AN ANALYSIS AND IMPLEMENTATION OF BLOOD TRAJECTORY FOR FORENSIC SCIENCE APPLICATIONS USING IMAGE PROCESSING

A

THESIS

Submitted towards the Requirement for the Award of degree of

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BY

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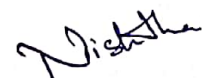**Registration Number: PH16EGG001CS**

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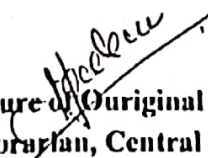
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Abbreviations

DNA	Deoxyribose Nucleic Acid
CT	Computer Aided Tomography
MRI	Magnetic Resonance Imaging
DSP	Digital Signal Processor
SAD	Seasonal Affective Disorder
CSI	Crime-Scene Investigation
CF	Computational Forensics
BPA	Bloodstain Pattern Analysis
MiRNAs	MicroRNAs

Dedicated

To

My Family

(My All Time Guides)

ABSTRACT

This last option is given the intent to add to computational forensics, hence another calculation in light of shot movement and picture handling is tended to. The proposed model assists with assessing weapon activity speed, point of effect, and shot time. The proposed framework is a self-loader model, which needs a few extra contributions during the calculation. In this way, the model can be portrayed in three modules. (1) Applying the edge discovery method for recuperating the oval from the info picture. (2) Tolerating the client input utilizing executed picture material. (3) Handling shot movement conditions based on client input. (4) Finish up the outcomes. In order to obtain the strong edges from the blood splatter images the edge detection technique is applied initially, then edges of blood spots are used for calculating the mean oval. Here the slop of oval is utilized to recognize the direction. Thereafter, the client input is used to for finding the angle of the ellipse. Further, the speed and time of flight is measured based on the angle obtained from the ellipse. Further, the equation of projectile motion is used to calculate remaining parameters. In this experiment gravitational force g $= 9.8 \ m/s^2$ has considered. This recreation is carried out utilizing the JAVA stage, the exhibition is assessed as far as the memory required and handling time expected for the gathered example pictures. The exhibition shows exceptionally fewer assets consuming methods for registering current realities. An old-style model is likewise contrasted with this strategy with legitimizing the arrangement. At last, for future expansion of the work some additionally suggestions are incorporated.

Keywords: *Blood splatter analysis, forensics, crime scene analysis, projectile motion, speed of impact, angle of impact, canny edge detection.*

CHAPTER-1

Introduction

The proposed work is motivated to design and develop an accurate and efficient blood trajectory analysis system. That technique helps us to recreate the crime scene. This chapter offers the key objectives and need of the proposed system.

1.1   Preface

Various genuine spaces have used the administrations of calculation. Fundamentally, the calculation is the foundation of PCs and their advances. PCs are present these days and utilized for tackling complex issues. In comparative ways, scientific science is a strategy of calculation and examination by which the estimate of the led wrongdoing is dissected. This innovation is useful for finding, breaking down, and recuperating proof of wrongdoing. In this way, criminological science is a part of science and innovation which include science, physical science, math, science, and others for finding and assessing current realities of the wrongdoing. In basic situations where less hazy realities and proof are accessible, the assistance of criminology is utilized to redress the issues.

The key area of investigation is forensic science, where the blood strain trajectory analysis is the main purpose of the investigation. The motivation of the proposed work is taken from the study of crime scene. During crime scene analysis blood strains will be very useful to discover direction and speed of weapon operated by the criminal. In this context, the blood trajectory analysis is the most appropriate method for collecting evidences. But, the long term preservation of crime scene is a difficult and expensive. Therefore, the digital images of crime scene have been captured, which can be preserved and utilized for long term. These digital images will be useful during further investigation. In this scenario, we can utilize the image processing and classical mathematics for measuring the time of flight, speed of weapon and the angle of weapon operation. These parameters are useful for crime scene re-creation. Therefore, the aim is introduce a simple to use technique or tool, which reduces the computational cost of blood strain analysis. This section provides

understanding of the work involved and domain of study. Additionally, provides motivation, objectives of the presented work.

1.2 Motivation

The proposed work is motivated from a research article ***Abhijit Shinde et al [1].*** According to the authors traditional techniques of Blood Source recognition results are not much effective and reliable. In this context the physical strings are most acceptable and popular method. The main objective of the work is to identify and reconstruct 3D trajectory of impact angle. The human input-based errors lead to a greater number of errors. This method neglects the gravity, and the distance between the blood source and the blood drop. The proposed algorithm is based on an analytical model created using images collected from the crime scene. The proposed algorithm some other image processing methods also like, the Ortho-rectification for image, canny edge detection etc. It uses distance from spatters, segmentation of blood spatter, and other details collected from the crime scene for the construction of mathematical model. The result obtained using this algorithm is analogous. This algorithm will automate the process of blood drop analysis and hence will minimize the probability of human error and the contamination at the crime scene. The algorithm can be further modified in future if we want a generalized approximation for spatter stains in multiple planes such as on walls around floor area. We consider that the blood trajectory here is a linear in nature, the model proposed can be enhanced further for development of an algorithm for the parabolic trajectory also.

1.3 Objectives

Main aim of the proposed work is to explore and implement an improved light weight, efficient and accurate model for blood stain trajectory analysis. In this context to achieve required goal of the work the following objectives are proposed for work:

1. **To investigate the techniques and tools available for blood stain trajectory analysis:** In this phase the different techniques and concepts are explored that are providing the guidelines and directions for understanding and designing the new technique for blood stain trajectory analysis.

2. **To design and implement a new technique for blood stain trajectory analysis:** by using the studied concepts and techniques a new model for time, speed and angle is proposed for implementation and design.

3. **To evaluate the performance of the given technique:** In this phase the experiments are carried out with the implemented technique. Additionally, it is evaluated on different performance matrix with the help of real-world data.

1.4   Need of System

The forensic science is a branch of technology and science where different kinds of techniques, tools and strategies are followed for identifying the facts and evidences for the crime scene. That technique are tools are used to precisely recover the events, crime type, weapon used, angle of impact and various facts that can help to justify the cases and finding the solution for the cases. In literature a number of techniques and efforts available that is claimed for analyzing the accurate blood stains. There are various purposes for analyzing the blood stains such as matching the DNA of criminal and victim, number of persons available in place of crime, and various others. Among some of the task are dedicated for finding the angle of impact, and speed. But precise outcomes are required during analysis for keen investigation and recovery of facts, therefore a newer system required that is precise and efficient for computation.

1.5   Scope of The Work

The proposed work is intended to design and implement a new model for blood stain trajectory analysis. Therefore, the work is first focused on recovering the recent contributions and models. Secondly, we have tried to recover the different concepts which can be used for designing a new model. In this context the entire work is focused on designing a technique that consumes the image processing and core mathematical domain for computing the following facts:

1. **Speed of hitting:** the proposed work first compute or measure the speed of weapon movements. Therefore, is help to understand how the crime is conducted, and in which intention the crime is conducted.

2. **Time of trajectory:** this fact provides the information about the how much pressure in the weapon is placed for hitting someone. That is helpful for identifying the level of aggression or hate.

3. **Angle of impact:** that fact told us in which angle the weapon is operated and where the impact is found on the victim's body.

1.6   Document Organization

This section provides an outline about the organization of the document, therefore plan about the different chapters and their relevant information is reported in this section.

a)   The chapter 1 provides the overview about the proposed study and efforts involved in this work. In addition of that how the thesis work is organized is also reported in this chapter.

b)   Chapter 2 offers the contents in two major part first part includes the recently developed concepts and techniques which are helpful for understanding and implementation of the required system. In addition of the review of different existing and emerging technologies contributed in the domain of blood trajectory analysis is also reported in this chapter.

c)   The chapter 3 provides the analysis and design of the proposed working model in addition of the implementation strategy in also reported in this chapter using the methodology of the proposed working system. Finally, the algorithm is formulated for implementation point of view.

d)   In this chapter 4 how the implementation of the proposed working model is being taken place is explained additionally the classes, methods, used library and developed systems GUI (graphical user interface) is explained.

e)   The chapter 5 demonstrates the experiments conducted and obtained performance outcomes. Thus, the details of experiments and the observations are reported in this chapter.

f)   Chapter 6 summaries the entire efforts as conclusions from the work and also discusses the future possibilities of the work for future extension.

Finally, in the last part of the document the Appendix is presented with the bibliography. It includes a list of journals and research articles referred.

CHAPTER-2

Background & Literature Review

This chapter provides the details about the existing concepts, techniques and methodologies as literature survey and the second part of the chapter provides the review of the existing contributions and research efforts.

2.1 Image Processing

The Image Processing (IP) is aimed at working such manner by which extraction of information from digital images become easier for applications. The process of image processing is performed using automated or semi-automated computer programs. Most of the Image processing algorithms work in three parts:

First, is belonging to those techniques, which are used for applications where raw and noisy images are captured and by using de-noising techniques we get enhanced image features. IP include the algorithms, which is used to calculate enhanced pixel values for enhancing the image objects. The enhanced information will help in utilizing it into the applications. An array of real numbers which can be represented in binary form is known as a digital image. The technique to improve the quality of images received from cameras or sensor taken from various applications is known as Digital Image Processing.

During image capturing through sensor or digital camera, when some disturbances happen due to different reasons like temperature or weather. The result is noise in captured image. The image is a corrupted by noise. Therefore the pre-processing is used to reduce or eliminate the noise. Noise can produce undesirable appearance of the image objects. The noise can reduce the visibility of image features. The low-contrast objects in image are damaged due to visibility loss. In addition, the image quality may affect the quality of service of hardware and software. So, before utilizing the image captured for application level analysis we need preprocessing of the image. The preprocessing involves the techniques to remove the noise. There are different types of noises which are frequently studied, each category have different statistical properties [3]. The IP follows the following essential steps:

- Acquisition of image using camera or any other sensor tools;

- Processing the image using certain algorithm or mathematical model;

- Produce result of the analysis either as enhanced image or a report based on analysis of the image.

Image processing is of two types namely, analogue and digital. Image processing technique used for printouts, photographs or hard copies of images is called analogue image processing. The images are analyzed using various interpretation techniques while using these visual methods. Computers are used processing and manipulation of the digital images; this is known as digital image processing. While using digital image processing techniques, the data is first pre-processed, then it is enhanced and finally information needed is extracted from the enhanced image.

