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RESEARCH ARTICLE

IMPACT OF BLOODSTAIN PATTERN ANALYSIS IN CRIME SCENE INVESTIGATION.

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Abstract

Bloodstain Pattern evidence can be used for sequencing events at a crime scene. Again, it can be used to trace the direction in which a body was dragged. In addition it can also be used to draw useful conclusions about the relative position of the victim/s, perpetrator/s and bystander/s (if any) in a crime scene. Stain patterns can be used for predicting the probability of events that might have occurred at a crime scene. Bloodstain Patterns cannot in particular be associated with an individual. DNA analysis of blood samples, blood serology test can be used as associative evidence for uniquely identifying an individual. This paper illustrates the process of bloodstain analysis in crime scene.

Introduction:-

Violent crimes accounted for roughly 26.6 % of the total number of crimes reported and hence recorded in the year 2014[1]. The FBI's (Federal Bureau of Investigation) Uniform Crime Reporting (UCR) Program, has defined offenses which involve force or threat of force as violent crime [2]. The investigation phase in itself can broadly be classified under the following 3 heads - 'Defining the Crime Scene', 'Processing the Crime Scene', and 'Information collection from and about the crime scene'[3]. The information in the form of testimony, hearsay evidence, real and original evidence is used for reconstruction of criminal events and thereby placement of such evidence before the juridical system to draw well analyzed conclusions [4]. So collection and interpretation of evidence does play an integral role in shaping the proceedings of a criminal case [4].

Most violent crime scenes are characterized by large scale blood spillage. The bloodstain patterns often are a static consequence of the dynamic events that had perspired at the crime scene. With a particular rise in homicide cases, stain patterns are often considered reconstructive evidences of great importance for reconstructing a crime scene, validating eyewitness testimony etc. Crime in itself forms the basis of 'Crime Scene Reconstruction'. Figure 1 provides a graphical description of the crime classification system endorsed by the UCR program conducted by the FBI [2].

As per the UCR program conducted by the FBI, Violent Crime primarily comprises of murder and non-negligent manslaughter, forcible rape, robbery and aggravated assault. The UCR program defines Violent Crime as those offenses which involve force or threat of force. In coherence with the crime definitions put forward by the UCR program, the National Crime Record Bureau, India, categorizes violent crime under the following heads – Murder, Attempt to Commit Murder, Culpable Homicide not amounting to murder, Rape, Kidnapping and Abduction, Preparation and assembly for Robbery, Riots, Arson and Dowry Deaths[1]. These crimes are under most circumstances accompanied by bloodletting events. It is this subset of crimes that we intend to work on this

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particular project. The 'Crime in India Report 2014' published by the National Crime Record Bureau, suggests that there has been a subsequent yet persistent increase in violent crime rate over the last 4 years(span 2010-2014). The crime classification chart is shown in figure 1.

