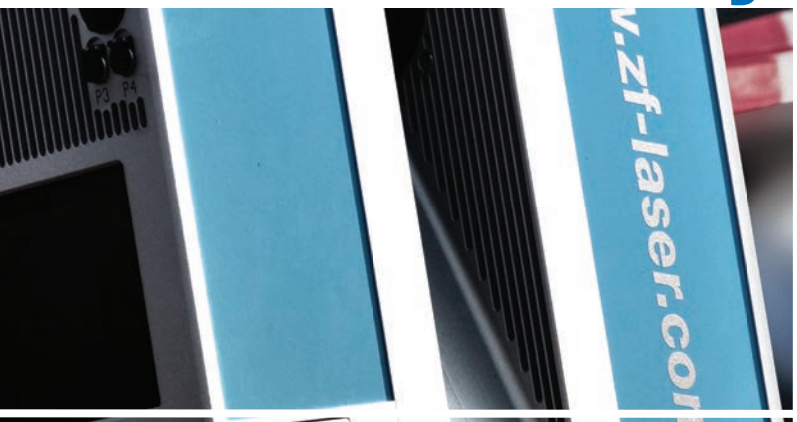
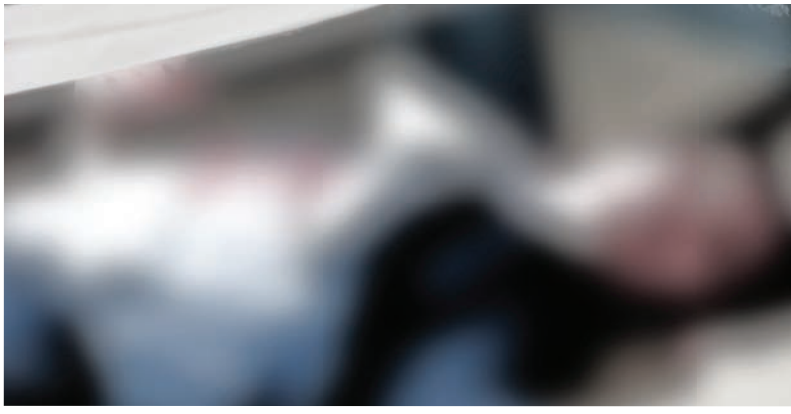
How we build reality

Zoller+Fröhlich

Case Study

High-end 3D processes at the Bavarian State Criminal Police Office (BLKA)





Company Overview

Z+F is one of the world's leading manufacturers in the field of non-contact laser measurement technology. Due to years of research, development and numerous successful engineering projects, Z+F is the forerunner in this field with a wealth of knowledge, experience and success.

When it comes to implementing future developments Z+F has always encouraged innovative thinking and open-minds. Our loyal and long-standing customers appreciate our continual innovations, support and the services we provide.

In collaboration with the Bavarian State Police Office (BLKA).

Our Partner

The *department for 3D processing* of the State Office of Criminal Investigation in Bavaria (BLKA) was founded in 2009 with the purchase of a terrestrial laser scanner (Z+F). The department is organized in the Forensics Institute (KTI) of the Central Photographic technique team. Highly qualified staff is required in order to benefit from this high-end technology. In Bavaria three specialised engineers in surveying and geomedia technology, one draftsman and several photographers are in charge of carrying out these 3D processes.

Due to the high demand, the 3D team is called to action only for capital crimes in Bavaria. At first, the 3D processing department was planned as a support unit, but soon specialized in criminal niches and became an own sector.

Applications and assignments:

- Visualisation of shot trajectories (after a shot trajectory determination by the ballistics)
- Examination of witness statements
- Determination of the suspect's size
- Bloodstain pattern analysis (in cooperation with forensics)
- Reconstruction of the crime (integration of infrared and luminol pictures in the 3D scan)
- Crime scene reconstruction, based on the geometry and video recordings
- Reconstruction based on traces
- Determination of penetration depth and volumes
- Creation of 3D models from photos
- Evaluation of CT data
- Preparation of data for 3D print

This case study is based on an article by Dipl. –Ing (FH) Ralf Breker (BLKA), which was published in "Kriminalistik", August/September issue 2014.

