Digital crime scene documentation, -reconstruction and -analysis

An experience report after interdisciplinary discussion using the 3D crime scene model.

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Abstract

At the moment, few methods are in development to capture a crime scene three-dimensionally with the aim to create a complete, digital model which, by use of the corresponding software, can be looked at from every perspective at the monitor. On behalf of the prosecution authorities, we have captured and reconstructed a real crime scene with the 3D-Laser scanning technology and presented the model to forensic specialists, coroners and the examining magistrate. This presentation was very impressing and fascinated all participants. A very lively discussion followed, which resulted in new findings and an important progress in solving the criminal case.

In a review of this discussion, we summarized and evaluated the impressions of the participants. Altogether, the possibilities of this new method are various and can lead to a more efficient and effective proceedings in solving a crime.

Introduction

Digital crime scene documentation, analysis and reconstruction are widely regarded as a promising future technology in forensic investigations. So far, however, there are only limited publications, which show that this technology has now been in use. Therefore it is important that these new methods are introduced not only theoretically but more and more also practically. In the following case it will be shown that coloured 3D-laserscanning has helped to interpret a murder case, which occurred in a country of the European Union in spring 2004. After initial investigations the Institute for Digital Crime Scene Reconstruction - DCSR Inc.- was called to 3D-scan the crime scene.

Materials and Methods

Crime scene (Material)

The scanning of the crime scene took place in a house where the victim lived alone. The room where the victim was found was the bathroom. Blood-spatters and bloodstains were scattered all over the floor and the walls. Also in the bedroom bloodstains and other traces could be found. The other rooms did hardly show minor traces and were not scanned.

3D-Laserscanning (Method)

To document and analyse the crime scene, we used the method of coloured 3D-laserscanning (Fig.1). Coloured 3D-scanning is a technology that first measures the distance between a focussed point and - depending on the resolution - up to 50 millions of points of objects in direct sight of the scanner focus. As the scanning laser beam turns around two axes, the three dimensions are primarily projected to a 2D-view. Each point of this 2D-view depends on the following variables: degree of the turning mirror against the chassis, degree of the turning device against the tripod, and the distance between mirror and scanned object. This distance is calculated by the time of flight of the laser beam (send-return-signal),) and a value for signal strength of the returning laserlight (which gives information on the light absorbing properties of the scanned material). With these variables, the X-Y-Z-coordinates of every point can be calculated. This process results already in a grey-shaded 3D-model. For a room of average complexity, about three scans have to be made, and after each scan, a high-resolution digital camera (at least 6 megapixels) is put on the same focus as it had the laser (Fig.3). A special lens with a low focal distance and a very low optical error-rate is also needed. The two data - grey-shaded 3D-model and the digital colour-pictures (as described above) as well as freehand close-up colour-pictures (Fig. 2) are mapped together. Thus, a fully coloured 3D-model with high-resolution textures at the regions of interest is generated which can be looked at with a special software.

Blood-spatter-analysis and measurements (Method)

In the digital 3D-models, any kind of measurement from one point to another can be made. For example it is possible to measure the height of the room, the distances between objects, etc. With the special software blood-spatters can be measured (see formula on Fig. 4) to recalculate their origin (Fig. 4 and Fig. 5).

Presentation at the meeting of investigators and the judge (Method)

The results of the scanned rooms (3D-model, blood-spatter-analysis and measurements) were presented interactively at the offices of the police and the law authorities with notebook and beamer. The model served as the base of an interdisciplinary discussion of the case.

Results

The resulting model can be seen in figures 6 to 11 (it is very difficult to give people an idea of the possibilities of a 3D-model that can be turned and twisted interactively in a few 2D-picures. Therefore we provide a demo-CD for better understanding, just contact the authors). The 3D-model was the base of all other following analysis:

Blood-spatter-analysis could be done easily and showed the place where the injured and bloody head lay when the victim was found. All other blood-spatters could be recalculated and were absolutely coincident with one source of the blood traces. It could be concluded that major injuries had been set at only one spot of the victim's head, and so obviously the victim had neither tried to defend himself nor had there been any struggle.

Measurements were done to verify the accuracy of the 3D-model: the police put measure-stripes next to several blood spatters (Fig. 8). By measuring the length of these stripes, the model could be validated in terms of measurement. There were only differences of a few percents.

The judge of investigation, the medical forensic doctor and the investigators of the police were lively discussing the case and put together all their considerations while looking at the model from all points of view and perspectives. Hypotheses of all people involved were discussed and the next steps of investigations were planned.

The findings of the obduction were (in short): blunt force trauma to the head and the chest with smooth edged separation of the left ear, fractures at the right side of the skull, bilateral serial rip fractures and signs of strangling - among other mostly blunt force injuries. As the cause of death the severe loss of blood and a heard contusion were indicated by the medical forensic investigators.

Bloodstain where b = 6mm and a = 12 mm.