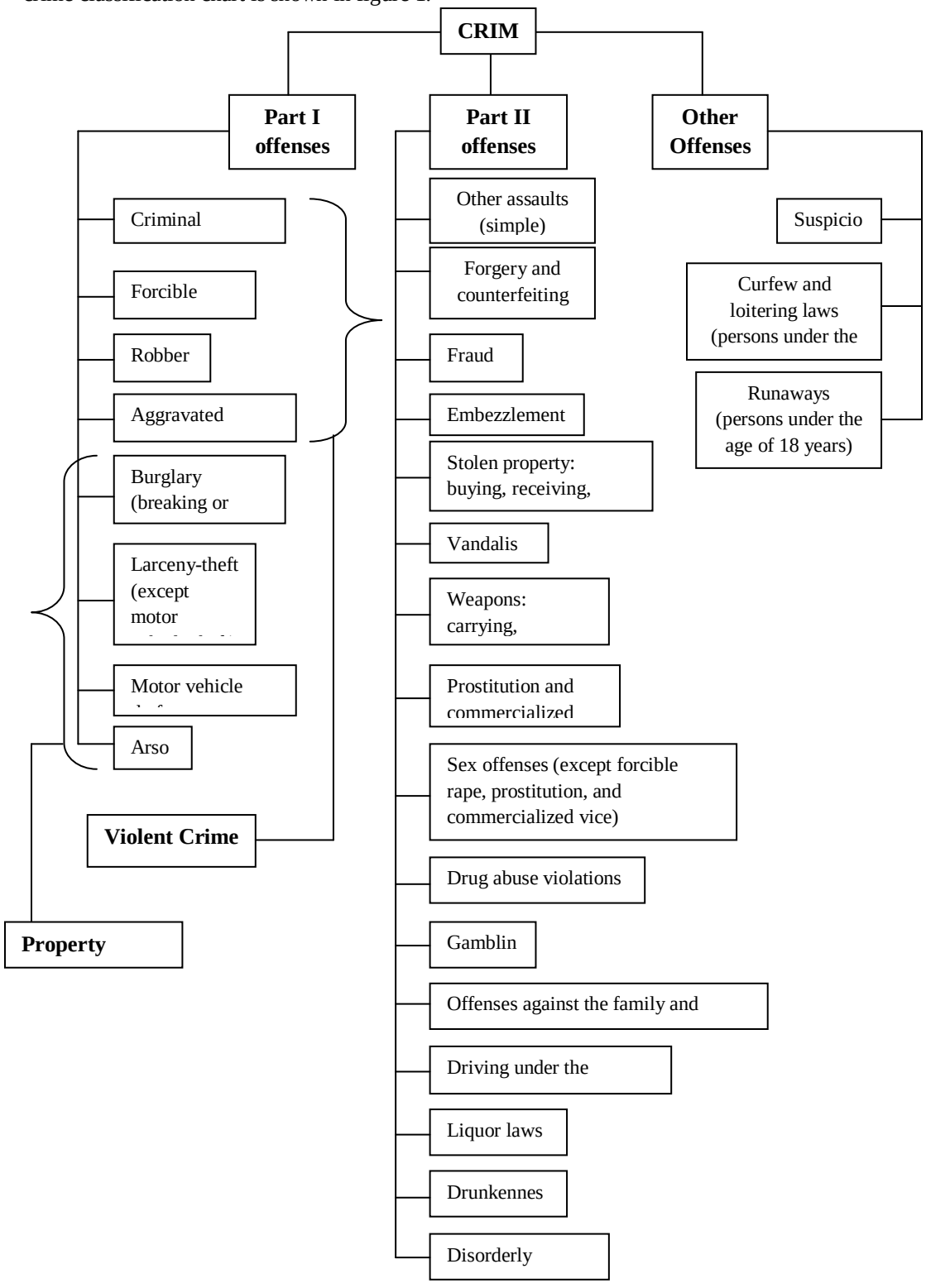

Figure 1:- A Crime Classification Chart.

Bloodstain Pattern Analysis:-

The Scientific Working Group on Bloodstain Pattern Analysis (SWGSTAIN) defines 'Bloodstain Pattern' as 'a grouping or distribution of bloodstains that indicate through regular or repetitive form, order, or arrangement the manner in which the pattern was deposited' [6]. J.J. Nordby, Ph.D., D-ABMDI defines 'Bloodstain Pattern analysis' as 'the scientific study of the static consequences resulting from dynamic blood shedding events' [7].

As a prelude to the use of Bloodstain pattern as a reconstructive evidence in a court of law, it would not be out of place to provide a graphical overview of how criminal offense is dealt with within the Indian juridical setting. Figure 2 summarizes the Juridical setting relevant to trial of a criminal complaint within the Indian juridical system [8].

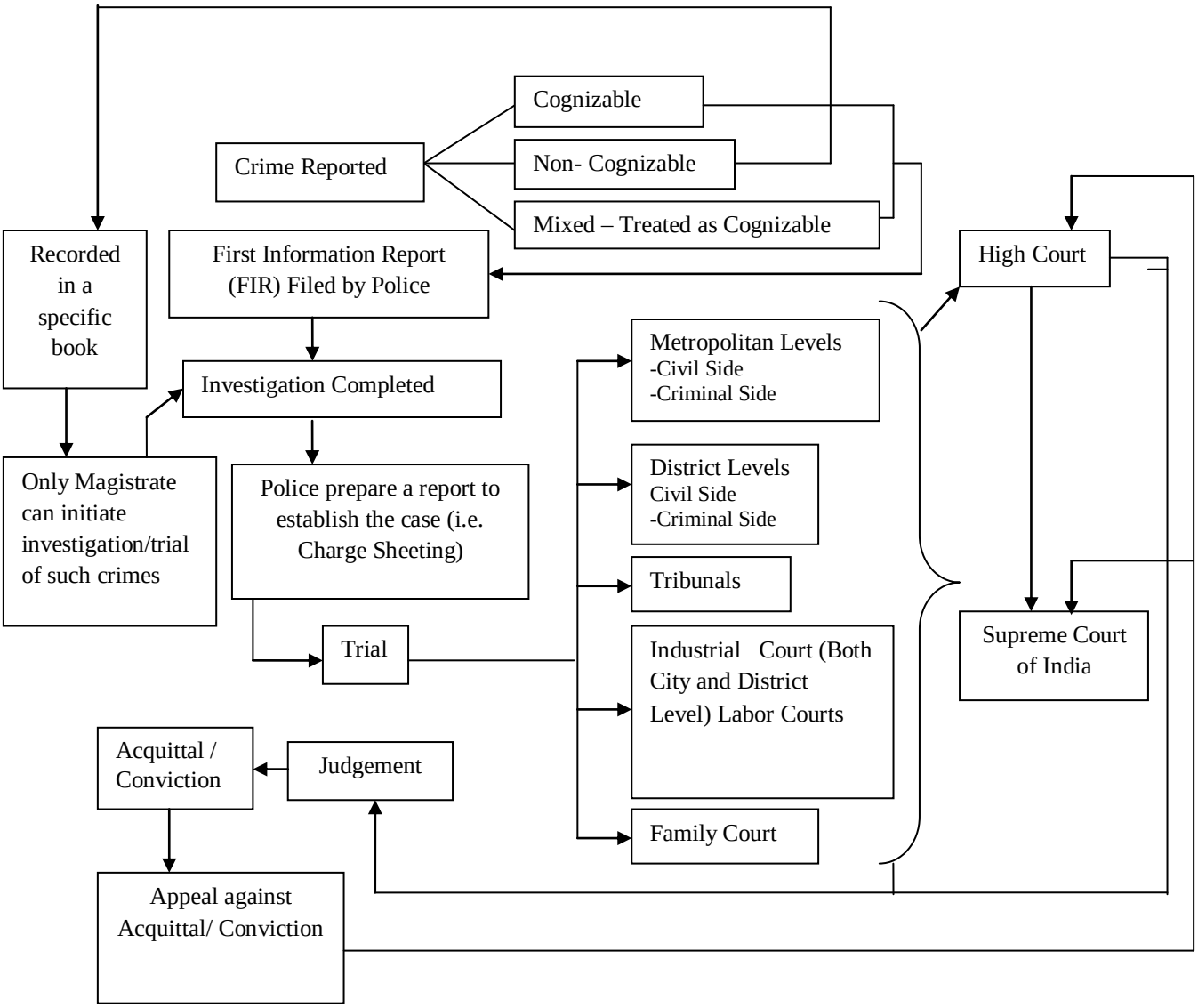

Figure 2:- Flow Chart describing the trial of a criminal complaint within the Indian juridical setting [8]

Once a complaint is made, based on the crime type reported (refer Figure 2), the criminal proceedings that take place can broadly be classified into 3 basic phases - Investigation, Inquiry and Trial[8]. Figure 3 provides a graphical overview of the process of criminal case proceedings within the Indian juridical system [8].