2.2   Importance of Image Processing

Digital images are processed using special computer software in order to improve image quality. The result of captured image has errors in the image pixels due to noise, by which image do not reflect the true scene. In both kinds of image capturing devices (i.e. analogue and digital) have some chances to affect by noise. There are some ways by the image is affected by noise [4]:

- If the image is captured from a photograph, then the source of noise is capturing device.
- Due to dust particles introduced by the scanner itself.
- Due to electronic transmission can introduce noise.
- Due to affect of mixed noise. The hybridization of impulsive noise and additive noise is used for mix noise.

Therefore the main problem is to diminish commotion from image. Subsequently we want a Sound Decrease process for wiping out commotion from a picture. In this cycle, data about the sort of commotion in the picture assumes a critical part. Be that as it may, ongoing advancement the nature of de-noising calculations are not gathering the prerequisite of utilizations. At present, we are not yet arrived at the lower bound on the Mean Squared Blunder (MSE) of the outcome because during feature selection from image is important. The feature selection results are greatly benefited in various applications. The purpose is to reduce the amount of data, and keep preserved image's structural properties. The main issue occurred when we work with

edge detection, because edges and noise has high-frequency values. Additionally, distorted and blurred edges are the crucial issue [5].

2.3 Applications of Image Processing

In applications like Computer vision and Remote sensing, etc. Eyes are the strongest sense organ of human body; this is the reason that visual information is retained by the brain for the longest time. Hence it is the most important type of information that the human brain perceives and interprets. Cerebral cortex is the ultimate control of the brain. It is the information processing center of human body. Cortex is responsible for some major higher order functions like sensation, voluntary physical actions, perception, association, thought and memory. One third of the cerebral cortex area is dedicated to processing of visual information collected by eyes. In the same way, computer based, system used for automated processing of pictorial data for its interpretation and manipulation is known as Digital image processing. Digital image processing has applications in various fields related to our daily working, for medical diagnosis and weather forecast like applications [6] [7].

a) *Intelligent Transportation System (ITS)* – ITS, is a large set of applications which involve modules like Traffic handling and automatic number plate recognition.

b) *Remote sensing* - In this application, sensors are used to prepare images such as world's surface form a satellites or scanners or camera mounted on a fighter plane. The sensed images are communicated to the Earth's base stations. It is very useful during crisis management, flood control, city networks, resource management and others.

c) *Moving object tracking* - This application is used to the estimate the movement and procures a visual perception of the moving item. The applications are: Movement tracking and undersea operations.

d) *Defense observation* – In different military applications this method is utilized to monitor the seas areas and a large area of land. It can also used in under sea monitoring applications. Here, these systems are capturing images and also identify the objects. The various boundaries like length, broadness, region, border, and conservativeness are set up to the objects.

e) *Biomedical Imaging methods* - For clinical analysis, various imaging devices are involved, for example, X-beam, Ultrasound, CT-scan, and other.

f) *Automatic Visual Review Framework -* This application works on the quality and efficiency of the object detection.

g) **Programmed investigation of radiant light fibers** – It provide an assessment of consistency in the contribution of the light, the fiber combined inside a brief span [8].

2.4   Different Types of Tasks

- **The applications involve the process of Image capturing, Storage, and Transmission**. By using the techniques of digitization, compression, and encoding-decoding [9]

- **It also involves the Pre-processing stage in computer vision** and artificial intelligent (AI) based system, which will help in autonomous vehicles and guiding robots, etc. [11]

- **The applications also requires Image Enhancement** and **Restoration** techniques for quality improvement of the image for human understanding [10].

- **Object tracking** and **Recognition also a main part of applications** which requires information extraction from images. Thus it works on the basis of description, interpretation, and classification. [11].

2.5   Issues and Challenges

Image processing involves in different issues and challenges. Some of them are given as [12] [13] [14].

✓   Basic location adjusting is the main concern in DSP based image capturing systems. Miserable and byte cluster moving tasks are delicate adjusting issues.

✓   Providing the constant image handling.

✓   Challenge in the carpentry Business to decide prior to handle the log correctly.

✓   Execution prerequisite is an extraordinary issue in equal figuring for constant picture handling to introduce the present status of the gathered information in

the field of equal programming and what's in store patterns in the ongoing picture and video handling as connected with equal registering.

✓ Ongoing picture handling represents a test for the machine vision fashioner. Taking the easiest model assuming we consider the results of a matrix of 64 pixels that are moving at a pace of 10 to 20 every second along the transport should deal with around 100,00 pixels each second. This worth will be multiple times assuming we need to consider spaces between the articles moreover.

✓ One more issue is the exceptionally high evaluation of the pixel memory. As we as a whole realize that a few essential cycles utilized in picture handling like edge discovery need a normal of at least 9 neighborhood pixels, and the pixel memory is now evaluated multiple times.

✓ Skeletonization capability or expects up to 10erosion or decreasing capabilities. These corrupting capabilities go about as size channels and dispose of articles up to the size of 20 pixels.

2.6 Forensic Science

In order to solve complex criminal problems the different scientific areas are used the collection of these areas are known as Forensic science. It is a common theme which club different types of forensic sciences. That is the type of the observation and it is also used for identification of the purpose of a case.

2.6.1 General

Perusing the day-to-day papers about catching hoodlums through present-day techniques for DNA testing and fingerprinting has stirred the interest of numerous potential Sherlock Holmes Numerous a youth today appreciates watching developers like Virus Documents and Criminal investigators on the Revelation channel, measuring how simpler we can collect proof of crime. Today, cops and experts are practicing this skill for detailed analysis of act of crime. Using this technology we can also provide significant proof of wrongdoing. PC Criminology World is a developing local area of experts engaged with the computerized legal sciences industry. It is an open source, low cost and easier to use. It may be useful for collecting and sharing of data [15].

It is a branch of science and technology, which is motivated by the law enforcement and logically proves the crime in the courtrooms by uncovering the

criminal behind the crime conducted. Additionally this branch of science provides ease in understanding how and when someone is legitimate or not. In this technology we are combining goodness of different scope of sciences, right from Science and Science to Physical science, Brain Research, Sociology, Geography, etc, Using this technology we will respond to the questions related to law enforcement. In this branch of science it is essential to test physical and natural evidences to make decisions about realities about the crime, when it worked out, and who was involved. Accordingly, criminological science capacity is significant in light of the fact that it might yield data that is more exact, exact, and dependable than observer declaration or even admissions. Such data, this way, can build the outcome of the two examinations and preliminaries in deciding the current realities of the case. The noteworthy legitimate turns of events and types of progress in criminological science have permitted it to change into a remarkably evolved science that consolidates various disciplines and an extensive number of researchers work has been done from DNA analysis and exploration techniques [16].

The scientists investigate contact and materials related to the crime for providing the assessments or criminal act. This branch of technology will work in three parts: toxicology, chemistry and biological technology. Specialists focus on different bits of the lost' body, mainly bones, to protect and verify the death, direction, ethnicity, age, and time of death. Sometimes such kind of technology can completed in very fewer time within 60 minutes, on the others hand some of them may takes a long time to be complete.

Until this point in time, legal science has had a critical commitment to saving many guiltless individuals from superfluously getting condemned to detainment or in any event, getting the death penalty. Measurable science is genuinely a lifeline and the epitome of equity!

2.6.2 Significance

Scientific science will be science utilized with the end goal of the law and accordingly any part of science utilized in the goal of legitimate questions is criminological science. In the broadest sense, criminological science is any science utilized in the goal of legitimate struggles. "Criminological" is established in the Latin word 'legal'. The word reference significance of "criminological" is "connecting with court or regulation" or "connecting with official courtroom". However, in lawful

phrasing, it might imply "this technology is able to deal with the guidelines and practice of different scientific subjects which will help to justify the criminal offence in front of court". It is a science composed with the components and events which may uncover the common conviction by both the real specialists and in laboratory [17].

The old Roman word was the site this discussion related to the managerial issues. But it was also followed by the metropolitan community, where it is much essential. Therefore, this technology is a real practice of implementing the science to deal with the discovery and exploration of target hidden in social and real world. Its utilization by the overall plan of guidelines recalls that it is from other science; the doubt for routine appearances in a power court sees a sensible researcher from differently trained professionals. Quantifiable science stays alive and getting together rules and science. No matter what the way that quantifiable science has been recognized by and by from the policing beforehand, as of presently the legitimate researcher anticipates a perseveringly more remarkable part similarly methods and in administrative issues.

Basically, no basic exists to the level of certifiable confirmation that is tremendous for all legal experts. Genuine affirmation could run in size from the little (for instance, a buildup grain) to the typically perceptible (for instance, a diesel truck). It might be essentially basically as astonishing as the lethargic body of a battered young person, as precarious as the minimal exhaust of fuel understanding a thought illegal conflagrationist propensities fire, or as dull as the piece of assortments in the ink of a tried will. This wide significance covers criminal arraignments in the broadest sense, nearby accomplices and customary guards, and condition and security work, as well true to form techniques like encroachment of approaches and remissness. On the other hand, in all-over preparing, the term is applied impressively more scarcely to the utilization of science the in the examination of the horrendous direct by the police and by the courts as a certification in settling the issue in any subsequent major. Legitimate Science is on a very basic level the utilization of science to control. Legitimate science is used to see criminal cases including a misfortune, like an attack, robbery, getting; assault, or murder, and typical cases like pantomimes, misdirection, or discourteousness. Quantifiable science likewise picks concerning whether rules or strategies have been shamed in the advancing of things related to food and drink, the social event of medication, developing unequivocal use, vehicle release affirmation,

utilization of water neatness, and really investigating in general mystery atomic weapons, and so on. The essential piece of applied Quantifiable Science starts with the affirmation or individualization that could simply be conceivable following coordinating compound [17].

