Bloodstain Pattern Analysis: An Introduction to Crime Scene Reconstruction

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Blood stain pattern analysis (BPA) is an approach to support forensic investigations in reconstructing the dynamics of bloody crimes. This forensic technique has been successfully applied in solving heinous and complex murder cases around the world and recently computer based BPA approaches have been designed to better support investigations both in term of speed & quality of analysis. Blood stain pattern (BPA) is defined as the examinations of the shape, size, locations and distribution pattern of blood stain, in order to provide an objective analysis of the physical events that give rise to their origin by application of concepts of biology, biochemistry, physics and mathematics. The scientific study / interpretation of blood stain patterns at a crime scene provide invaluable evidence for sequereing, reconstruction of events that might have occurred at the crime scene. From documentation phase to final interpretation. Blood stain pattern analysis is deeply rooted in the principles of physics, fluid mechanics, medical science, computer science, mathematics etc. This paper is largely aimed at reviewing the multidisciplinary work that has already been under by scientists round the world to understand. Again, like most other disciplines of forensic science, the reliability and error rates associated with the interpretation of blood stain pattern still stands questionable.

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Introduction

Locards' principal of exchange states that "when two objects collide or come in contact with each often, there is always transfer of materials from or object to the often."[1] The study of evidence at a crime scene is particularly based on this principle. Blood stain pattern analysis is defined as the scientific study of the static consequences resulting from dynamic blood shedding events.[2] Thus in a violent crime scene with sufficient amount of bloodshed, blood stain pattern analysis often plays a significant role in proving or refuting the statements of the suspect, victims, by stander/ eyewitness (if any) within the judicial setting. The stains along with the wound suffered by the victims/ could also be used for part/full reconstruction of crime scene. Blood spatter analysis is performed by forensics expert at crime scene

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where impact on a body has caused blood to fly off and land on surrounding surfaces. The resulting stains are affected by means physical variables such as speed, liquid density and the material properties of the surface. BPA focuses on analyzing blood stains found in a crime scene with the view to recreate the events leading to these blood stains. The objective is to identify the cause of the blood stain. Often referred to as the bloodletting event. The aim of BPA is trace the stain from individual droplets back to their source. Once a blood droplet exits the body, it travels along a unique trajectory tow and the surface it is going to impact. This trajectory resembles a parabolic path & while the droplet is marveling along this path radial contractions on oscillators of the droplet occur.

History

Blood stain pattern analysis has been used informally for centuries but the first modern study of blood stains was in 1895.[3] The second modern origin of the study of blood stain pattern analysis is the Sam Stepper case in 1954, when the wife of an osteopathic physician was beaten to death in her home. The finite formal blood stain training course was given by MacDonnell in 1973 in Jackson, Mississippi. In 1983, the International Association of Blood stain pattern analysis was founded by a group of blood stain analysis to help develop the emerging field of bloodstain pattern analysis.[4]

Blood

Blood is a tissue that is circulated within the body to assist often parts of the body. This connective tissue has specialized cells that allow it to carry out its complex functions. For a healthy person, approximately 8% of their total weight is blood. For a 70kg (154Ib) individual, this equals to 5.6 L (12uspints).

Biological considerations of blood

Blood contains three components or blood cells that are suspended within plasma. The three components are – erythrocytes, leukocytes and thrombocytes. Plasma is the yellowish fluid that carries the erythrocytes, leukocytes and platelets. It is composed of water (92%), protein (7%) and often materials such as salts, waste and hormones.

Chemical Consideration of Blood

Upon existing the body bloodstain transit from bright red to dark brown, which is attributed to oxidation of oxyhemoglobin (HbO_2) to methemoglobin (iret-Hb) and hemichrome (HC).

Physical Consideration of Blood

In physics, there are two continuous physicals states of matter, solid and fluid. Once blood has left the body if behaves as a fluid and all physical laws apply. Gravity acts on blood (without the body's influence) as soon as it exists the body. Viscosity is the amount of internal friction in the fluid. It describes the resistance of a liquid to flow. Surface tension is the force that maintains the shape of a drop of liquid, such as blood. When two fluids are in contact with each often (blood and air) there are forces attracting all molecules to each other.