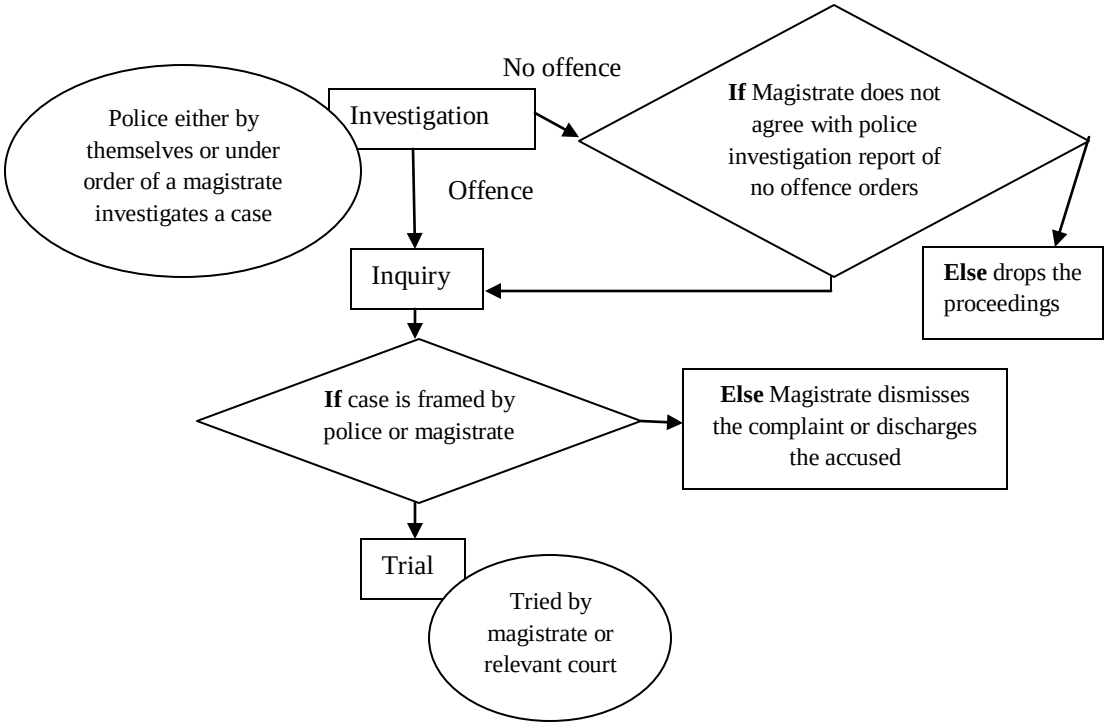

Figure 3:- A flowchart documenting how a criminal case is processed within the Indian juridical system [8]

Crime Scene Investigation and Reconstruction:-

Crime Scene Investigation and thereby Reconstruction in its turn particularly involves 3 basic phases (refer Figure 4). They are,

- Defining the Crime Scene
- Processing the Crime Scene
- Information Collection from and about the Crime Scene [3]

Defining the crime scene refers to identifying the activity areas relevant to a particular criminal event [3]. The Primary Crime Scene is the area where the original crime occurred. The Secondary Crime Scene comprises of the subsequent crime scenes [3]. The size of the crime scene can further be classified as Macroscopic and Microscopic [3]. While Microscopic focuses on specific type of physical evidence at the crime scene, Macroscopic refers to one particular crime location composed of many microscopic crime scenes [3]. In defining the crime scene, it is of utmost importance to understand the type of criminal offense that has been committed at the scene [3]. It can range from homicide, robbery, rape or an admixture of all. In analyzing evidence, it often stands integral to know the physical location of the crime scene (i.e. Indoors, Outdoors, Vehicle etc.)

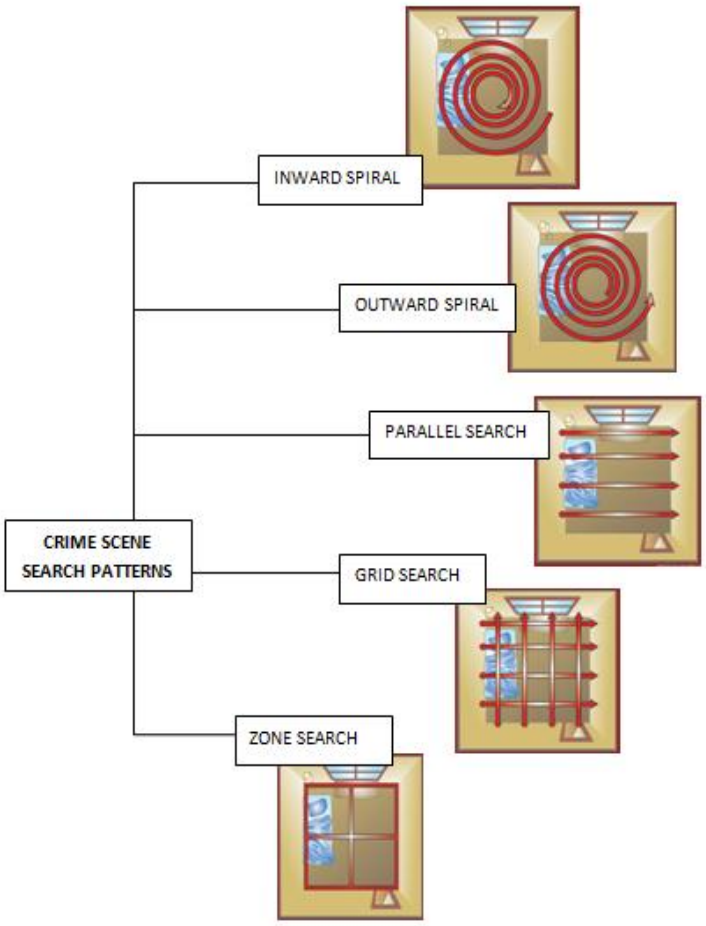

Figure 4:- Crime Scene Investigation – a broad overview [3]

