C40 Use of Automated Image Analysis Techniques to Determine Impact Velocities in Bloodstain Pattern Analysis

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After attending this presentation, attendees will understand some principles of automated image analysis and its application to the determination of impact velocity in bloodstain pattern analysis.

This presentation will impact the forensic science community by providing automated methods to determine normal impact velocities of bloodstain patterns. This will enhance the capabilities of bloodstain pattern analysis and crime scene reconstruction.

Bloodstain patterns are deterministic signs of the blood drop volume, impact velocity, and impact angle. Bloodstain pattern analysis is however not straightforward, because the physical relation between the drop impact and the resulting bloodstain is complex and non-linear. For instance, the formation of bloodstains involves a complex interplay of fluid mechanics, heat and mass transfer, the presence of a complex fluid with a deforming free surface, and a solid substrate with specific roughness and wettability. In 2005, Hulse-Smith, Mehdizadeh, and Chandra showed in the Journal of Forensic Sciences that the number of spines (or fingers or rays) at the periphery of a bloodstain could be used together with the stain size to determine both the impact velocity and the initial drop size for the case of mm-size droplets impacting perpendicularly to a target surface. The determination of the impact velocity and the drop size is relevant to the determination of the region of origin of the blood spatter, if parabolic trajectories are to be reconstructed. The hypothesis behind the work presented here is that automated image analysis techniques can be reliably used to count the number of spines and correlate it to the impact velocities.

To this end, automated image analysis algorithms are designed and implemented in the Matlab® programming language, with the ability to accurately detect the edge and centroid of a drop, from where the fingering or ring shape of the drop is described. Given a photograph of a bloodstain, the boundary of the drop is first extracted. This is done by segmenting the image and detecting the boundary between the drop and the background. Then the boundary in the 2D image is converted into a 1D curve using a distance transform, where the coordinates of a point in the boundary are mapped to its distance to the center of the boundary points. The bumps on the boundary are well preserved in this 1D curve. The number of spines is then obtained by detecting and counting the peaks in the 1D curve, using standard calculus methods.

For mm-size drops impacting at measured velocities between two and five m/s, the number of spines determined by automated image analysis techniques was found to be as reliable as the number of spines counted manually. The method of Hulse-Smith and coworkers was then applied to determine from the number of spines and from the stain size the impact velocity, which was found to be within 20% of the measured experimental velocities. High-density particleboard wood and wallpaper substrates were used, and 100 drops of human blood were tested on each substrate. Other applications of the automated image analysis and pattern recognition methods are discussed, such as the ability to measure the ellipticity of a stain, or the ability to interpret three-dimensional profilometry measurements of bloodstains. The role of the knowledge of drop size and impact velocity on the reconstruction of parabolic trajectories is also discussed.

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Bloodstain, Image Analysis, Parabolic Trajectories