2.6.3 The Organization of Forensic Science

Legal researchers are typically skilled in a particular field of quantifiable science, such as dormant prints, addressed reports, following proof, or weapons, to name a few, due to the deeply perplexing nature of criminological science. Researchers who can be measured can be divided into three key groups:

- ✓ Clinical examiners and other professionals who conduct post-mortems and clinical measurements are included in the category of criminological pathologists.
- ✓ Criminological researchers include attorneys who work in law enforcement or secret laboratories in charge of many specific tests and investigations, such as toxicology, ballistics, follow-up evidence, etc.
- ✓ Related Researchers: These include logical specialists who lend their knowledge to the field of criminology, such as legal odontologists, scientific botanists, quantifiable anthropologists, and so on. These scientists apply their knowledge to the

2.7 Crime Analysis

Terrible conduct evaluation is a calling and cycle where a ton of quantitative and close to home strategy is utilized to isolate information vital to police affiliations and their associations. It unites the evaluation of terrible way of behaving and hoodlums, awful conduct misfortunes, tangle, individual fulfillment issues, traffic issues, and inside police tasks, and their outcomes support criminal assessment and indictment, watch settle, horrendous lead avoidance, reducing frameworks, definitive thinking, and the evaluation of police endeavors [19] [20] [21].

"Bad behavior examination" unites a large number of assessments performed inside a police affiliation, besides proof (counting DNA) evaluation and some regulatory assessment related to organizing, staff (e.g., extra time, got out and travel

leave, pay), and hardware. Certain analysts could invest critical energy in unambiguous capacities, clearly (as per the sorts of bad behavior assessment underneath), but regardless, inside a police association, we see bad behavior information examination as a lot of procedures performed by terrible conduct subject matter experts.

Terrible conduct evaluation is both a calling and a lot of techniques. The trained professionals, who perform awful conduct evaluations, and the techniques they use, are focused on helping cops with ending up being all the more remarkable through better information. The information that specialists give can help:

- ✓ Break infringement
- ✓ Plan strategies and procedures to stop approaching infringement
- ✓ Find and secure blameworthy gatherings
- ✓ Charge and convict transgressors
- ✓ Further, develop life quality and secure life
- ✓ Work on inside exercises
- ✓ Center around the post and assessment
- ✓ Perceive and revise neighborhood
- ✓ Future resource organizing and dealing with necessities
- ✓ Approve convincing plans
- ✓ Public care

2.7.1 Types of Crime Analysis

Such bad behavior assessments are composed around a couple of factors, counting the nature and wellspring of the information, the strategies applied, the consequences of the assessment, the regularity and rehash of the evaluation, and the goal assembling and reason. No typology will whenever to accomplish a ton of definitions that are totally specific or broad; we should consistently be ready for a couple moves past in definitions relying on the conditions, as well as pivotal contemplations and techniques to arise. The objective of this part is to give an arrangement for the obsession and work of terrible conduct trained professionals, to help with terrible conduct evaluation coaching and preparation, and to help with able exercises like game plans of presumptions, occupations, and responsibilities.

- Even more expressly, thinking to the extent that classes help the bringing in additional ways than one:

- It helps police associations with perceiving districts requiring improvement in both assessment and response and ensures that their specialists are giving a full extent of organizations

- It helps specialists with perceiving districts in which they need to encourage capacities and to plan consistently, step-by-step, month-to-month, and yearly tasks

- It helps analysts with requesting things and planning plans for thing dispersing

- It helps capable associations with organizing planning and composing

- It highlights which strategies and mechanical assemblies end up being better for which purposes

There are critical characterizations of bad behavior examination, mentioned from clear cut for general:

a) Crime information examination,

b) Tactical bad behavior assessment,

c) Strategic bad behavior assessment, and

d) Administrative bad behavior assessment.

Wrongdoing knowledge examination is the evaluation of information about individuals attracted to encroachment, especially steady guilty parties, repeat misfortunes, and criminal affiliations and affiliations. It desires to see more about the setting of the lives, occupations, works out, habits of reasoning, and plans of these people and affiliations, utilizing this data to track down ways to deal with hindering or upsetting poisonous turn of events, once in a while through need essential, arraignment, and military or paramilitary activity, yet likewise strategies that don't rely on endorsement, as engaged weakness.

Cycles and methodologies of bad behavior understanding assessment include:

- Constant culprit and setback assessment

- Criminal history assessment

- Associate examination

- Item stream examination

- Correspondence assessment

- Online diversion examination

"Criminal insight investigation" is generally created as a calling lined up with wrongdoing examination, drawing from a custom of military knowledge and applying its procedures to homegrown "foes" like coordinated wrongdoing undertakings. It has prospered in public, global, and unique reason associations like the U.S. Government Agency of Examination, the U.K. Security Administration, and Interpol; in U.S. Combination Focuses and in extremely enormous nearby police associations.

Tactical crime analysis is the assessment of police data composed towards the transient progression of the watch and canny requirements and sending of resources. Its parts of information integrate the examination of the room, time, transgressor, setback, and the same old thing for individual high-profile infringement, go over episodes, and bad behavior plans, with a specific focus on bad behavior series (see Overall Relationship of Bad behavior Specialists, 2011, for implications of bad behavior configuration types). By far most of the data used in essential bad behavior assessment comes from police enlightening assortments, especially police reports of encroachment.

Cycles and systems of key bad behavior assessment include:

- Reiterate event assessment

- Bad behavior plan assessment

- Associating known blameworthy gatherings to past bad behaviors

To the extent that hoodlum "profiling" or criminal logical assessment occurs inside area police workplaces, we view it as characteristic in the essential assessment process, as its spotlight is very normal on a movement of bad behaviors.

Vital wrongdoing examination is the evaluation of information worked with toward the new turn of events and evaluation of extended length draws near, courses of action, and equilibrium strategies. Its subjects unite extended-length quantifiable models, problem areas, and issues. Notwithstanding the way that it continually starts with data from police records systems, key assessment regularly facilitates the social affair of key data from various sources through both quantitative and significant methods.

Cycles and frameworks of basic terrible conduct evaluation include:

•   Design examination

•   Trouble spot examination

•   Issue examination

The basic obligation this makes to the insight of crucial terrible conduct assessment is that we consider "issue evaluation" as a piece of it. In different dissemination, "issue appraisal" routinely exists as a substitute kind of evaluation, or extensively outside of the awful conduct evaluation field.

A definitive bad behavior examination is an assessment composed of the administrative necessities of the police association, its organization, and its neighborhood. As an overall grouping, it integrates different strategies and things, performed both reliably and on request, including experiences, data printouts, guides, and diagrams. Models integrate liability assessments by district and shift, official development reports, responses to media requests, bits of knowledge obliged grant applications, reports to nearby get-togethers, and cash-saving benefit assessments of police programs. In this class, we subsume the grouping depicted as "tasks examination" or "police activities investigations in certain texts.

Cycles and procedures of authoritative wrongdoing investigation include:

•   Districting and yet again districting examination

•   Watch staffing investigation

•   Money saving advantage investigation

•   Asset organization for extraordinary occasions

2.8   Computational Forensics

Computational Forensics can be defined as a methodology of recreating the crime scene for solving of criminal cases using computer-based processing of images, voice, audio or video data for accurate results of the investigation. The word "computational" refers to computer-based analysis of image, audio or video data or other prominent disciplines like computational advertising, computational chemistry.

Computer based techniques are used in forensics because these techniques error free and unbiased and help in revealing facts that can remain unseen with naked human eye.

Computational techniques help the human examiner in the forensic case study basically in three ways. Firstly, it helps the investigators to overcome their human cognitive limitations and hence computational techniques can support the examiner in his/her daily casework. Secondly, forensic studies involve processing and analysis of bulk data in various dimensions which is beyond the ability of the human brain. Thirdly these computer-based can be used or the representation of knowledge gained by human experts, they hep to implement reasoning and recognition abilities in machines. The aim of using computer in analysis is to provide an opinion, this the basic challenge of artificial intelligence and hence we can say automated systems cannot replace human examiners even in near future. The modern era crime investigation will be benefited by the combined intelligence of machines and human; hence we can say that the computer-based analysis enables forensic experts to[23]:

- Discover and enhance the samples or traces of evidences for further investigation.

- Analysis and identification of the objects collected as evidences in a manner so that these results cancan be used for further investigation.

- Examine the accuracy of the examination method.

- Set standards and report the examination procedure of data for forensic study.

- Analyze huge dada files efficiently.

- Use charts and other visualization methods to show the results of analysis.

- Help the examiner in interpreting the results and its argumentation.

- Uncover hidden facts from data analysis, formulate new rules and hence contribute in generation of new knowledge.

Hence to conclude we can say that computational forensics use various approaches to [24]:

- For the reconstruction of the crime scene or the accident area for accurate inspection.

- Collection and analysis of the evidences collected from the crime scene.

- Recognize, quantify and group various people, objects and happenings.

- Visualize the collected information to identify the linkages and associations.

- Identify how the collected finding can be used in court to prove the crime.

Another work process for investigation, which is more practical in nature is known as Crime-Scene Investigation (CSI). CSI includes photography of the crime scene and proper documentation of the details noted at the crime scene. The next step is to collect and preserve evidences collected from the crime scene, which is followed by the analysis of evidences. After the evidences are tested in laboratories all collected data is integrated to produce results, which led to the reconstruction of the crime scene and report writing. These reports are presented in courts to aid in fair judgement. As we all know that forensics is used to analyze previously committed crimes, but now it is finding greater application in analyzing data to prevent future crime and terrorism.

An upcoming interdisciplinary field for researches deals with assumptions-based investigation of some specific kind of forensic problems. It is known as Computer Forensics (CF). CF moves towards the solution of the problem using computers for data analysis and finding results. The primary goal of this system is to find and enhance the forensic knowledge [26]. CF uses knowledge-based system for deep understanding of the forensic problem, particular specific scientific methods used for better analysis and finally apply computer-based algorithms for data integration and visualizing the results of analysis.

There are a wide variety of beneficiations of Computer Forensics. Some of the most evident offerings of the forensic domain are to:

- It helps to standardize crime investigation and result deduction; hence it increases the effectiveness and efficiency of the process.

- As testing of forensic methods is time consuming, CF helps to test the methods implemented using scientific foundations and data on large scale to analyze their strengths /weaknesses and also determine their error rate.

- Collect, organize and hypnotize data and create new data sets as per requirement. Data collected during investigation can be erroneous, computer-based algorithms can help to synthesize data sets and draw meaningful results.

- Computer-based systems help to standardize the work process. The technical setup supports the concepts and terminology used and hence leads to a more feasible and realistic system to work.

2.9   Blood Spatter Analysis

Much of the time found at the areas of furious wrongdoings, the assessment of bloodstains can give key bits of knowledge concerning the occasion of events Bloodstain Model Examination is a quantifiable discipline wherein, among others, the spot of losses still up in the air at crime locations on which blood has been shed. Along these lines, we concentrated on insights regarding blood splash examination and their example examination in picture handling frameworks.