Once the Crime Scene is broadly defined, the next phase of the Investigation process deals with 'Processing of the Crime Scene'. At the very onset, the Crime Scene Investigator establishes contact with the Law Enforcement Officer in charge of the crime scene. Also he/she makes a list of other people such as other law enforcement officers, coroner's personnel, public safety personnel, civilians etc. who have or have had access to the crime scene in question. The next step towards processing a crime scene is securing the scene by use of police line tape or other means in order to prevent unwanted access to the scene by casual passerby, people with malicious intentions etc. The scene is secured in order to leave all evidence at the crime scene undisturbed by wandering individuals. Once secured, the scene is subjected to initial overall survey by investigating officials. At this point, the officials leave all evidence undisturbed and develop initial theories based on apparent understanding of the crime scene. The officials also mark out potential evidence in the initial walk through phase. The first responders as also enforcement officials take into account the entry /exit points in the scene that require attention. This phase also requires the officials to make a list of equipments and precautions that the officials would need to take in order to document as also search the crime scene. The crime scene is thoroughly documented by way of Notes, Videotaping, Photographing and Sketching [3]. Once clearly documented, systematic search patterns are used in order to avoid missing out on any piece of physical evidence present at the crime scene [9]. The different search patterns that are used to search a crime scene have been graphically documented in Figure 5[9].

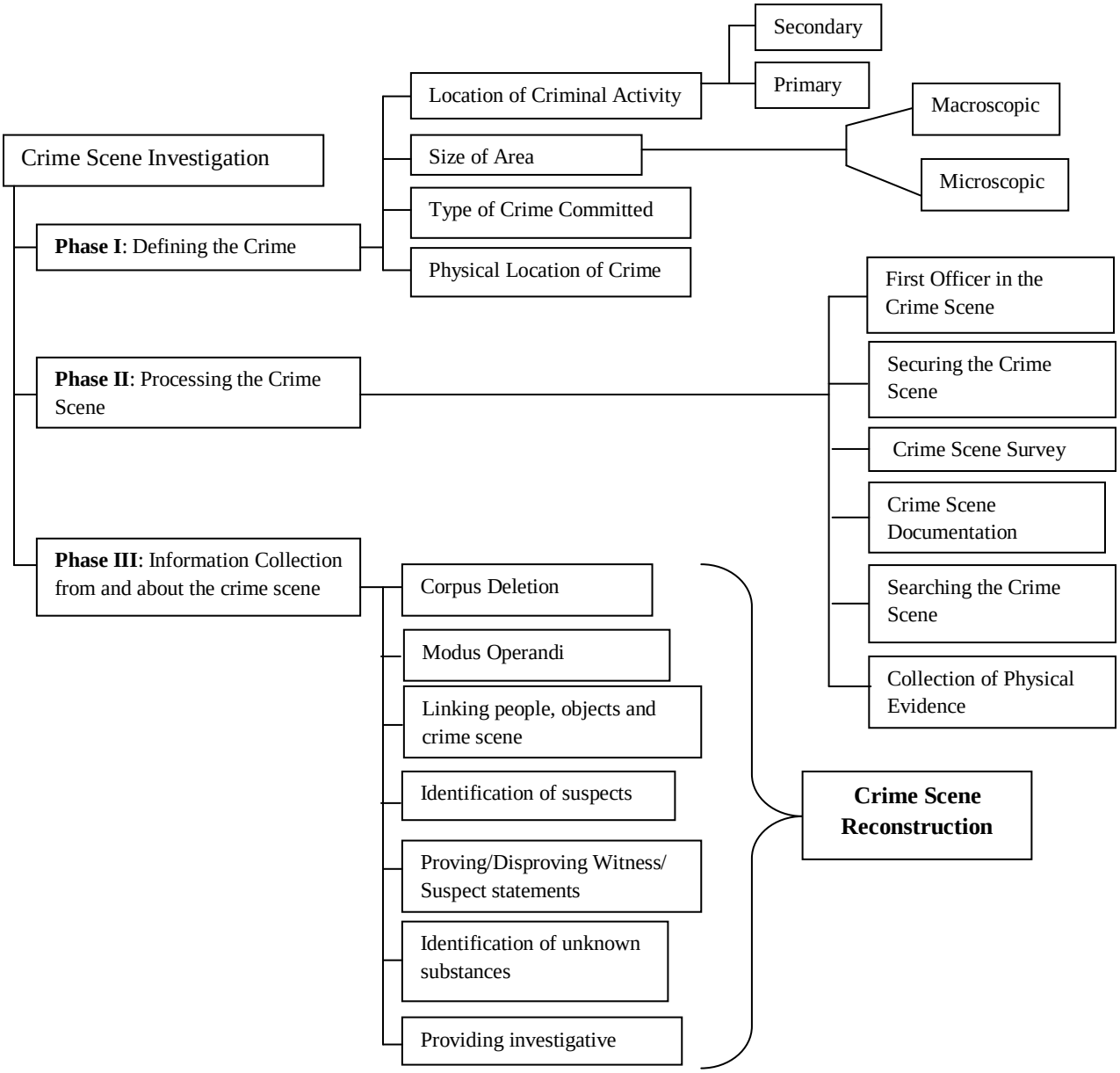

Figure 5:- Search patterns used for collecting evidence from a crime scene [9]

Evidence – Legal Perspective:-

In order to prove/disprove a hypothesis formulated, the court warrants evidence and its interpretation by an expert. The legal system classifies evidence or rather 'relevant' evidence as – Testimony, Real evidence, Hearsay evidence, Original evidence, and Documentary evidence (refer Figure 6)[4]. Evidence is termed 'relevant', when the facts that are subject to prove or disprove in a court of law amount to

- Facts in issue, i.e. those which need to be proved by one party;
- Relevant facts, i.e. those which tend to prove the facts in issue;
- Collateral facts which may for example affect the credibility and/or competence of a witness [4].