(1) $SIN\ \theta = \frac{b}{a} = \frac{6}{12} = 0.5$

or

(2) $SIN\ \theta = \frac{Width}{2a} = \frac{12}{2(12)} = \frac{12}{24} = 0.5$

$\theta = (SIN^{-1})\ 0.5 = 30°$

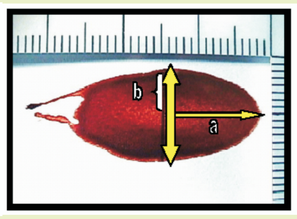
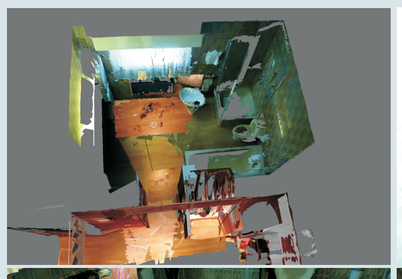
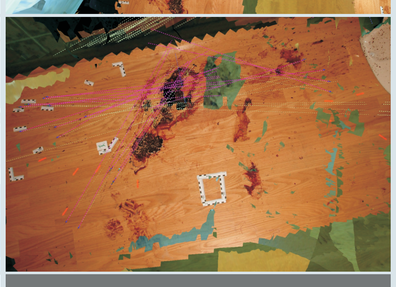
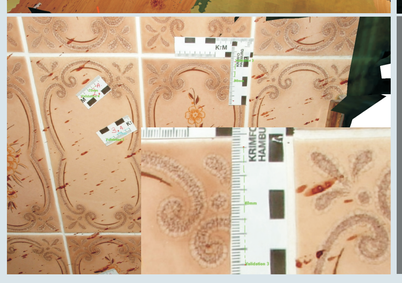


Fig.1 left
Deltasphere 3000 3D-Laserscanner
Fig.2 top left
Blood-spatter to analyse
Fig.3 down
Color-mapped-scans of the 3 positions of the Laserscanner

Fig.4 top right
Measurements in Bloodstain
Fig.5 top middle
Formula to calculate the angle of impact







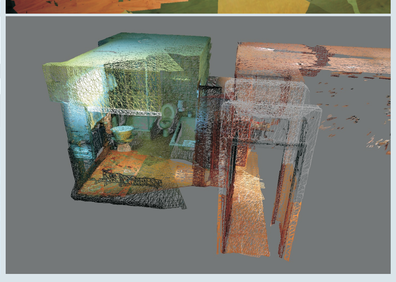


Fig.6 left
Reconstruction of the crime scene (overview)
Fig.7 right
Blood-spatter-analysis on the wall

Fig.8 left
Blood-spatter-analysis of the wall (side view)
Fig.9 right
Blood-spatter-analysis on the floor

Fig.10 left
Measurement validation using the mapped photos
Fig.11 right
Wireframe view of the reduced model

Epilogue

The DNA-analysis of the traces at the here presented crime scene proved to be a hit of the DNA-database. The suspected criminal was searched for a long time and was finally captured in another European capital. He turned out to be a one-armed man, which underlined the way of how the victim was killed and suited to the safe kept material found at the crime scene. Unfortunately we will never know, whether the conclusions of the discussion were right - the suspected murderer hung himself in the prison only hours after being captured and without any confession.

Discussion

Until now the documentation of a crime scene has been a mere patchwork of pictures taken from the crime scene, from the traces, the victim, the weapons and other safe kept material. To give a 3D-impression of the crime scene, photogrammetry can be used, but it has its limitations in the composing of many pictures and/or of high polygon objects like curves and almost all natural material, especially the human body.

The coloured 3D-laserscanning offers new possibilities, which can improve not only documentation of the crime scene but also shorten and facilitate investigations of the case. By 3D-scanning of a crime scene, every object in sight of the laser is documented whether or not it may be regarded of importance. In case of new aspects of a case, which occur later, objects, which have not been looked at until then, can obtain new interest. By 3D-laserscanning their positions have been kept with accuracy as in the original and untouched crime scene.

If a blood-spatter-analysis is needed, common procedures are used like measuring with cords, which is a time consuming operation. The virtual 3D-model offers a new approach and, moreover, it does not require the presence of the investigator at the crime scene. In our case blood-spatter-analysis was quite easily done apart from the crime scene in our office and it offered conclusive results.

The greatest advantages of virtual 3D-models are seen in the possibilities of interdisciplinary discussions in the presence of the model with forensic specialists, judges, victims, witnesses and suspects. Every proof and every testimonial of the involved persons can be verified by the model, which furthermore can be multiplied for every investigator. It is apparent that discussing a case by use of our virtual model empowers imagination and enhances new ideas but it can also be used for the synthesis of presumptions and of course also for falsification. As an example, it was possible to show that blood spatters, even those which were further away, were in a direct line in the direction of the origin, and therefore it was likely that the blood source was not moved during the killing. On the basis of a patchwork of pictures, this would have been impossible.

Crime scene documentation is a very critical part of crime scene investigation. The information of non-documented objects are lost for solving a crime, if they are not conserved. The results show that the new technique of 3D-laserscanning can be used as alternative or in addition to usual methods.

Conclusion

3D-laserscanning is a new method, which is already used not only for testing but already in real criminal cases. In the here presented case it was used successfully for blood-spatter-analysis and measurements of the crime scene. Moreover, the resulting 3D-model served as the basis for a lively, interdisciplinary discussion between the judge, the medical forensic doctor and the crime scene experts, which lead to further conclusions in the case.

Further research is needed to better evaluate different approaches of 3D-laserscanning in forensics. Already now it can be stated that this method promises better quality and reduces risks in crime scene documentation, reconstruction and analysis.

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