2.9.1 General

At most of the brutal crime scenes we found heavy blood stains. It is created during the bleeding from the victim's body. There is a deep rooted in any case very lengthy procedure by which an especially set up criminological master can explore individual blood spots. Blood sprinkle evaluation is performed by criminal science pros at bad behavior spots where the effect on a body has made blood take off and appear on encompassing surfaces. The resulting stains are impacted by different veritable factors, similar to speed, liquid thickness, and the material properties of the surface. Regardless, of the condition of the stains, for this present circumstance, the sprinkle configuration, reveals information that can mean a lot to well-informed authorities. Coming about overhauls have prompted the improvement of Blood Sprinkle Evaluation as a criminological specialization [27].

Since blood approaches are as per explicit genuine standards, organized bloodstain plan experts can inspect the blood-check abandoned and make decisions

concerning how the blood might have been shed. From what could transmit an impression of being at crime scene, in this scenario the experts are categorizing and analyzing the information using the spread of blood, movement of blood drops, created patterns, and different etchings will help specialists in recreating the crime scene and also help to figure out the sequence of occasions that happened. This kind of confirmation is also useful for experts to analyze and crack the case.

2.9.2 Definition

Bloodstains are formed by the drops of blood that come from a source, travel through air and reach the target-stained area. The pattern formed by the droplets of blood is known as blood-splatter. Forensic studies aim at the reconstruction of the crime scene and the positioning of the blood source serves this purpose; the forensic experts are expected to produce such results [28]. To determine the position of the blood source we need to reconstruct the situation that was actually when the crime was happening. This is done through backward arrangement of the facts and data collected from the crime scene. A mechanical theory of drop fragmentation, routes and impact was used to illuminate blood spatters formed by gunshot wounds in a famous case of Phill Spector, where problem was to identify whether blood from a back spatter could travel a distance of 1.8 m[29]. The phenomena of the backward reconstruction of the bloodstains using the model for the flight of drops are called Backward reconstruction of drop trajectories.

Blood splatter examination is a gigantic piece of any scientific examination, which manages crime location examinations, which need reproduction of the crime location to get a more profound look and bits of knowledge into the crime scene by self and also provide the ability to figure out the story behind the crime conducted in the crime scene.

2.9.3 Significance

Blood splatter assessment is the particular examination of the decent implications coming about due to dynamic blood-shedding exercises. A thorough examination of bloodstain plans at wrongdoing areas every now and again creates urgent confirmation. The spreading, size, and kind of bloodstains on a suspect, setback,

grounds, roofs, walls, or on substances at the scene can help with changing these blood-shedding exercises. Bloodstain design assessment can likewise assist one with surveying the believability of reports given by an onlooker, a casualty, or a dubious individual associated with the demonstration. Actual sign holds on to be seen, safeguarded, evaluated, and analyzed.

Blood splash examination being a specific field in the criminological examination [30] is a huge part of current crime location assessment. While only one out of every odd investigator needs to become talented at it, each criminal investigator must essentially grasp the significant standards and occasions and have the option to fittingly record verification and data at the scene, for a further utilization in investigation of the crime. The idea of blood splatter analysis will permit us to collect bloodstain at the crime scene using the digital photography. It is believe that the blood splatter analysis will able to provide additional information about the crime and crime scene which could uncover deliberately basic confirmation. This could integrate real factors like the aggressor location, the crime scene, the weapon type was used for attacking the victim, the number of spots, the direction of shot taken, and the cuts that happened. The directional information can also be recovered which told us about the events happened during the course of crime, additionally the collect evidence can be argues with the facts provided by an eyewitnesses.

2.10   Bloodstain Pattern Analysis

Bloodstain Pattern Analysis (BPA) is a subject of study about the shapes, sizes, distribution and locations of bloodstains. The aim of this study is to measure actual happening and how the blood spots are created. BPA is a sub-stream of forensic sciences, which deals with the investigation of the blood stains discovered at the scene of crime. The main aim of BPA is to explore and approximate the probable trajectories of various stains by calculating their impact and the glancing angle, and consequently calculate their area of origin [31].

BPA describes both kind of event what had occurred with victim or what was not done during the crime. This information will help the investigating officer for crime scene recreation, cross verification of witness statements, and proving the culprit's act.

2.10.1 Principles of Bloodstain Pattern Analysis

To see the value in how specialists decipher bloodstains, one must initially deal with the blood features. Blood is combination of two substance plasma and serum, and also contains solids substance like red, white platelets, and proteins. Blood is a type of liquid which reside inside the body, and also it is in liquid form when it leaves the body. But when the blood leaves by a cut or scratch, it converted into solid. An individual who suffers from hemophilia, in such case blood will start to bundle. After leaving the body blood start condensation within a few minutes. Additionally, it starts framing a dark, gleaming gel type substance. Also with the time it becomes more and more hard. The availability of blood clots in a crime scene indicates that assault was brutal, or the attacked victim was injured and bleeding [32].

Bleeding can be happening in a number of different ways depending upon the how the injury will happen. According to the injury it creates different type of patterns on the floor or walls.

Types of Stains

Bloodstains are assembled into three chief sorts: idle stains, move stains, and expected or influence stains. Withdrawn stains merge drops, streams, and pools, and normally result from gravity returning again to a hurt body. The transfer of stains is developed through the object which is in contact with existing bloodstains. This will be happen due to wipes, swipes, or by moving the body from one place to another. Impact based stains are created when the blood is following projectile motion using air and it scattered on surface, but it may incorporates spouts, sprinkles, and showers of blood [33].

Blood scatter is recognizing by its impact sprinkle (most of the time it is created when power is used over the blood) or projection based strain (it is created by transmitting, shower, or sprinkle). The blood spot formation is completely depends upon the speed at which the blood leaves the body and the amount of power employed for weapon operation.

2.11 Projectile

An object on which gravity is the only force acting is known as a projectile. There are many examples of projectiles like missile, bullet or a rocket. If we consider influence of air resistance negligible than an object dropped from rest can be also

considered as a projectile, or even an object thrown straight upwards or at an angle to the horizontal plane is also a projectile [34]. Hence, to conclude we can say that any object that is tossed upwards or thrown downwards and it continues its mobility by its own inertia and is only effected by the gravitational force of the earth is known as projectile.

According to the definition, projectiles have only force of gravity acting upon them, if any other forces are also acting at the same time then that object cannot be considered as a projectile. To explain projectiles in a better way let us consider figure given below, as we see a free-body representation of a projectile, the object propelled is moving at a constant velocity and hence acceleration is zero. The velocity of the object is divided into its horizontal and vertical components. In projectile motion only the vertical velocity effects and horizontal velocity is zero due to the effect of gravity. The shot movement is a unique instance of a two-layered movement. A molecule moving in an upward plane with a fundamental speed and experiencing a drop (plunging) speed increment, shows shot development.

There are a number of examples available to describe projectile motion like a ball is thrown away from a top of a building, jump of a swimmer from a diving board, or firing a bullet into horizontal direction. In these scenarios, we are considering that the medium on which the object is travelling not have any influence on their motion. But in real world when the object is moving on air can be influenced by the speed and pressure of the air. For instance, when a diver is diving from the air plane with the parachute will land safely on the ground [35].

2.12 Literature Review

This section offers a review of the recent literature and core contributions in the field of blood stain trajectory analysis.

MicroRNAs (miRNAs) have drawn expanding interest as a potential biomarker for measurable body liquid recognizable proof since they show cell type-explicit articulation as well as display high natural dependability. *Eva Sauer et al [36]* plan to distinguish solid miRNA markers for the ID of five forensically significant body liquids and to lay out an instinctive methodology working with the assurance of the beginning of obscure examples.

A hypothetical model was proposed by *P. M. Comiskey et al [37]* which was utilized to foresee forward blood splash designs coming about because of a gunfire wound that pre-owned round nose shots. The excited fracture of a blood layer situated ahead and beside the shot is viewed as in the structure of the permeation hypothesis. The size scattering of blood is not entirely settled, which considers the extrapolation of a blood splash cloud being catapulted from the back side of the objective where the projectile departures. Then, drop courses are mathematically assessed representing gravity and air drag, which is impacted by the joined streamlined point of interaction of drops through the air. The model predicts the number and area of unmistakable stains, as well as the stain dispersal as a component of distance from the wellspring of blood. To test the anticipated consequences of the proposed hypothesis, exploratory information was gathered by shooting shots from a handgun that utilized 9mm Luger copper full metal coat projectiles. The simultaneousness between the anticipated and tentatively estimated information is viewed as great.

Blood marks examination is a typical procedure utilized in legal sciences. Notwithstanding, the ongoing strategies utilized have their constraints and deviations. The most ordinarily utilized geometrical model depends on the straight development of a blood drop, which ignores air obstruction and gravitational power which influences generally mass focuses in a space of the room. The point of *Richard Billich et al [38]* is to plan the flight direction of blood drops in a trial climate with the utilization of a gun and to assess the choice of supplanting this present reality flight direction with an all the more precisely quantifiable illustrative estimation. A trial model was made which mimics this present reality of scattering of blood on account of gun use. Blood tests with a volume of 100 ml were put into a plastic sack and were taken shots at. The end goal of the examination was to arrange a wooden chamber (aspects: 2 x 2 x 2 m). Plastic packs containing blood tests were hung in the chamber and situated in the chamber's middle. Blood tests were shot from a distance of two meters by a Taurus .357 magnum handgun. Magnum.357 FMJ ammo was utilized. Each shot was recorded by a rapid camera under a 90° point put on the example's level at a 2 m separation from the chamber. In view of the physical and exploratory models, it was resolved that the genuine flight direction of blood drops might be characterized by an explanatory estimation while keeping up with legitimacy for 90 % of blood drops. The illustrative estimation doesn't fundamentally vary from the ballistic bend and genuine flight

directions in instances of lower flight speeds and blood drop sizes of under 0,5 mm, important blood drops situated a good ways off of under 0,5 m from the starting place. From the movement of the bends catching the trip of blood drops it was found out that to utilize mathematical models, it is ideal to utilize bloodstains found under 1m from the combination point, the explanation being the way that the deviation brought about by the utilization of the illustrative estimate is insignificant and doesn't cross 3 mm. The utilization of the illustrative estimate with distances of the north of 2 m prompts deviations of multiple mm when contrasted with the real world. The result of these examinations shows that this present reality flight direction contrasts very little with the ballistic bend and explanatory estimation under the given exploratory circumstances. In wrongdoing recreations, the point of frequency (point of effect) of a blood drop affecting a flat surface gives a ton of data connected with the idea of the wrongdoing. Around here, the results of the ballistic bend and the allegorical estimate are almost indistinguishable, particularly for blood drops with low beginning rates, which comprised the larger part under unambiguous trial conditions.