Evidence based on its use in understanding a crime scene can broadly be classified into two broad groups – Associative Evidence and Reconstructive Evidence. Associative evidence, in its turn, can also be used for reconstructive purposes. While Finger-mark, Fingerprint, Foot-mark, DNA(from Hair, body fluids), Ear-mark, Bite-mark, Handwriting can particularly be used as associative evidence for uniquely identifying an individual, evidence

such as Firearm, Shoe-mark, Fibers, Paint, Glass, Tool-mark, Soil, Drugs, Fire debris, Explosives, Pollen Grain help, Bloodstain Pattern help in crime scene reconstruction.

The different types of Reconstructive Evidence are Temporal/sequential evidence, Directional evidence, Positional Evidence, Action and Associative Evidence [10].

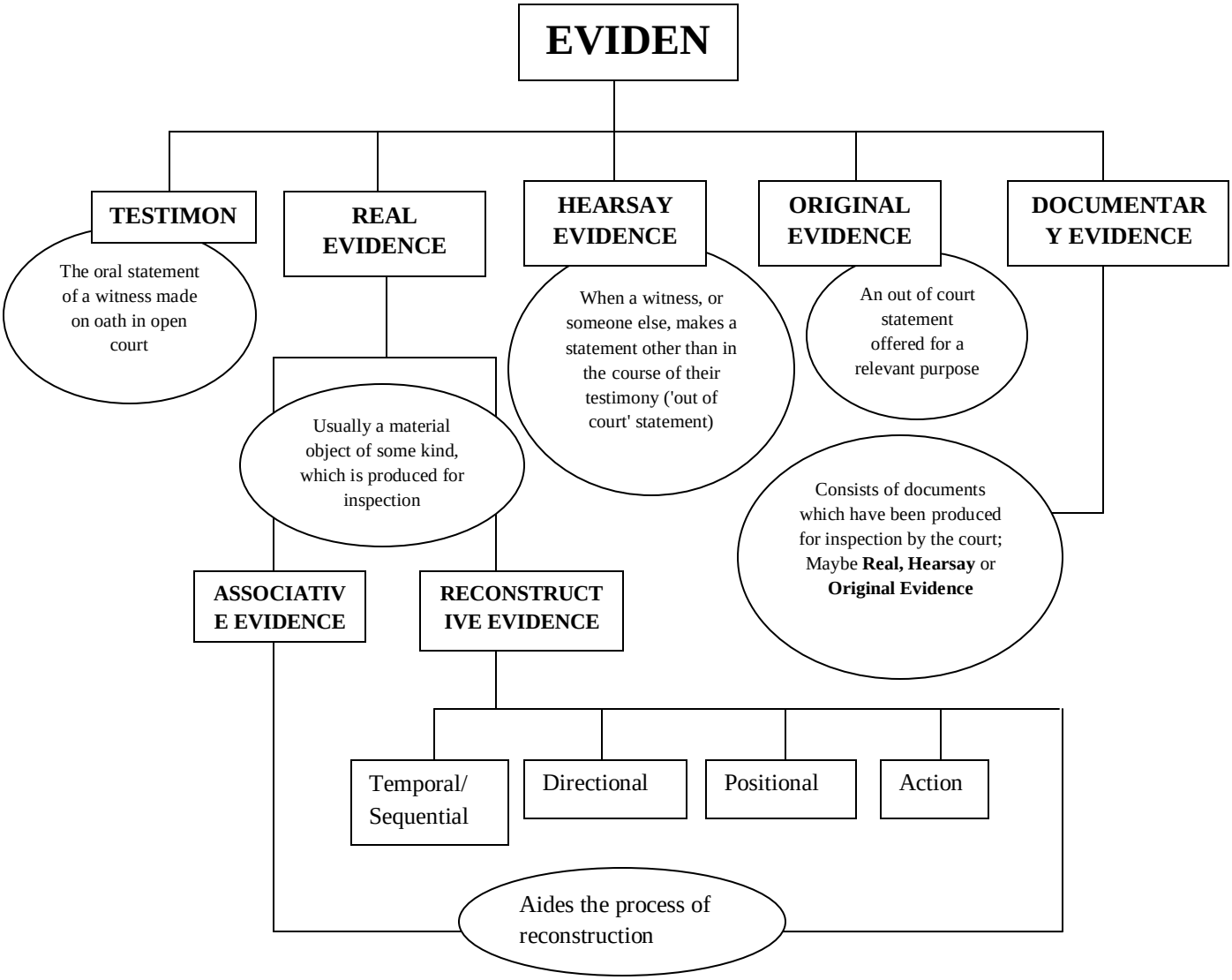

Figure 6:- Evidence classification table [4]

Evidence Interpretation- a case study:-

A core concept in crime scene analysis is that 'nothing is co-incidental, nothing just happens'. This core concept of crime scene reconstruction is based on four basic principles. They are, Locard's Exchange Principle, Nicolas Stenos Principle of Superposition, Principle of Lateral Continuity by Steno and the concept of chronology [13][14]. As of date, Locard's principle forms the backbone or rather the basics of forensic science and provides the foundation for the forensic linkage triangle (refer Figure 7) [13].