The Technology

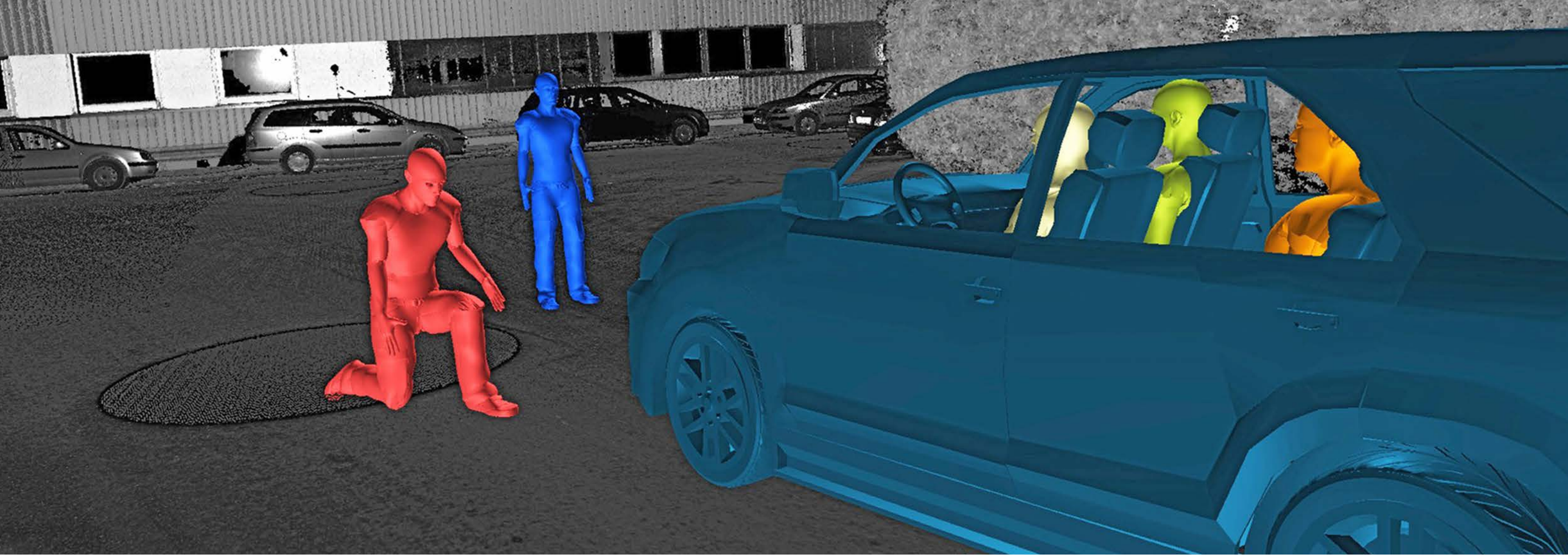
The BLKA utilises two laser scanners: the Z+F IMAGER® 5010C and the previous model Z+F IMAGER® 5006h. The Z+F IMAGER® 5010C sets new standards for 3D laser scanners, based on the development of the reliable and very fast phase comparison method.

The measurement processes are optimized for every imaginable assignment, due to the very short scan time and high usability. The laser system is classified according to laser class 1 and can be used in open spaces without any restrictions. The laser scanner has a maximum range of 187 m and captures more than 1 million pixels/sec.

The Z+F IMAGER® 5010C features an integrated and calibrated HDR camera. After the scan process, the laser scanner takes colour pictures which are being mapped onto the pointcloud automatically during pre-processing. This guarantees realistic colour information in the scan data, also in extreme lighting conditions. It's particularly important for cultural heritage preservation.