The law enforcement framework relies on criminological science for fair dynamics which relies upon blood scatter examination by and large. The fundamental issue here emerges because of the crime location defilement as it prompts proof that can't be acknowledged as validation. Another significant angle is that blood splash examination significantly relies upon the capability of the measurable master. As the course of blood splash investigation has an excess of human mediation, it might prompt different blunders, and conflicts lastly may prompt misinterpretations. To keep away from these circumstances *Abhijit Shinde et al [39]* proposed a strategy that utilizations pictures of the blood scatter from the crime location and utilizations picture handling methods to remake the wellspring of the blood. The proposed technique involves Otus' strategy for thresholding and the Hough change strategy for edge recognition.

Theresa Stotesbury et al [40] fostered a mechanical gadget that consolidated gravitational and spring pressure powers to shape splash designs. This redid gadget utilizes either two or four springs (k1 = 267.8 N/m, k2 = 535.5 N/m) that are associated in equal, it will make seventeen effect speeds having a reach between 2.1 to 4.0 m/s. presently we utilize an electromagnet to hold the effect or in a few spring expansions. While the client catches the video film utilizing a fast camera, he has some control over the arrival of the magnet too. The side and the base perspective on the effect occasion

are observed utilizing a polycarbonate base. This arrangement makes 24 examples and these are examined utilizing a HemoSpat. Area of beginning approximations fell inside a mediocre reach ($\Delta X_{av} = -5.5 \pm 1.9$ cm, $\Delta Y_{av} = -2.6 \pm 2.8\ cm$, $\Delta Z_{av} = +5.5 \pm 3.8$ cm), going with circulation examination for the utilization in exploration or bloodstain design preparing. This work gives a structure to those engaged with fostering an intense effect gadget.

As per *Aisling A. Galligan et al [41]* Criminological diagnosticians who posthumous the casualties of firearm savagery are many times posed inquiries connected with the places of the person in question and the shooter during the legal actions. Taking reference to a situation where an official revealed a shooting occurrence, the assertion of the cop gave off an impression of being in direct conflict with the assertions of different spectators, the validation at the scene, and the last resting position of the departed's body. A direction examination of two shot injury pathways (only one of which was momentarily debilitating) was performed to evaluate the legitimacy of the official's decree and measurable movement was utilized to make a court show. A conversation of the ongoing companion investigated writing is incorporated.

Daniel Attinger et al [42] led tests in a controlled climate to produce an informational index of blood scatter examples and afterward examined them at high goal. To create these splash designs the creator utilized a rifle with various types of slugs. Because of shots, minute blood beads are framed that movement inverse to the projectile heading. These shots made a backscatter on a banner board target sheet. In this paper new blood with anticoagulants was utilized; its hematocrit and temperature were additionally estimated. Distance between the blood source and the objective, shape size, and speed of the projectile was likewise thought about. Various different boundaries were likewise investigated in a less methodical manner. The informational collection obtained is fitting for preparing and research in scientific science and blood design examination.

Theresa Stotesbury et al [43] investigate the crown development elements of obtuse power influence on a dainty film of sheep's blood. Three weapons - a hammerhead, a simulant homerun stick, and a metal bar - were utilized to influence blood on fiberboard, fabric, and wipe. Influence speed was controlled utilizing a custom

effect gadget. Fast recordings were gathered and broken down with movement following and registering programming. Curiously, crowns were not seen to frame in that frame of mind of nine preliminaries where every weapon struck the bloodied wipe. The widths and levels where perceptible crowns were framed were estimated and run between 0 to 105 mm and - 0.4 to 36 mm, individually. The bloodied material sort was seen to impact the size and state of the crown; in any case, the weapon heads utilized in this study didn't. Three strange instances of edge precariousness were seen where drops were sent the other way of the extending crown. This work upholds the possibility that the development elements of systems brought about by dull power influence are complicated. Detectable crowns can frame with a scope of calculations and in this way produce beads that begin at focuses not quite the same as the contact interface between the weapon head and blood.

A procedure of working out the beginning of blood and trails shaped at the crime location that could give influence headings and positions had been introduced by **Shahid Iqbal et al [44]**. The size of bloodstains, the volume of droppers, and spikes around the stain line transferred on the bead influence speed and drop width. It was entirely typical to find bloodstain designs in a vicious experience, and through legitimate translation, they could give exceptionally basic realities about such an occurrence. Exact estimations and advanced camerawork could gauge the free level of uninvolved drops, the highlights connected with the impact of the surface, and the force engaged with carnage. Four wandered types of stains were made and human blood with heparin as an enemy of coagulant was taken. The blood volumes taken were: 10 ï l, 5 sick, 1ï€l, 0.5ï, 0.25ï, and 0.1ï€l. A pipette (Eppendorf) and accuracy needle were applied for figuring and releasing the blood sprinkling. Blood beads were allowed to fall uninhibitedly by hand by squeezing the needle of the needle delicately so that drops were isolated from the tip of a tempered steel hypodermic needle in their own structure. Separately, all volumes were cycled progressively multiple times to make four sorts of contact stains and scatter stains on various surfaces utilized. The outcomes were found through Relapse Coefficient Connection, One-Way ANOVA, and Two-Way ANOVA which showed importance genuinely. The subsequent stains were then inspected and shot with a computerized camera.

Kristina Apocopic [45] examined Blood as quite possibly the main organic follow that is in many cases tracked down at the crime location. Because of the

significant data, it contains, being a vital criminological tool is thought of. Investigation of various parts of bloodstains can add to explaining the conditions under which a few fierce violations have been committed. Such essential data can point criminal examinations in the correct heading and assist with tackling the wrongdoing. Now and again, it can likewise assist with the legitimate assurance of criminal offenses which can prompt more exact and more fitting discipline for the culprit. It is vital to decide the grouping of occasions during the commission of rough wrongdoing including blood. Examination of various parts of bloodstains incorporates proper strategies from inherent sciences, especially techniques in atomic science and furthermore from math, physical science, and science. Legitimate information empowers the translation of results and makes it conceivable to draw nearer to reality, settle that specific wrongdoing and deal with the culprit. Subsequent to establishing that it is the blood by utilizing serological tests, DNA profiles, which represent the givers of various bloodstains are gotten. For the responses about the succession of occasions and instruments of the production of explicit gatherings of bloodstains at the crime location, the examination is highlighted the morphological investigation of bloodstains.

The reason for **Nathan Kwan et al [46]** was to decide the precision of the FARO Focus3D laser scanner matched with the FARO Scene programming in assessing the area of the beginning of bloodstain designs on a perplexing surface. Ten bloodstain designs were made utilizing a specially constructed bloodstain apparatus to gauge the area of beginning (x= beginning to the surface, y=origin to the right half of the apparatus, and z= beginning to the floor). The example was checked utilizing the FARO Focus3D laser scanner, and photos were taken utilizing a Nikon D7000 camera and overlaid onto the 3D model to give the higher goal. The scene was delivered and the area of the beginning was determined utilizing the FARO Scene program. The mean contrast between the determined and genuine area of the beginning is 8.3cm in the x, 1.0cm for the y, and 4.7cm for the z-course. The SD for the x, y, and z headings was ±3.6cm, ±0.8cm, and ±3.0cm separately. This method extraordinarily worked on the precision of the area of beginning assessment from 22cm to under 10 cm in all aspects. Another satisfactory exactness reach ought to be laid out for bloodstain design examination since this technique has been demonstrated to be considerably more precise than customary strategies with an adequate area of beginning inside 22cm.

Generally, when casualties and crooks leave the crime location, they leave bloodstains and some ordinary blood designs. The primary point of *A. K. Kröll et al [47]* was to examine whether the shape and size appearances of bloodstain designs give a method to classify speed and arm development precisely. In this examination, five workers produced blood engraves while moving over a distance of 10 m with a blood source joined to the right arm. The workers covered this distance at three distinct velocities (i.e., strolling, running, and running) and with two different hand developments (i.e., swinging arm versus non-swinging arm). The blood designs framed were gathered on a tear-safe paper put on the ground. By straightforward visual assessment, regular mathematical bloodstain designs were perceived: While moving gradually with a swinging arm, circle-like dribble examples or circles were made. Then again, sluggish development with a non-swinging arm framed wave-like examples. One more significant finding of this trial is that the length and width of the circles and waves essentially expand in connection with the step length (cm) and speed of movement (m/s). At the point when the examination was restricted to strolling and running tests, groundbreaking, right classifying was achieved in 89% by including the length and width (cm) of the circles and waves in a subsequent refinement capability. A new percipience equation for recognizing blood trails shaped by strolling is planned to run development. The examination of the spreading and estimation of the circle and wave-like dribble structures, containing the speed of development and biomechanical properties (i.e., arms development) can essentially add to a particular wrongdoing view foundation.

Nusrat Jahan Shoumy et al [48] present an honorable hypothetical strategy followed by a calculation for examining the direction way of straight blood scatter drop moving in view of a picture of a crime location. Straight blood splash drop has some particular examples with moderate drop size (Reynolds number, Re >= 1) and curved or round formed stains. Their free flight directions are non-straight like allegorical movement or movement with drag. Up to this point, works have been finished utilizing Stirs up's regulation just for blood-bead-free flight direction of movement with drag, which is appropriate for tiny drops (Reynolds number, Re << 1), like fog. In any case, it isn't reasonable for moderate drop sizes. Thus, we present two locales of the drag force dealing with the bead, Stirs up's regulation and Newton's regulation district contingent upon their size, speed, and Yet again esteems. It likewise thinks about the

bothering way for the drop's development, giving space for a little blunder, δ, for the point and speed. Thus, a more reasonable reproduction of the direction way alongside the point and speed of blood splash drop contrasted with accessible ones. The proposed technique could be exceptionally useful for blood scatter picture examination for crime location examination in not so distant future.