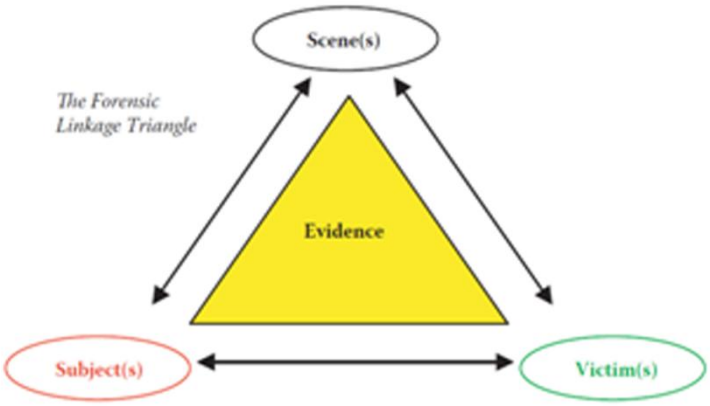

Figure 7:- Based on evidence and the principle of exchange, the forensic linkage triangle is used by forensic scientists to establish the interrelationship between the scene, subject and victim [13].

Based on the Principle of Superposition, it can be considered that the artifacts at a crime scene are also deposited in layers in a time order, from oldest to youngest, unless otherwise disturbed or altered [13]. Figure 8 represents an image from a crime scene that emphasizes this order or time sequence of events at the crime scene.

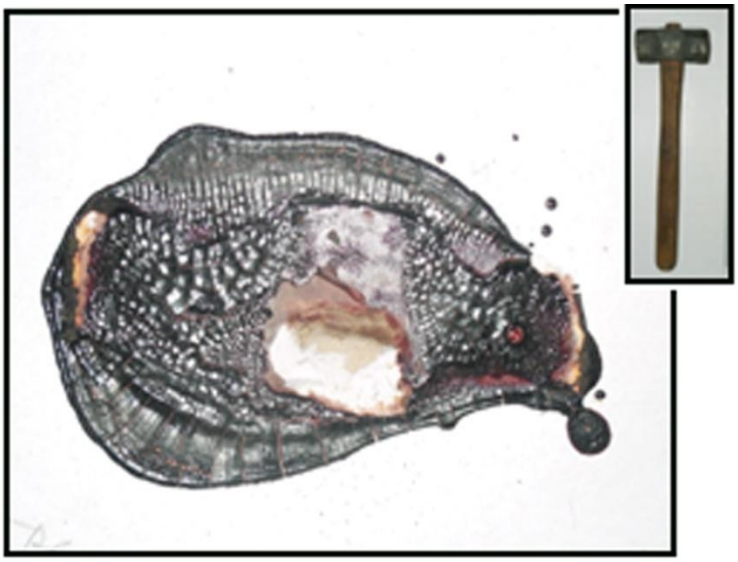

Figure 8:- A crime scene image exemplifying Steno's Principle of Superposition.

From the image it can be clearly predicted that The sledge hammer head was placed (had it fallen on the blood pool blood would have spilled on all sides of the pool) on the blood pool, was allowed to dry and later when it had almost dried the hammer was removed leading to the formation of the void in the stain pattern. The events that led to the formation of this stain pattern can clearly be sequenced.

In relation to the crime scene, Steno's Lateral Continuity states that two layers that are near in time and space but are not directly associated belong to the same time frame if they have sufficient evidence of similarity(i.e. similar spatter stains) and have only been dissociated due to subsequent alteration(refer Figure 9) [13].

Figure 9:- A crime scene image exemplifying Steno's Principle of Lateral Continuity.

Though apparently dissociated, if substantial similarities exist (eg DNA, size dispersion) between the stain patterns deposited then they can be considered to be the result of a single deposition and caused by the same event. The void pattern in itself clearly mirrors the concept of Steno's Lateral Continuity [13]. When encountered with a void pattern the analyst can easily infer that, the pattern of blood did not stop abruptly but has been interrupted by the presence of an object or living being ; or has particularly been altered(i.e. removed) .

As per Bevel and Gardener [13], the steps taken to reconstruct a crime scene can be summarized as follows (refer Figure 10).

- Physical evidence and data collection from crime scene
- Specific event segments are established based on data/evidence collected(time snapshots)
- To work out which event segments are related to each other
- Sequencing the related event segments, to establish a flow of the event
- In order to resolve contradictions, all possible sequences are considered and auditing of evidence is done as and when required
- Based on sequence of the event segments, preparation of the final sequence of events is done.
- Finally the flowchart of the entire incident is prepared and the sequence is validated.