Several accessories are available for the laser scanners, e.g. the Z+F SmartLight, the Z+F T-Cam (thermographic camera) and much more, which open new possibilities for laser scanning.

Z+F IMAGER® 5010C



The virtual crime scene with 3D models
Image: BLKA

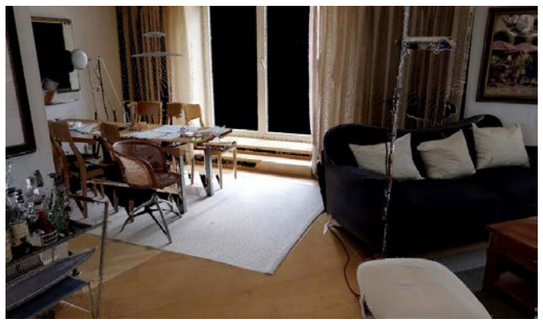
3D processes at the BLKA

The “raw scans” of a terrestrial laser scanner (TLS) contain no colour data and are displayed in different greyscales depending on the intensity of the reflection. Many laser scanners have an integrated camera, in order to assign realistic colours to the point cloud. The result is a topographically correct and coloured image of the reality in 3D.

This applies for single scans. But as soon as multiple colour scans are registered, a problem occurs in the overlap due to different lighting conditions that will cause distinctions within the point colour. The result is a crime scene with colours which, however, don’t necessarily correspond to the reality. Zoller + Fröhlich has solved this problem by integrating a HDR (High Dynamic Range) camera in the Z+F IMAGER® 5010C. This camera allows an almost objective colour rendering through multiple exposure steps. The fine tuning of colour levels between scans can be optimized with different softwares, such as Z+F LaserControl®.

The filtered and coloured pointcloud of a crime scene, the “virtual crime scene”, is ready for publishing after the digital correction. The data shows a familiar image of the reality. The crime scene can either be used in the courtroom or by the police for investigation purposes.

Unfiltered point cloud



Filtered point cloud
Image: BLKA

The 3D crime scene overview

This is a flight through the crime scene. The animation path is set manually. The advantage to a conventional film, recorded with a camcorder, is the possibility to examine the scene from any location in the room and to break away from the recording location. It gives the user a strong spatial impression of the environment.

Coloured orthographic scaled plan

Z+F LaserControl® offers the opportunity for an orthographic display. An orthographic sight is a distortion-free perpendicular recording of a surface. Removing the ceiling, for instance of a scanned apartment, there is a clear view from above of the scanned area. It’s then possible to generate a screenshot. Since the dimensions of the point cloud are known, it’s easy to assign a scale to the image and to plot it in the requested format. This is the common processing method of the BLKA. The advantage of such plans is obvious: all registered data is shown in 2D without much effort. There is no subjective selection, thus not only the data will be visualized which the investigator wants to show, but all which has been detected. The result is a photorealistic plan, where also details are recognizable.

Orthographic layout in RGB
Image: BLKA

Display of visual range through geometries
Image: BLKA

Panorama viewer

The crime scene is photographically documented with a HDR camera. These pictures are typically used to colourize the laser scan, but the BLKA also uses them as a separate investigation tool with special software.

A nodal point adapter with a reflex camera, positioned in the optic axis of the laser scanner, is used to record the environment. After the laser scan, five pictures are taken from the same position with different exposure times and from distinct angles. The result is a high quality panorama, where both dark and bright areas are recognizable. The advantage of such 360° panoramas is the high resolution, which enables to distinguish also the smallest detail. The recording position can't be changed as it is possible in real 3D. One can however combine the panorama with the 3D scan to create new, virtual panoramas from arbitrary places with various visualization programs.