Mike Illes et al [49] investigate the reconciliation of inventive advancements into measurable science-preparing drives and their impact on understudy commitment and profundity of learning. Novel circumstances arranged showing rehearses were explored and executed determined to upgrade the nature of specialist measurable science preparation. In particular, an essential bloodstain design examination course was intended to give and test mechanical educational developments. College understudy reviews recommend that a mix of advances that unravel the difficulties of a crime location is a solid, drawing-in, and viable methodology for itemized preparation in bloodstain design examination.

Philip Joris et al [50] proposed a programmed, virtual methodology that utilized fiducial markers and computerized pictures for bloodstains design examination (BPA). BPA is a sub-stream of criminological sciences that is connected with the review and examination of the blood stain engraves gathered from the wrongdoing prospect. The fundamental reason for BPA is to uncover novel realities about the occasions that occurred at the crime location, potentially affirming or dismissing the suspect's assertion. The trademark point of BPA is to rough the region and wellspring of blood. The regular strategy for blood design examination is known as hanging, in this technique a piece of string is joined to each stain, and afterward, it is permitted to openly move. This addresses the direction of the blood. This strategy was utilized in many places yet, it had a lot of downsides. To eliminate these issues, the writer's strategy, consequently reproduced a solitary direction outline from different pictures, here client input limit was at that point characterized. Impersonation crime locations were made and analyzed to evaluate the methodology. Results approve the right technique and viable upgrades, recommending that the proposed procedure might turn into a significant asset for basically investigating bloodstain splash designs. The product utilized for this examination is called Hemo Vision. This product is presently utilized as a demonstrator and will be additionally created for viable use in measurable examinations.

CHAPTER-3

Proposed Work

Legal science is an innovation that assists with investigating crimes. Accordingly, by utilizing these methodologies execution of the law becomes plausible. Scientific science includes an alternate part of science for tracking down the goal of lawful questions. In the broadest sense, scientific science is an innovation that is utilized for the goal of lawful issues. In this specific situation, vicious wrongdoing where blood stains are created should be broken down. In this present circumstance, a specialist is utilized for approximating the position, point, and speed of the weapon worked. Furthermore, various procedures are accessible in that case to give precise insights concerning scene of the crime. Additionally, the proposed methodology of estimating and analyzing the blood stain examination is also detailed in this chapter.

3.1 System overview

Forensic science is a subject of multi disciplinary science and technology. That branch is of science utilized for the investigation of crime locations. Consequently, various procedures and ideas i.e., science, physical science, designing, and others are utilized for finding current realities and data to reproduce the genuine occurrence of wrongdoing. Hence, these strategies are useful for addressing different serious offenses. In various types of reality assortment and investigation of wrongdoing for finding the proof, it is expected to examine the different accessible proof in wrongdoing spots. Among different sorts of proof, blood stains in wrongdoing spot is a fundamental reality for crime location examination.

The blood stain investigation for a crime location is useful for finding various realities, for example, the point of the weapon worked, speed, the sort of weapon utilized, and the accurate time. The aim of this study is to measure the different facts about the crime investigation by utilization of blood splatter. That will also help to estimate the realities of the action and weapon speed. In this way, the proposed work includes the strategies of picture handling, shot, and effect of gravity for the exact assessment of the necessary realities. Subsequently, a superior method for blood stain examination is portrayed. Moreover, endeavors are put for recuperating different data like the point and speed of the worked weapon. The proposed method isn't totally

computerized it needs a few extra contributions for tracking down exact data. A mathematical model is formulated for analyzing the blood spots in crime scene using the limited user input and the digital image of blood spots. This next segment conveys a fundamental impression of the recommended work the definite display of the proposed framework is shown in the following segment.

3.2 Methodology

The proposed blood stain examination procedure includes a portion of the suppositions which are portrayed here first. Further, the proposed procedure is made sense of with its fundamental parts and utilitarian perspectives.

3.2.1 Blood Spots

In this experimental study we are considering two types of blood spots. The example of both the considered blood spots is demonstrated in figure 3.1 and figure 3.2. In figure 3.1, a direct drop of blood and it isn't scattered in any way (unpredictable model). Appropriately, it is normal that the drop comes at 90^0 point. In this manner, that blood drop makes a circle.

Similarly in the figure 3.2 the given blood spots are scattered and in movement at a specific direction. In this figure the blood is forming a specific elliptical pattern on the surface of the ground or wall. The described both the types of raw images can directly utilizable with the proposed blood splatter analysis.

3.2.2 Angle and speed

In order to calculate the angle of impact and speed of weapon we are discussing the proposed method in this section. Figure 3.3 shows the fundamental outline of the shot movement. Where an individual is standing up at a specific level and tosses an item in two situations. In the primary situation, the item is simply dropped at a specific level, subsequently, the point of the shot movement is 90°. Furthermore, in the following situation, the article is discarded with some work than the shot movement having some point from the contact surface. Likewise assuming we consider a similar model with the blood stain creation as indicated by figure 3.3. The justification behind created blood spots is the point at which a blood drop transfer from a known position A to the target position B, in this scenario the blood drop at the angle of 90*, during

this scenario the blood spot is formed the pattern as shown in figure 3.1, and that implies it makes a straightforward circle. Then again, when some power and point are delivered in a blood drop, then the blood drop is transferring a distance between two points and follows the path from 0-2. In order to demonstrate the pattern created by following the projectile motion is demonstrated in figure 3.2. Both the kinds of images are utilized for analyzing the crime scene by using the three different domains of the technology and science i.e., picture handling, shot movement, and basic numerical models.

3.3   Proposed system

The proposed computational model for the blood stain examination and realities recuperation is shown in figure 3.4. Moreover, the utilized practical parts likewise made sense that is utilized for middle-of-the-road calculation for the proposed framework design. This part gives our clarification of the proposed framework.

Bloodstain tests: These are the underlying contribution of the framework. That is an arrangement by which the information blood stain pictures are given as information. From that point onward, the data is handled for tracking down the expected realities. That is fundamentally the client's contribution to the blood spot tests in the type of a computerized picture. The computerized pictures are made with assistance out of pixels (mathematical qualities). These various qualities (0-255) are utilized to address true articles. Utilizing the information picture, the point and speed of the weapon are determined. However, the caught pictures that contain the blood stains, are not generally clear hence to find the critical data for the info pictures the highlights of the information pictures are extricated. In this manner, the subsequent stage is the element extraction from the info picture.

Edge detection: Fundamentally, for removing the fundamental data there are different sorts of component extraction procedures that are accessible, for example, variety highlights, edge, and texture features. In order to design the proposed approach the edge features is considered. Basically, in an image edge feature indicate the different objects and corners of the objects. The edge distinguishing methodology is executing the various mathematical concepts to locate the corners of the objects. Additionally, using this technique we are also trying to identify the main objects hidden in image. The shrewd edge highlight extraction technique manages five key stages in particular smoothing (sound decrease), tracking down angles (stamping), non-most extreme

concealment (advancement), twofold thresholding (assessment), an edge following (conclusion).
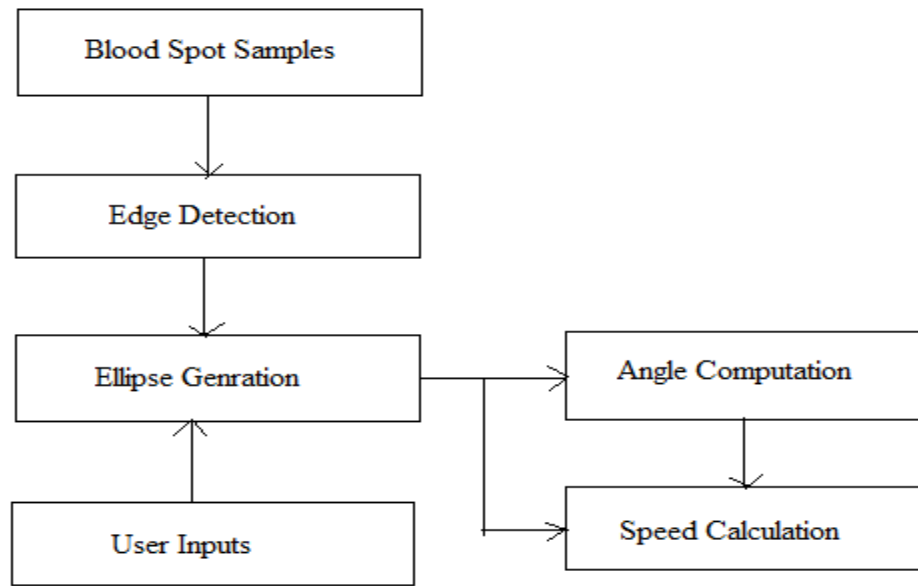
Figure 3.4 Proposed blood stain analysis model

Smoothing is the initial step of edge discovery in the vigilant edge locator approach. Fundamentally, it is expected that when a picture-catching gadget is utilized then it is constantly impacted just barely by the commotion. The commotion content in the picture can influence the performance of edges extraction. During this stage of image analysis the key spots and objects are located and refined for further processing of image. This stage is also known as the smoothing of the image where the noise and non strong object lines are neglected. Additionally, it locates the essential points for approximating the strong edges. Basically this method will help to identify and understand the recovery of unmistakable evidence of edge. Finally, the strength of edges are calculated. for this purpose we can utilize any distance or similarity measuring technique. There are two distance works that can be used i.e., Euclidean distance and Manhattan distance.

$$|Gr| = \sqrt{Gr_x^2 + Gr_y^2}$$

And

$$|G| = |G_x| + |G_y|$$

Here, the main condition shows Euclidean distance and the second is Manhattan distance. Additionally the slop of the edges are defined by Grx and Gry of the coordinates x and y. Figure 3.5 shows the two stages of vigilant edge identification, the first portrays a smooth picture, and the following is the edge's solidarity.

Yet, to work on the edges, which are not plainly an adequate number of we need to register the bearing of edges θ utilizing the underneath capability.

$$\theta = arcTan\left(\frac{|Gr_y|}{|Gr_x|}\right)$$

The ensuing stage is the non-most noteworthy camouflage. That is used to classify the edges which are strong or weak. In this context, the whole neighbor pixels higher values are preserved and remaining residual is removed from the entire input image. Thus, the principal inclination picture is turned on bearing 45∘ and 8-associated neighbor focuses are utilized. Furthermore, the edge strength is verified. In order to calculate the edge strength the pixel directions are also being used which provide the positive and negative relationships. At long last, when the objective pixel's edge greatness is higher than the pixels are secured and remaining are removed from the image.