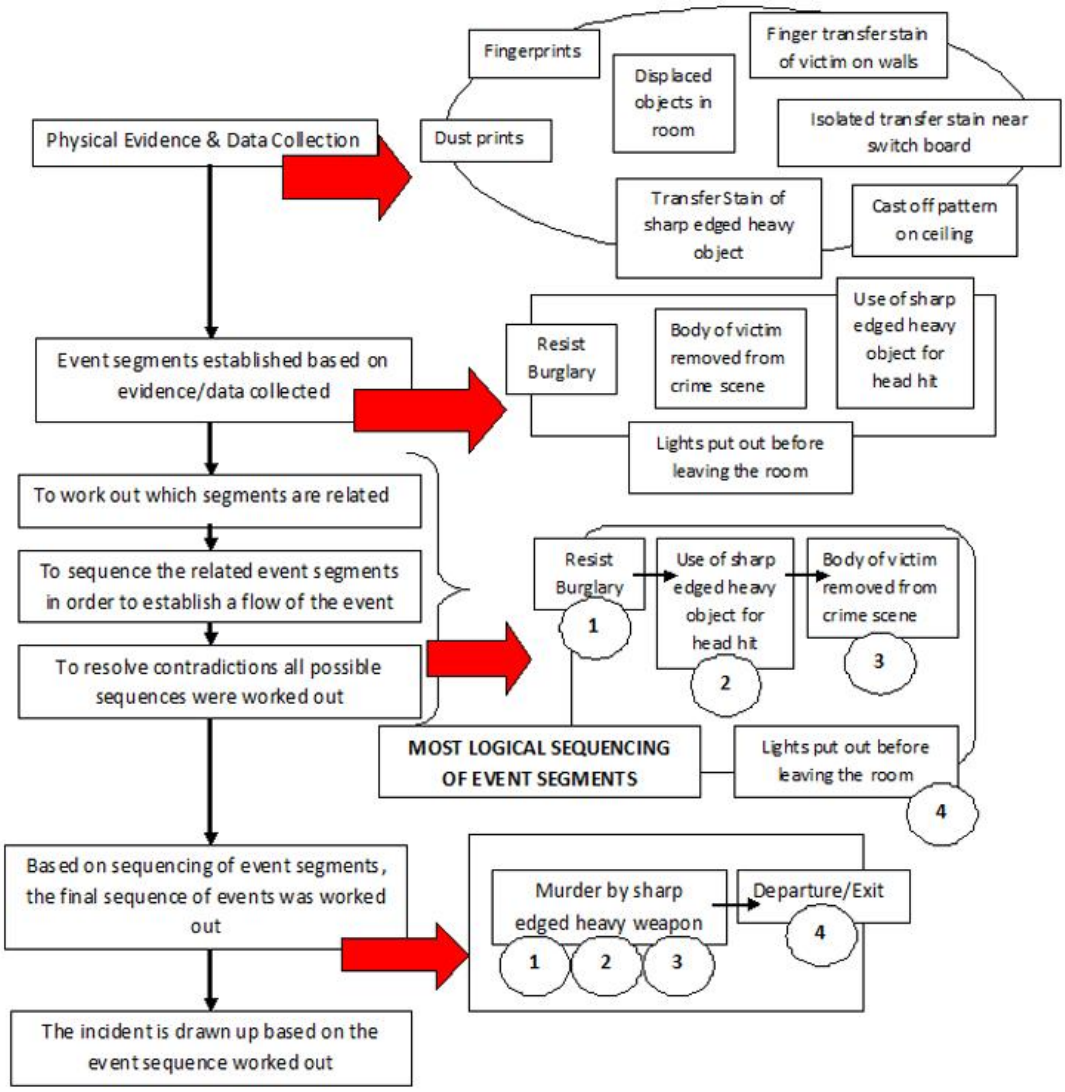

Figure 10:- Graphical representation of the different steps used for crime scene reconstruction.

The round structures numbered 1, 2, 3 and 4 represent the order of the associated event segments that contribute to a particular event. The event segment 'Resist Burglary' is marked as '1', the segment 'Use of sharp edged heavy object for head hit' is marked as '2' as it succeeds event segment 1. Similarly, event segment 3, 'Body of victim removed from crime scene' succeeds event segment 2 and logically precedes event segment 4, which is not related to event segments, 1, 2 and 3. Event segments 1, 2 and 3 in sequential order add up to form event 'Murder by sharp edged heavy weapon'. Event segment 4 is a part of the event segments that build up event 'Departure/Exit'.