The virtual crime scene

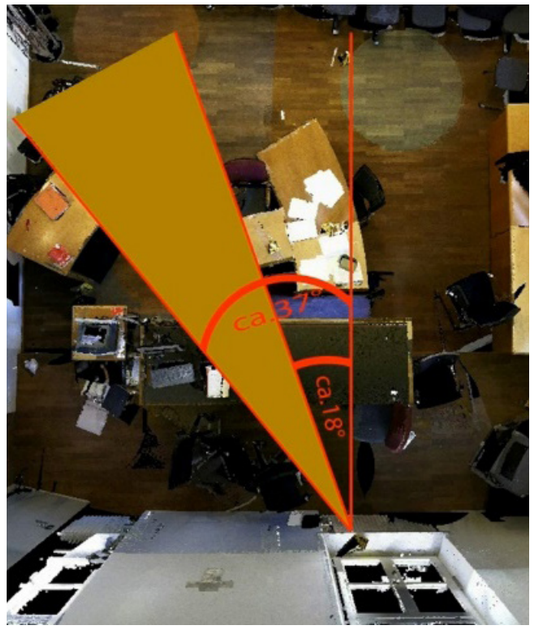
The great advantage of the laser technique is the additional third dimension which is provided by the laser scanning data, the "virtual crime scene". It allows a virtual walk-through the scene. The scene can be viewed from any position, e. g. to verify testimonials near a window. Relevant views (living room, bedroom, etc) can be predefined and it's not necessary to navigate from A to B anymore. The Walk-Through-Mode simplifies the navigation in the room and it's therefore also easy to learn for inexperienced users.

Several measure features are integrated in different software packages, such as distance and angle determination measurement functions. It's possible to insert models, e.g. figures, geometries, etc. as well. Also a level function is available, by which different areas of the scan or models can be shown or hidden. If necessary, virtual figures can be faded in or out for witness or suspect interrogation and positioned according to statements. Contradictions of declarations are therefore quickly noticeable. Also other expert opinions of forensic science and medicine, which possess spatial reference, can be displayed. For instance, a forensic medicine report, luminol and bloodstain pattern analysis, the view of a witness and shot trajectory analysis by ballistics can be combined in one data set and be given to the user. The reliability of the report of different faculties can thus be verified. Moreover, such a presentation provides transparency in the courtroom. Further advantages of this application are that inspections of the crime scene become obsolete and the crime scene is virtually viewable for many years.

Visualisation of the shot trajectory

In case there are bullet holes on a crime scene, ballistic probes (cylindrical metal sticks) are typically placed inside them. During post-processing, the scanned probe can easily be extended and represented in a program as a model, cylindrical or conical geometry three-dimensionally. The spatial angle of the probe is extremely precise, due to the fact that the probe is recorded with millimetre accuracy. It is also possible to visualize an exact bullet trajectory in the 3D scene, calculated by ballistics experts.

3D field of view reconstruction to verify a witness' statement
Image: BLKA



3D Visualisation of the shot trajectory
Image: BLKA

Luminol glow (left) and calculated image in the scan (right)
Bild: BLKA

Integration of infrared and luminol pictures in the 3D scan

Luminol is an active substance, which reacts to haemoglobin. It allows to visualize removed or blurred bloodstains. Luminol emits a blue glow that can be seen in a darkened room. The glow lasts only for a short time, but the effect can be documented by a long-exposure photograph. If photographed again from the same position, but with normal lighting conditions, it's possible to overlay both recordings with an image processing program. The result is an image, which shows both the illuminated situation and the chemical luminol reaction. This processed image can be inserted into the laser scan. The image is displayed topographically and spatially correct, due to common points (fugues, distinctive points, targets).

The same applies to infrared images (> 700 nm), which capture the bloodstains that are out of the visible light spectrum. The advantage of this technology is obvious: bloodstains which have been treated with luminol or recorded with infrared (e. g. profiles of shoes) can be accurately documented and potentially linked to a suspect. The forensics specialist can easily reconstruct the dynamics of a crime, if the luminol traces are available in 3D. Thus, the luminol method becomes more transparent for the judiciary and saves the forensics specialists many technical questions in the courtroom.