The fourth step is known as twofold thresholding. Here, the protected pixels in the last step are named with the assessed strength, where nearly are presumably obvious edges. In any case, some of them are impacted by the commotion. Consequently, to separate between both a limit conspire is utilized. The thresholding assists with grouping edge qualities in more grounded and frail edges, to protect them. Consequently, when the pixel's solidarity is higher than the limit are marked areas of strength for as else it is named as more vulnerable edges. The edge tracking is the final step of the method. The solid edges are included as the final consequence of edge detection process. What's more, from powerless edges, just those edges remained careful that has an association with the solid edges. Subsequently, to recuperate the edges from the picture Edge following is fundamental. Utilizing Mass examination, pixels are described by related Masses. In like manner, pixels with a direct relationship with 8 neighbors are kept saved.

Ellipse generation: the edge location strategies help to recuperate the edges/bends/shapes in the first pictures. Also, eliminate the other unimportant information. In this way, from the info pictures, just shape data remains and data, for example, variety and others are eliminated. For this situation, the picture edge that contains blood spots as curved structures is removed to be utilized in the following stage for processing the point and speed of the weapon.

User input: the proposed model is designed in such manner by which we need limited inputs from the outside of the system for approximating the facts like speed and angle of weapon operation. There are two key inputs are described as:

1.   The known fact is the attack is done on the Height of body
2.   The distance between both the points of the blood spot and the body position

Both the key inputs are essential during the approximation of actual facts hidden in crime scene investigation.

Angle Computation: To process the point an essential thought is shown in figure 3.6. The execution of this strategy is conceivable in the 3D climate or true situations. Be that as it may, the accessible examples of blood stains depend on 2D. Accordingly, we utilize the method given in the figure.

By utilizing the 2D model we set up a mathematical design of the framework. Consequently, it is expected that the picture contains different blood drops. Along these lines, a typical point is closed. This line is used for tracking the entire circle of the blood drop demonstrated in figure 3.7. Accordingly, a picture material is created which contains a fanciful line that is gone through the joined circle. The directional information is obtained from the line connected with external surface of the eclipse. The length of the line is with the end goal that it crosses the nonexistent line.

In this scenario, that intersection of the line is a point, therefore the two lines which is created by two coordinates are formed by a common coordinate and can be notified as (x_1, y_1). The two other coordinates of the lines are given as (x_2, y_1) and (x_2, y_2). Therefore, we have two coordinates for describing two different lines, which is intersecting each other at a specific angle. In this experiment we assumed that this angle is the angle of impact. In classical mathematics for estimating the angle between two lines we can use the formula of slop S, which is defined as:

Slop between two coordinates A (x_1, y_1) and B (x_2, y_1)

$$S_1 = \frac{y_2 - y_1}{x_2 - x_1}$$

And, second slop is computed between A (x_1, y_1) and C (x_2, y_2)

$$S_2 = \frac{y_2 - y_1}{x_2 - x_1}$$

Thus,

$$\tan\theta = \frac{S_1 - S_2}{1 - S_1 S_2}$$

$$\theta = \tan^{-1}\left(\frac{S_1 - S_2}{1 - S_1 S_2}\right)$$

Here the θ is describing the impact angle of weapon, which is the main aim of this calculation. Next, we are discussing the approximation of speed and time.

Speed calculation:

When we are working with the motion for estimating the time and speed then the Newton's law is a noteworthy concept, in this context, we are going to use the same concept for studying the blood splatter analysis under projectile motion. Therefore, in order to uncover the hidden fact at the crime scene like speed of the weapon we are utilizing the equation of projectile. The basic form of the projectile motion is given by:

$$S_y = u_y t - \frac{1}{2} g t^2 + h_0$$

Where, the speed is indicated by S_y for traveling the blood drop in horizontal direction, $u_y = u * \sin\theta$, $u_x = u * \cos\theta$, the initial speed of the object is given by u, the gravitational force g $= 9.8\ m/s^2$ is considered, and the time of flight is denoted by t, and the height of body is given by h_0.

Here, we need an user input as the value of h_0, which is indicated as h_1 in further formulation. Additionally, the horizontal distance between body position and blood splatters is also available thus we can estimate the time of flight. Thus, we can utilize horizontal range formula as:

$$S_x = u_x t$$

Thus

$$t = \frac{S_x}{u_x}$$

Where, the time of blood drop flight is indicated using t, which is similar in values for both the ends. Thus

$$-h_1 = t . u \cos \theta - \frac{1}{2} * 9.8 * t^2 - S_y$$

$$-h_1 = t . u \cos \theta - 4.9 * t^2 - S_y$$

Here we know about the t thus

$$C = 4.9 * t^2$$

So,

$$-h + C = t * u\cos\theta - S_y$$

And we can also write the above equations

$$P = -h + C$$

$$\frac{P}{t} = u\cos\theta - \frac{S_y}{t}$$

$$u\cos\theta = \frac{P}{t} - \frac{S_y}{t}$$

$$u = \frac{1}{t\cos\theta}(P - S_y)$$

Here, the symbol u is indicating the weapon operation speed.

Now, we are calculated the all the required primary parameters which are essential for describing the happening of the crime. These parameters are angle of impact, flight time and the speed.

3.3   Algorithm

Hence, the above explanation is arranged as a series of steps in form of an algorithm. The aim is to utilize the collected evidence from the crime scene using the digital images or photographs for cross examines the facts about crime. In this context, a detailed formulation of the required model has been explained in previous section. In this section, we are discussing the sequence of process utilized for uncovering the required parameters from the raw digital images. The table 3.1 provides the required steps of calculating the speed of weapon, angle of impact and blood drop flight time. The algorithm described the process using both i.e. input of the given algorithm as well as the consequences formed after processing of the information given.

Input: The crime scene image I_b which consist of blood splatter, two user input coordinate A and B, height of body H

Output: angle of impact θ, time of flight F and speed weapon S

Process:

1. $R_{row,col} = ReadInputImage(I_b)$

2. $E = ComputeEdge(Canny, R_{row,col})$

3. $Line = CalculateOriginLine$

4. $\theta = calculateAngle(A, B, Line)$

5. $t = \frac{S_x}{u_x}$

6. $u = \frac{1}{t\cos\theta}(P - S_y)$

7.   Return θ, t, u

Table 3.1 Proposed algorithm

3.4   Chapter Summary

The proposed work is aimed to help the forensic science project and thus we select the domain of blood stain analysis and crime scene recreation. The chapter

includes the details about the proposed system to implement it for simulation. The described system works on the blood spots images and helps to compute the speed of weapon operation, time of flight and the angle of impact. In order to demonstrate the system, the model is explained and the process steps are summarized using algorithm. In further chapters we will also discuss the implementation and deployment of the model additionally the performance based on the experiments are also explained.

CHAPTER-4

Implementation

In this chapter the details of system implementation and deployment of the proposed blood stain analysis technique has been discussed. This chapter highlights the key details about the implementation thus classes, methods and GUI are discussed in this chapter.

4.1   Tools and Techniques

Implementation of the proposed blood splatter analysis technique utilizes the software and hardware for supporting the development and deployment of the considered system. The essential requirements of both hardware and software has discussed as:

(A) Tools-

Net Beans IDE 8.0.2: User Interface Design

(B) Technology/Framework-

Framework - JDK 1.8.0

(C) Hardware Specifications-

Storage space 25 GB

Main Memory 2 GB Minimum

Processor Intel P4 or higher

(D) Software Specifications-

Operating System: Windows 8 or higher

4.1.1 NetBeans IDE 8.0.2

NetBeans IDE is the power IDE for Java 8. With its editors, code analyzers, and converters, you can quickly and effectively upgrade your applications to use new Java 8 vernacular creates, for instance, lambdas, utilitarian errands, and method references. The NetBeans Stage is a dull design for Swing applications. It gives the "pipes" that,

already, every designer expected to stay in contact with themselves — saving state, partner exercises to menu things, toolbar things, and control center simple courses; window organization, and so on. The NetBeans Stage gives these out to the holder. You don't need to code these or other central features, yourself, any longer genuinely. See what some NetBeans-based applications look like. The stage doesn't add an impressive proportion of the above to your application — in any case, it can save a monstrous proportion of time and work.

The NetBeans Stage gives a trustworthy and versatile application plan. Your application doesn't have to look anything like an IDE. It can save you a significant length of progression time. The NetBeans Stage provides you with a time of attempted plan for no good reason. A plan that upholds plausible progression sharpens. Since the NetBeans Stage configuration is specific, everything except hard-to-make applications is lively and extensible.

4.1.2 JDK 1.8.0

The Java Improvement Unit (JDK) is a thing improvement condition utilized for making Java applications and applets. It combines the Java Runtime Environment (JRE), a center individual/loader (java), a compiler (javac), an archiver (compartment), a documentation generator (Javadoc), and different instruments anticipated in Java movement. Java Improvement Unit is a load of the going programming parts that are relied on to make Java-based applications.

Java Compiler: Java compiler is a javac instrument organized in/holder organizer of the JDK establishment record. The javac gadget (got to utilizing javac charge) examines class and association point definitions, written in the Java programming language, and orders them into bytecode class reports. It can also deal with explanations in Java source reports and classes.

Java Interpreter: Java go-between is utilized to disentangle the .class Java reports that have been gathered by the Java compiler (javac). Java translator is gotten to utilizing java charge. The java demand begins with a Java application. It does this by beginning a Java runtime condition, stacking a predefined class, and calling that class' indispensable strategy.

Java Disassembler: The javap demand is the annihilating device of JDK that obliterates somewhere near one class document. Its yield relies on the choices utilized. In the event that no decisions are utilized, javap prints out the pack got and open fields and strategies for the classes to go to it. The javap prints its regard stdout.

Java Header Document Generator: Java Header Record Generator (Javah demand line mechanical gathering) produces C header and source records that should acknowledge neighborhood procedures. The conveyed header and source reports are utilized by C errands to reference a difference's model components from the local source code. The .h record contains a struct definition whose association matches the arrangement of the differentiating class. The fields in the struct diverge from model components in the class.