Angel of Impact

There are three angles of impact -

(a) Alpha (a)
(b) Beta (β)
(c) Gamma (γ)

All three angles are related through the following trigonometric equations.

$$\sin\alpha = \frac{w}{\ell}$$

$$\tan\beta = \frac{\tan x}{\sin\gamma}$$

Where,

ℓ = length of ellipse

w = width of ellipse

Point and area of convergence to determine the point/area of convergence an analyst has to determine the path the blood droplets travelled. The point of convergence- is the intersection of two blood stain paths, where the skin core from opposite side of the impact pattern. The area of convergence is the box formed by the intersection of several stains from opposite sides of the impact pattern.[5]

What can investigators learn from the analysis of a bloodstain?

Type and velocity of weapon.
Number of blows.
Handedness of assailant (right or left handed)
Position and movements of the victims and assailant during and after the attack.
How long ago the crime was committed.
Written death was immediate on delayed.[6]

BPA Terms

Spatter -Blood stains created from the application of force to the area where the blood originated.
Origin/ Source - The place from where the blood spatter came from on originated.
Angel of impact - The eagle at which a blood droplet strikes a surface.
Parent drop - The droplet from which a satellite spatter originates.
Satellite spatters - Small drops of blood that break off from the parent spatter when the blood droplet hits a surface.
Spines- The pointed edges of a stain that radiate out from the spatter. Can help determine the direction from which the blood traveled.[7]

Classification of blood stain pattern

Gardner and Bevel (In press& 2004) have grouped blood stain patterns into two basic categories.
Passive stains and Dynamic stains.
Passive stain result from an action often than a directed force to a blood mass.
Dynamic stains are created by forceful even where fluid blood is projected out from a source under some force on compression.

Classic blood stain pattern:

Spatter patterns occur when a blood mass is broken up in to droplets.
Directionality – When a droplet of blood strikes a surface perpendicular (go degree) the resulting blood stain will be circular thus the length & width of the stain will be equal.
Cast -off - blood stains -cast -it occur when blood is projected or thrown onto a Surface from a bloody object in motion.
Arterial patterns - Arterial patterns result from blood projected into the scene under pressure from the artery on heart.
Pattern transfer - Pattern transfer occurs when the wet bloody object comes into contact with another surface.
Splash patterns - Splash Patterns occur when a volume of blood is projected into a scene with minimal force characterized by a large central stain exhibiting minimal distortion.
Wipe patterns -A wipe pattern occurs when an object moves through a preexisting blood stain. Sometimes the object that wiped through the blood can be identified for example a broom.
Saturation patterns - Saturation patterns occur when blood had been drowning into porous materials such as rugs, cloth and clothing and usually tend to destroy often blood patterns of interest.
Body image - Body image patterns occur when the bleeding body has been lying in the blood, which seeps from the wounds. The blood pools from around the outline of the body & as the blood solids separate from the serum. The original position of the body is imaged on the surface.[8]

Principles of blood stain pattern

BPA uses principles of biology (behavior of blood), physics (cohesion, capillary action and velocity) and mathematics (geometry,

distance and angle) to assist investigations in answering questions such as:
Where did the blood come from?
What caused the wounds?
From what direction was the victim wounded.
How were the victim and perpetrator positioned?
What movements were made after the bloodshed?
How many potential perpetrations were present?
Does the blood stain evidence support on refuse witness statements? [9]

Physical evidence
Physical evidence refers to any tangible article small or large, which tends to prove or disprove a point in question. It may be used to reconstruct the crime, identify participants or confirm or discredit an alibi.

Types of physical evidence:
Transient evidence.
Pattern evidence.
Conditional evidence.
Transfer evidence. [10]

Detection & documentation of stains at a crime scene
When it comes to documenting blood stain patterns based on visibility of pattern to the naked eye there are in particular 2 types of blood stain pattern/ prints one could come across in real life. latent blood stain pattern & visible blood stain pattern. Given the fragile nature of blood stain pattern at a crime scene, stains are often accompanied by noise or are superimposed. by other stain in course of subsequent events at the crime scene. Luminal and blue stain have often been used to detect latent or waited blood stain that has been a challenge for forensic investigations. Infrared Digital Imaging (IR), ultraviolet Digital Imaging & Hemascein (a Fluroscein based material) are some applications that can be used for locating and enhancing blood stain that are particularly latent on faint to the unaided human eye. [11] There are three basic crime scene /environments from which or in which an analyst needs to study/ interpret blood stain pattern and hence reconstruct the crime scene. [12]
They are Active scenes, released scenes & cold scenes.[13]