Spatial check of witness statements

Such 3D models are also perfect to check the statements of witnesses. The virtual camera allows analyzing the scene from any possible position in the scanned area. The camera can be positioned at a window, from where a witness could have seen the crime. The height of the camera can be adapted to the witnesse's size. As previously mentioned, the combined process of the point model with the other models is a great advantage of the workflow.

Additionally, the maximal visual range of the witness can be displayed and the result can be preserved in an advisory statement. Also afterwards, on the basis of the traces, i.e. of a witness statement, models can be repositioned in the scan. These can be cars, figures or objects which were altered or aren't in the crime scene anymore. These can be inserted in the visualization.

3D bloodstain pattern analysis

Bloodstain pattern analysis has been carried out by the forensic medicine for many years. In addition, relevant blood drops are chosen and the trajectory is calculated by a mathematic formula. In order to document the results, strings are spanned from the blood drops to their origins and then photographed. The smarter, faster and more accurate solution is using the laser scan and algorithms to determine and visualize the trajectory. This method has been used abroad for many years, e. g. by the "Gendarmerie Nationale" in France or "Metropolitan Police" in London. Also the LKA Berlin and the local forensic medicine have a team, with many surveyors and forensic medicine experts, which apply 3D processes. Also in Bavaria, in cooperation with forensic medicine, the bloodstain pattern is analysed with a special software. The basis is a laser scan of the area with bloodstain pattern. Additionally, a high resolution photo is taken.

By means of measuring marks, which are both in the photo and in the laser scan, the image can be projected onto the scan. On the outline of the blood drops, ellipses are drawn up and the algorithm - which also takes gravity and air resistance into account - calculates the trajectory automatically. The selection of blood drops and the later interpretation of the results of the 3D bloodstain pattern analysis are made by forensic medicine experts. The process results can be easily exported as 3D models in the virtual crime scene or represented as 3D animated graphics.

Blood stains
Image: BLKA

Conclusion and outlook

For further applications, e.g. suspect size determination, reconstruction and measurement of injury patterns or determination of penetration depth and volume, other measurement methods are used or combined (e. g. close range scanners). Generally, several 3D technologies are used in forensics science, such as laser scanning, photogrammetry or also CT-data applications.

The advantage of the 3D process for the Bavarian police and the courts is evident. The crime scene conservation in 3D and the visualisation possibilities of the course of events create a transparency which has never existed before in such form. The exact simulation and measurement possibilities open up new ways for crime scene investigation.

Many new projects are planned, such as physical correct representation of lighting conditions at the moment of the crime, the work of finite elements or the motion capturing. These techniques need some years until they will be fully established. Much educational work and training is necessary and the technical equipment must be improved. In the future, the 3D technique will be used in many forensic faculties.

It will be important to combine new and established technologies in order to find ways how to use the additional potential.

Point cloud with thermographic and HDR image

Z+F T-Cam

Innovations of Z+F

Zoller + Fröhlich GmbH is constantly developing new hardware and software solutions, which are very important for forensics science.

An example is the Z+F T-Cam (thermographic camera). It is an external solution for the Z+F IMAGER® 5010C and 5010X, which acquires infrared information after the laser scan. The camera creates a 360° thermographic panorama automatically and provides precious data for the crime scene analysis. The Z+F SmartLight is a light source, developed as well for the Z+F IMAGER® 5010C and 5010X. During the image acquisition, the LED is controlled that it lights up the picture area of the camera perfectly. This allows high resolution images in extreme lighting situations, also without external light, and reduces the battery drain.

The Z+F IMAGER® 5010X and Z+F LaserControl® Scout allow automatic registration in the field and in real-time - even without targets! The scanner is equipped with additional sensors, which support the device's position and orientation estimation. This works indoors, as well as outdoors.

With the Z+F IMAGER® 5010X and Z+F LaserControl® Scout, Zoller + Fröhlich revolutionises laser scanning with the Blue Workflow.

For further information please contact your local Z+F Partner or visit our website www.zf-laser.com

Z+F IMAGER® 5010X

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08/2015