorbed deformation energies are not possible – even with such detailed 3D-data.

The scanned collision damages on the vehicles in combination with a 3D-model of the undamaged vehicle allow an accurate documentation of the deformation depths in all three dimensions and thus an estimation of the totally absorbed deformation energies.

RECONSTRUCTION OF MULTI VEHICLE COLLISIONS ON A SWISS HIGHWAY

The accident happened on a Friday afternoon on a Swiss highway. Six cars were involved, six people were killed.

It began with a side collision between two passenger cars (a Mitsubishi Sigma hit a Ford Ka). It was followed by a loss of control for both vehicles, skidding on the wrong road side and resulted in a head on collision with a third car (an Audi A3). All drivers in these three cars were killed.

Immediately after this triple collision, the Audi A3 had a bad collision with a Citroen Saxo that went underneath the Audi A3. The two passengers on the right side seats in the Citroen Saxo were killed immediately.

The Mitsubishi Sigma had a second collision with a Subaru Justy that hit its left rear side. The Mitsubishi Sigma was turned in a counter-clockwise rotation on its driver side and rotated horizontally in the counter-clockwise direction. After several collisions with the right guard rails and a third collision with a Subaru Impreza, that hit its left side (A pillar and roof) it laid finally on its driver side.

The Subaru Impreza and the Subaru Justy came to a stop after further collisions with the right guard rails.

The first head on collision happened at about the permitted speed of 100 km/h.

The time between the first two collisions and the subsequent collisions could not be reconstructed.

The Police (State Police Zurich) and our services made a detailed recording of the whole accident site with standard photographs, photogrammetry and 3D-LASER-scans. The 3D-LASER-scanner was positioned at 5 places to cover the whole accident site including pre-crash tire marks produced by the Mitsubishi Sigma and the Ford Ka.

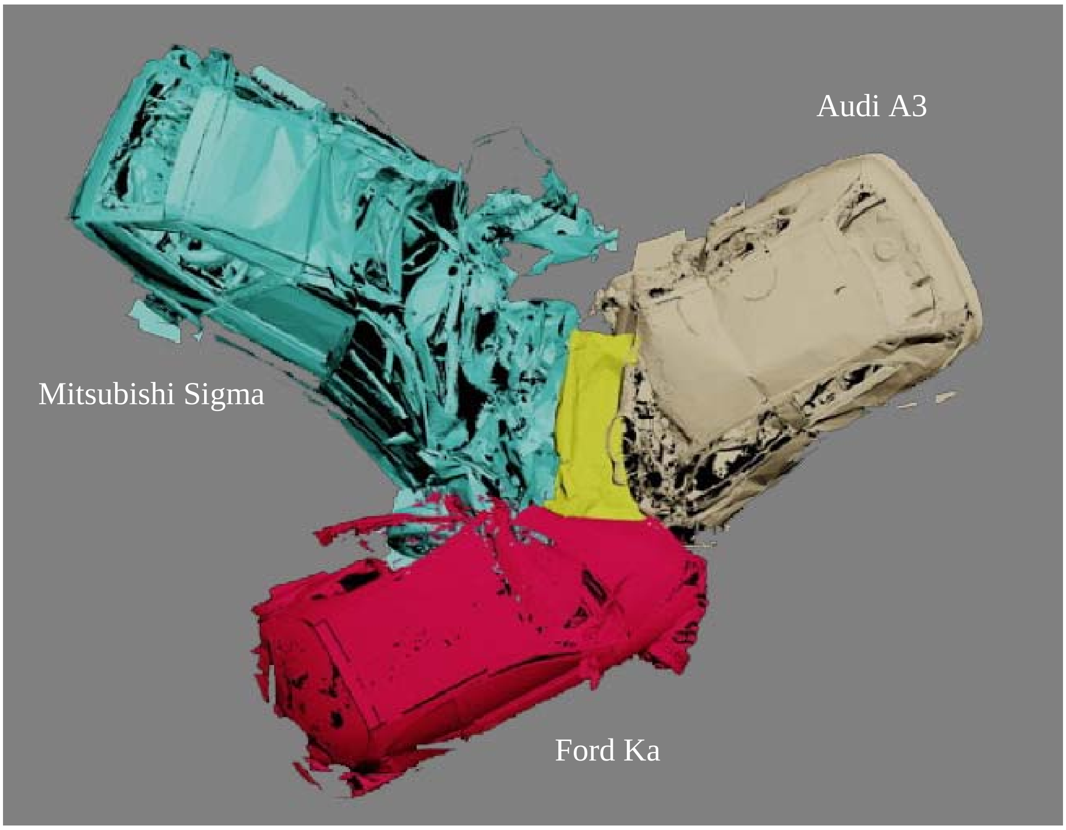

Fig. 4 – Main collision between the Mitsubishi Sigma and the Ford Ka against the Audi A3

The examination of the accident site included a large number of measured distances and trace complexes and the final positions of the six vehicles as well as micro traces collected from guard rails and other contact areas. Photographs and measured positions of the collision areas on the side rails as well as photographs of the involved vehicles and the debris on the road surface were available.
All vehicles and the clothing of the victims were secured for further examination.
Micro traces were collected from the involved vehicles and from the clothing of the victims as evidence of contact.
Then 3D-scans of all involved vehicles were recorded and the damaged areas of the vehicles checked for morphological matches to reconstruct as many collision configurations as possible.
The Scientific Forensic Service was asked to examine the entire accident and to do a complete analysis of what had happened. Especially it had to be found out which vehicle(s) had collisions with each others. A second question was, which vehicle had killed which person(s) and where.
The combination of all available scientific methods finally allowed 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, glass and plastic traces).
This was the basis of the accident reconstruction with PC-Crash for the dynamical part of the accident analysis. The movements of the six vehicles within the whole accident could be reconstructed. The question about how much time elapsed between the different phases of the accident could not be answered accurately.

ACKNOLEDGEMENTS

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REFERENCES

For technical details see: www.gom.com (ATOS III) and www.leica-geosystems.com (HDS6000)