How evidence is collected
Blood stain samples can be collected for BPA by cutting away stained surface or materials, photographing the stains and drying and packaging stained objects. The tools for collecting blood stain evidence usually include high-quality careens (still and video), sketching materials, cutting instruments and evidence packaging.[9]

Scientific basis of interpretation of the stains
As suggested by many forensic analyses, blood stain pattern analysis is not particularly a new discipline in itself. The roots of blood stain pattern analysis as forensics know it in the modern day world dates back to the 1800. [12] To understand the different stain pattern, it is indeed important to have a clear understanding of the physical mechanism & scientific principles that control fall, spattering of blood at the crime scene. Forces of cohesion, adhesion, gravitation, Surface tension primarily control the formation of blood stain pattern at a crime scene. [14]

Digital aid in interpretation of bloodstain patterns
The blood stain pattern were first analyzed using the stringing method & then the data was subsequently entered into the modified Backtrack program to demonstrate that the new version of the backtrack program could also handle angled surfaces**.** [15] In this regard this might be interesting for the readers to know that Backtrack [16] & Hemostat [17] are

popular toolkits that are used for manual yet partly computer assisted analysis of blood stain patterns obtained at a crime scene. Though widely used, yet these toolkits require the intervention of an experienced blood stain pattern analysis to determine parameter of input and hence interpret results.

Limitation

Like most other disciplines in science, forensic science and particularly blood stain pattern analysis is also affected by bias. Bias related to blood stain pattern analysis can particularly be classified under two broad heads. They are context bias and confirmation bias.[18]

Discussion

From the information provided in the previous sections of the document, one can very well conclude that blood stain pattern analysis is indeed an interdisciplinary study area that has generous contribute from fields of mechanics, physics, mathematics, computer science, chemistry & medical science but there still remain certain loopholes as mentioned in controversy. The research work on BPA in its core is based on the age old Biblical dictum "Blood never lies" the authors believe that the multidisciplinary nature of blood stain pattern analysis is what truly makes this domain of study lucrative and indeed interesting. The fact that blood follows the laws of fluid mechanics and reacts similarly under similar physical conditions from the basis of blood stain pattern analysis. Again, wound analysis helps the shady of blood stain patterns there by helping the analyst in drawing up inferences relative to the type of tool that had been used to cast the wound. There are well drawn up methodologies in place for directional analysis, location of the area of origin of an impact spatter in a crime scene. Tools like Backtrack & Hemostat have truly aided the rigorous manual process of blood stain pattern interpretation that was undertaken by analysis in previous times. In order to fill in the gaps within the literature on blood stain pattern analysis, the authors intend to build a system that could co-relate the blood stains on the cloth in of the individuals to other blood stains at the crime scene, based on which it could thereby make probabilistic predictions up the positions of the victim, perpetrator, bystander/ eyewitness (if any). The author believes such a system would add objectivity to inference that could be drawn about the position of individuals in a crime scene together with predicting their role in the same.

Conclusion

From literature review it can be safely concluded that various surfaces, concrete, fabric react differently to blood stain dropped by similar physical mechanism. There also exist intra-surface differences that impact or rather influence the formation of blood stain pattern formation. For example, fabrics based on texture, porosity, absorbing power impact the formation of the blood stain pattern. Again, study shows volume of blood, impact force as also fall height have significant effect on blood stain pattern formation. Proper documentation of crime scene is the first step towards accurate interpretation, reconstruction & hence presentations of blood stain pattern evidence within a legal setting. They in violent crime scene with sufficient amount of bloodshed, blood stain pattern analysis often plays a significant role in proving or refuting the statements of the suspect, victims, bystander/ eyewitness (if any) within the judicial setting. The stains along with the wound suffered by the victims/ could also be used for pant/ full reconstruction of crime scenes.

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