Using laser scanning technology to determine bloodstain origin

Abstract

In forensic science, knowing the point of origin of bloodstains can help to determine the sequence of events in a violent crime. FARO technology has been deployed in academic research in Canada aimed at discerning the accuracy of impact bloodstain patterns on the walls, floors and other surfaces in crime scenes. In laboratory conditions, researchers at the University of Toronto Mississauga used a FARO laser scanner Focus^{3D}, FARO Scene software and FARO's Forensic Plugin to assess 30 impact patterns.
The researchers found that the FARO technology:

- delivered results that were within accepted ranges indicated by current scientific literature
- could gather accurate data more quickly than other methods, and
- could help in presenting a visual of a crime scene to help a court understand the details of a crime.

Introduction

At violent crime scenes, forensic investigators will use bloodstain pattern analysis (BPA) techniques to assess the physical characteristics (size, shape) of individual bloodstains as they try to work out what may have happened. For example, knowing the position – and particularly the height – of a blow may indicate whether an injury was defensive or offensive.

As blows are struck into liquid blood, impact patterns are created, with blood droplets – by their shapes and directional trails – creating elliptical stains that can be analysed to determine the point of origin (PO). Traditionally, this analysis was undertaken by crime scene investigators using a series of strings to trace the source of multiple elliptical bloodstains back to an intersection (an area of convergence, AOC).

However, the stringing technique is not perfect. It assumes droplets travel in straight lines, but gravity and air resistance will mean many droplets take a curved, parabolic path. Moreover, physical stringing is both labour-intensive and time-consuming, and the process of attaching strings alters the crime scene, as well as being prone to human error. As a result, virtual stringing methods (eg: BackTrack, HemoSpat) have been devised, and investigators have also explored the use of laser scanning – which is both quicker (completed within an hour, as opposed to the several hours taken for physical stringing) and preserves the crime scene.

Laser scanning involves the use of an infrared laser to accurately capture millions of data points in a point-cloud. By undertaking multiple scans from different scanner positions (cross-referenced by physical markers) and recording both the horizontal and vertical angles of results, investigators can build up a three-dimensional representation of the crime scene accurate to ± 2 mm for distances from 10 m to 25 m. Alongside the infrared laser-derived data, colour information is also collected. As a result, digital images are converted into high-resolution 'virtual scans'. Once all laser points, photographs and bloodstain ellipses have been matched and marked, the closest point of intersection for droplet trajectories can be calculated.

Laser scanning a multiple-surface space

Forensic science researchers had studied the core FARO technology previously, but had only looked at bloodstains on a single surface, whereas crime scenes may have stains on several surfaces at different angles to each other. The latest research, therefore, assessed the accuracy of the FARO tools in a confined space, simulating a room with a floor, two walls and a slanted ceiling, plus an irregularly angled object (roughly resembling a couch), in the corner.

A custom-built impact rig was then positioned in the structure. This had an impact arm that could strike into a small volume of sheep's blood with a consistent force at different distances. Ten impacts were performed at each of three distances; after each impact, the researchers examined the surfaces and selected four or five suitable bloodstain clusters each containing at least four elliptical stains. With visual reference markers applied within each cluster, photographs were then taken.

A series of 360° laser scans using a FARO laser scanner Focus^{3D} were also undertaken both before and after impacts (the 'before' scans helped accurately assess the position of the impact rig). In addition to the laser scans, which gathered data on distance and intensity, red/green/blue (RGB) colour scans were also undertaken. The researchers were careful to apply a suitable resolution (1/4) and quality (3x) for each scan to ensure that scans could be quickly completed while ensuring suitable density and statistical accuracy of data points. Data was saved to the scanner's SD card and then downloaded for review and analysis in FARO Scene software.

The program generated a coloured point cloud, which was then aligned with the photographs. Between four and 24 bloodstains were then selected in order to calculate the PO – depicted as a red, star-shaped object – and distances to the walls and floor were confirmed using FARO Scene's inbuilt measuring tool. The researchers then performed a detailed series of statistical analyses covering the accuracy and reproducibility of the PO determination in all 30 impact tests.

Accurate, reproducible – and automated

The experiments showed that the calculated POs differed from the known POs, but the differences were within the range of acceptable differences identified in previous forensic science literature, while the standard deviations showed good reproducibility of results.

The FARO researchers compared their results to previous research which had compared physical stringing and virtual stringing software using BackTrack and HemoSpat. This research's results were consistent with those experiments, but may be more relevant to future forensic investigative needs. First, the researchers understood that the BackTrack software was no longer being developed, while FARO remains in active development. Second, both rival approaches required manual entry of distance information, and did not work with laser scanners. Consequently, they identified:

"The FARO method has the advantage over these two accepted methods in that distance information can be quickly obtained in an automated fashion, allowing shorter time spent on crime scenes recording measurements. There is also the added benefit of being able to quickly obtain a visual of the crime scene for use in court, which can aid a jury in understanding the details of a crime."

Conclusion

This research built on earlier investigations into BPA techniques looking at physical stringing and other virtual stringing approaches. While recognising some potential opportunities for future research – expanding the analysis to cover multiple surface at varying angles, and curved surfaces – it concluded that the FARO method is "a plausible alternative to current methods of BPA".

The journal article mentions some work undertaken using another FARO technology (ScanArm), though says this is more suited to small objects and small areas. The FARO laser scanner Focus^{3D}, on the other hand, is able to quickly do an automated 360° scan of a large area.

[1] *This white paper draws on research originally published in a 2015 article by Rebecca Lee and Eugene Liscio, "The Accuracy of Laser Scanning Technology on the Determination of Bloodstain Origin", in the Canadian Society of Forensic Science Journal, and based on research originally undertaken at the University of Toronto Mississauga.*

An example of a point cloud generated to give a three-dimensional representation of the area scanned, opened in the FARO Scene software.

Calculated Point of Origin, represented by a red star-shaped object, as determined by the software, following selection of appropriate bloodstains within clusters.

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