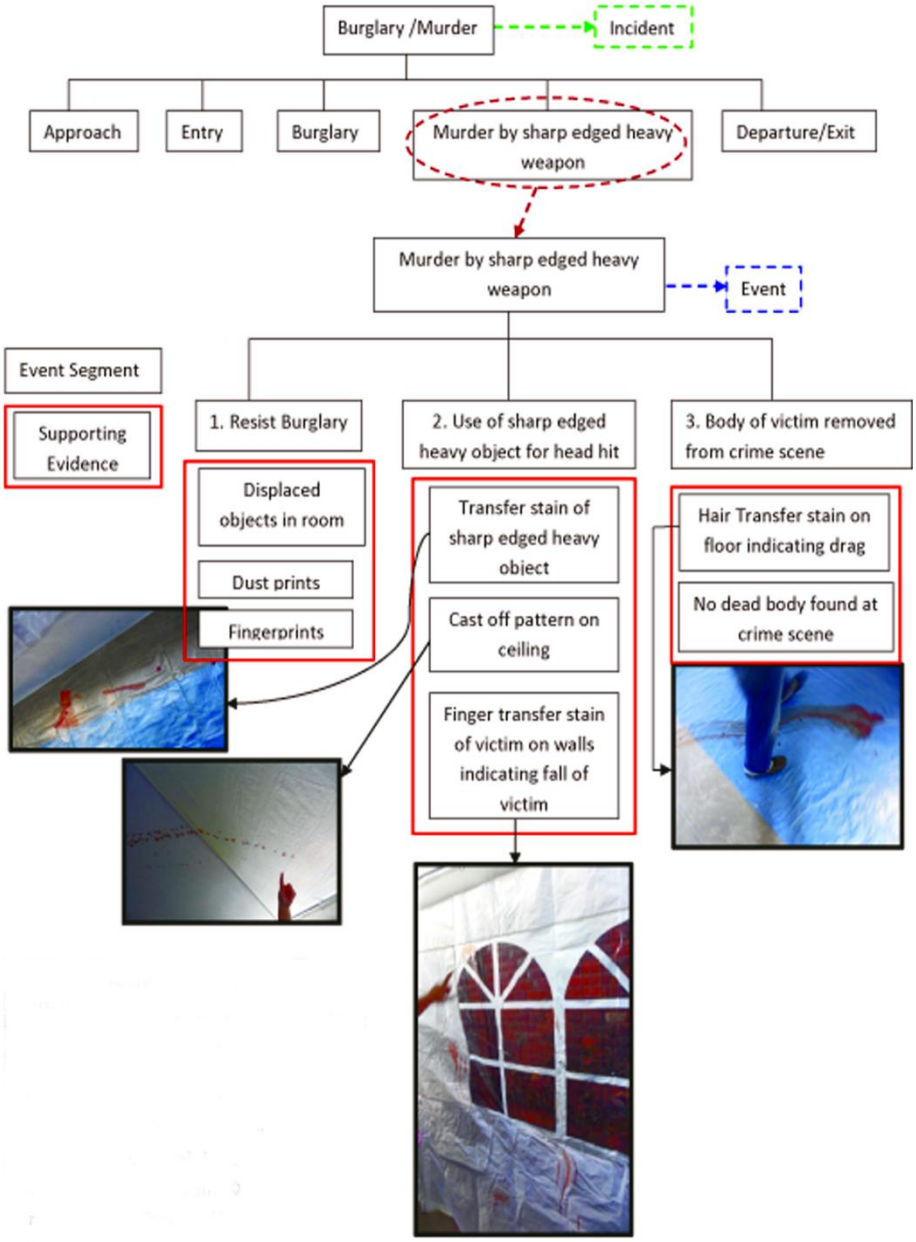

Figure 11:- A crime scene reconstruction with the help of physical evidence, which directly contribute towards drawing up of respective event segments, which in their turn contribute to making up of event/events. The events add up to explain the criminal incident that has perspired [13]

A crime scene of burglary together with the murder of the victim was recreated/ simulated. Figure 10 represents a particular event from the scene and the ancillary event segments. The optimal sequence of events that had occurred at the crime scene was worked out based on available circumstantial evidence and data collected from the crime scene (refer Figure 11). A probability value is attributed to each event sequence based on previous similar crime events and logical reasoning. The sequences are ranked based on the probability value calculated. The optimal solution of the sequencing problem is found by marking out the sequence that has the highest probability. 4. Scope for Research

It is particularly difficult to backtrack what had perspired at a crime scene based on evidence. This is because uncertainty is a characteristic feature of most violent crime scenes. Even for an expert it is difficult to be sure of what has actually occurred at the crime scene. Often an expert's opinion is affected by contextual and confirmation

bias. One only gets to know the flaws in a crime scene reconstruction process when an individual present at the scene at the time of crime confesses without inhibitions. This uncertainty and overwhelming number of parameters that govern the flow, formation of a bloodstain pattern is what makes this domain a multi-disciplinary treasure trove of research opportunities.

Considerable interest has been taken towards tracing/backtracking the possible source dimensions for a passive drip stain from a weapon. A system has been proposed to predict the possible radius of a particular drip stain. Now the radius might be similar for two particular sources from which or along which blood drips. Herein lies the need for study of other circumstantial evidence at the crime scene. Again, passive blood drops often overlap. Someone might walk over the drip stains. All these parameters add to the complexity of the study and interpretation of bloodstain patterns at the crime scene. Complex, particularly mixed stain patterns, diluted stains even on plain, smooth, non-absorbent target surface are difficult to analyze. Temperature plays a crucial role in relation to blood flow characteristics. How does fat content in blood affect stain patterns? Does it at all have any effect on bloodstain patterns at a crime scene?

Fabrics are a common occurrence at any crime scene. Does a worn out piece of linen fabric of a certain thickness record stain patterns similarly to a 5 times washed linen fabric of similar weave, thickness? Is the difference statistically significant? The experiments undertaken and the work done by White and Slemko [14-16] on stain patterns recoded on fabric target surface answers the aforementioned questions only in part. On most occasions it is impossible to calculable the area of origin (i.e. the 3D position of impact) from impact spatter stains on fabric. No mathematical model has yet been devised to calculate the impact angle of a stain formed on fabric target surface. The reason for this being the large inter and intra class variability in fabric texture, thickness, absorption/porosity etc. Again salivation, sweating on fabric affects the stain patterns formed on fabric. However, human sweat as also saliva composition varies based on food habits of an individual, environmental condition in which he/she lives etc. As a result, experiments with sweat vary from one laboratory to the other and are difficult to standardize.

Transfer stains on fabric and smooth, plain, non-absorbent target surface often provide essential support for crime scene reconstruction. Interpretation of weapon transfer stains, foot, shoe, hand print transfer stains in relation to the amount of blood in contact, target surface texture etc. forms an important area of research.

Positional prediction of victim/s, bystander/s (if any), perpetrator/s in a crime scene involving blunt force trauma, rifle shot, sharp edged weapon can be done on the basis of bloodstain patterns. Unavailability of a wide benchmarked dataset , large number of variable parameters such as room dimensions, height of concerned individuals, human joint movement, fragile nature of stain patterns etc. make development of such a mathematical model complex thereby facilitating extensive research within the domain. Difference between a wipe and swipe stain still stand unexplored.

Conclusions:-

Evidence or rather Physical evidence does not speak up for itself, Physical evidence warrants proper interpretation. Primarily, Associative and Reconstructive evidence contribute towards the reconstruction of a crime scene. Bloodstain Patterns can effectively be used in coherence with other circumstantial evidence for the reconstruction of a crime scene, to validate the statement of eyewitness/es (if any), to sequence events that might have occurred at a crime scene etc. Crime Scene Reconstruction in its turn aids the process of crime scene investigation and the presentation and interpretation of evidence in a criminal court.

However, evidence interpretation within a juridical setting as of date is largely dependent on the discretion of a skilled expert witness. A mathematical model could particularly help towards minimizing contextual, cognitive and confirmation bias and reinstate faith of the scientific system on the whole process in place for Crime Scene Investigation and presentation with a juridical setting.

Owing to the large number of environmental parameters that affect stain pattern formation and the uncertainty that plagues crime scene reconstruction Bloodstain pattern stands as a multidisciplinary domain that warrants inputs from research communities of widely varying disciplines.

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