Java Documentation: Java Documentation deals with code. The Javadoc contraption comes as a piece of the Java Improvement Unit that parses the statements and documentation remarks in a blueprint of Java source records and conveys a differentiating plan of HTML pages portraying (which is to be expected) general society and got classes, settled classes (however not dark interior classes), interfaces, constructors, systems, and fields. You can utilize it to make the Programming point of interaction (Application Programming Point of collaboration) documentation or the execution documentation for an arrangement of source records.

Java Debugger: The Java Debugger, is an essential component of JAVA technology which offers the provision to analyze the JAVA code and produce the logical and syntactical issues in the code lines. It is incorporated with the Java Virtual Machine.

Java Applet Watcher: This is used to see the Java applets. The applet-watcher accuse connection points of the reports or resources doled out by URLs and show each applet referred to by the chronicles in its own window.

4.2   Code Implementation

This section involves the different classes referenced or implemented with their functional point of view. Additionally, the implemented methods and functions are also reported in their subsections.

4.2.1 Reference Classes

This section includes the different reference classes that are used for implementing the proposed blood stain analysis technique for cyber forensic. Table 4.1 contains the list of essential classes and their working in the proposed system.

S. No.	Classes	Description
1	java.util.ArrayList	The array list is a type of high-level data structure. It is used to store data arrays using program during the application execution
2	java.io.FileInputStream	In java for describing the file and/or directory path we use this API.
3	java.sql	This API is used for handling data storage by enabling the communication between JAVA technology and a relational database.
4	javax.swing.filechooser	In order to provide input to the system in terms of a file or directory this swing GUI will be used to select for user input
5	java.io.File	This class is used for defining the file system path and objects. In simple words it is a representation of file system and it's objects.
6	java.io.BufferedReader	Inspects content from a character-input stream or buffering characters for effective representation of the characters, their groups, and other application.
7	javax.imageio.ImageWriter	An abstract superclass for encoding and writing images. This class must be

| subclassed by classes that write out images in the context of the Java Image I/O framework. |

Table 4.1 Reference Classes

4.2.2 Implemented Classes

This section discussing about the essential implemented classes, not all the classes involved. The aim is to provide the briefing about the considered classes which played important role on system development.

S. No.	Classes	Description
1	Blood_Spatter_Angle _detection	This class contains the main class of the implemented system which helps to execute the project
2	Grayscale	This class is used for converting color image into a gray scale image using the RGB values
3	ImageEditor	This class is a supporting class which help to develop the canvas for preparing the drawing on the frames
4	MyEdgeClass	This class is a helper class which is used for extracting the edge feature values identified using the canny edge detection technique
5	Cannyedgedetector	This class provides the implementation of canny edge detection technique

6	Utility	This class is providing the different utilities for implementation such as the image read, write, store, etc.
7	DelectAngle	This class is a GUI based class which is used for computing the angle for the blood drops

Table 4.2 Implemented Classes

4.2.3 Functions and Working

This section provides the understanding about the implemented methods or functions which are helpful for intermediate computations for the implemented system. The table 4.3 shows the functions and their descriptions.

S. No.	Functions and Methods	Description
1	getConnection	This function is used to establish the connection between front end GUI and the database
2	storeImage	This function is used to read and store input image to the database
3	showImage	This function is used to obtain the image data from data source and represent in GUI
4	Showlist	This function is developed to retrieve the list of images and organized using the combo box
5	setHighThreshold	This function is used for computing and applying the thresholding during execution of canny edge detection algorithm

6	performHysteresis	This function reuses the image array to store both luminance data from the image, and edge intensity from the processing. This is done for memory efficiency; other implementations may wish to separate these functions
7	normalizeContrast	This function helps the canny edge detection technique for normalizing the constraints for optimizing the edges recovered

Table 4.3 Functions and Description

4.3   GUI Design

In this section, details of the implemented GUI (graphical user interface) are provided for better understanding of the system working process. Therefore, each diagram listed in this section is explained:

1. **Main screen:** that is a GUI based class implementation. This class is initial window of project screen which works like a wizard for conducting the experiments. That figure is reported as Figure 4.1.

2. **Browsing the image:** the figure 4.2 shows the acceptance of initial input image. The image is selected by the user from the local or network computer and uploads to the system implemented. After that the function is used to read and display the image data in the GUI.

3. **Image conversion:** the implemented figure 4.3 shows the image conversion therefore first the previous image is forwarded to the system and then the grayscale image computed using the initial image input. In next the required features such as the LBP (local binary pattern), canny edge detection technique, and the color grid movement-based features are calculated. Moreover, the calculated features are also listed in a kind of list which is demonstrated in figure 4.4. Among them the edges are become essential features for the proposed system therefore the calculate edge feature is also represented in graphical manner in this screen.

4. **Angle computation:** the figure 4.5 shows the canvas which is used to accept the line from the user, on the basis of precisely input of line the system calculates the coordinates of line and calculate the angle using the computed and produced input parameters.

5. **Time and speed:** the time of trajectory and speed of drops are calculated in this screen figure 4.6. That is calculated on the basis of input angle and the techniques of projectile motion.
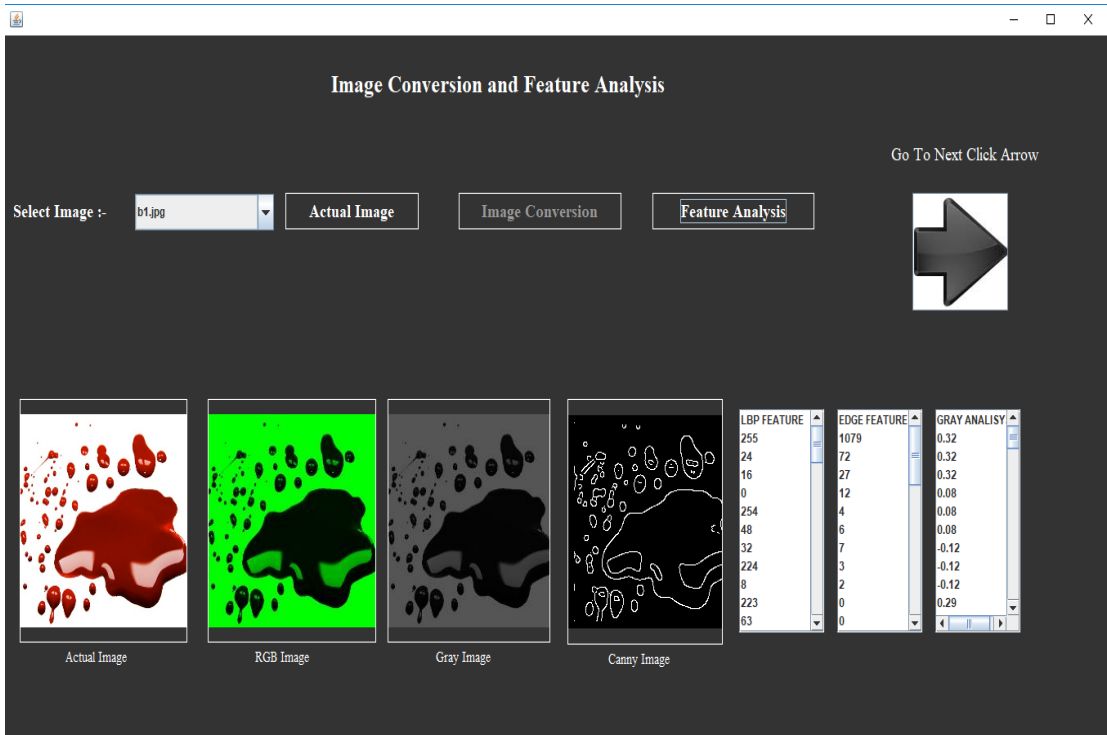

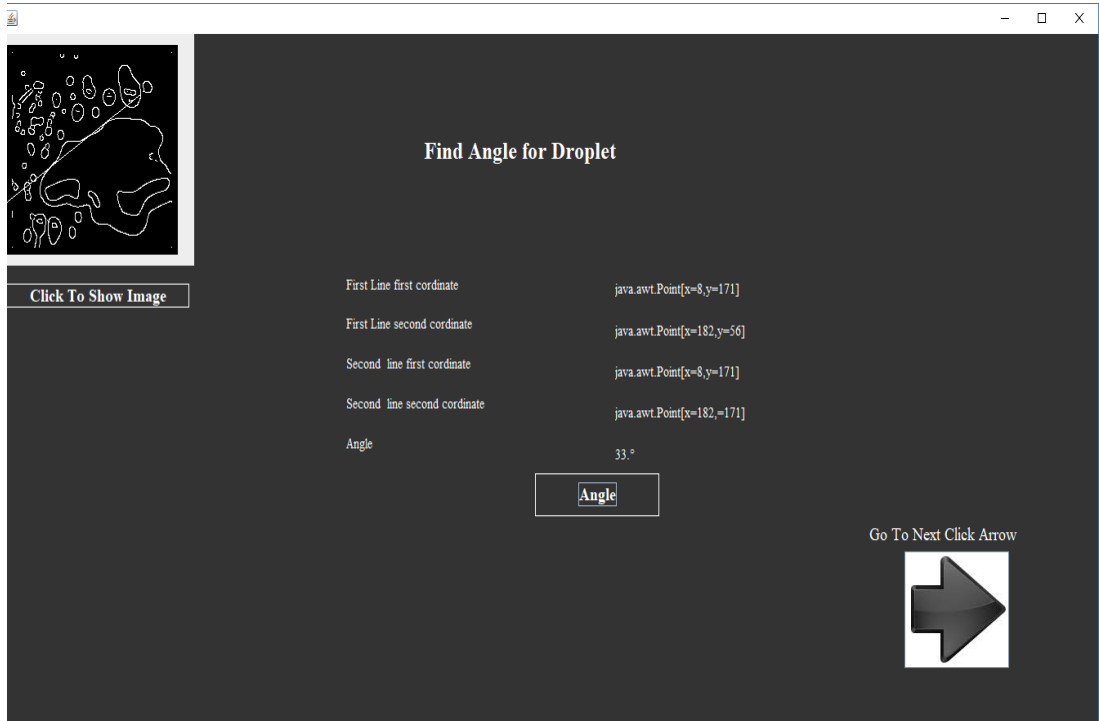**Figure 4.1 Main Screen**
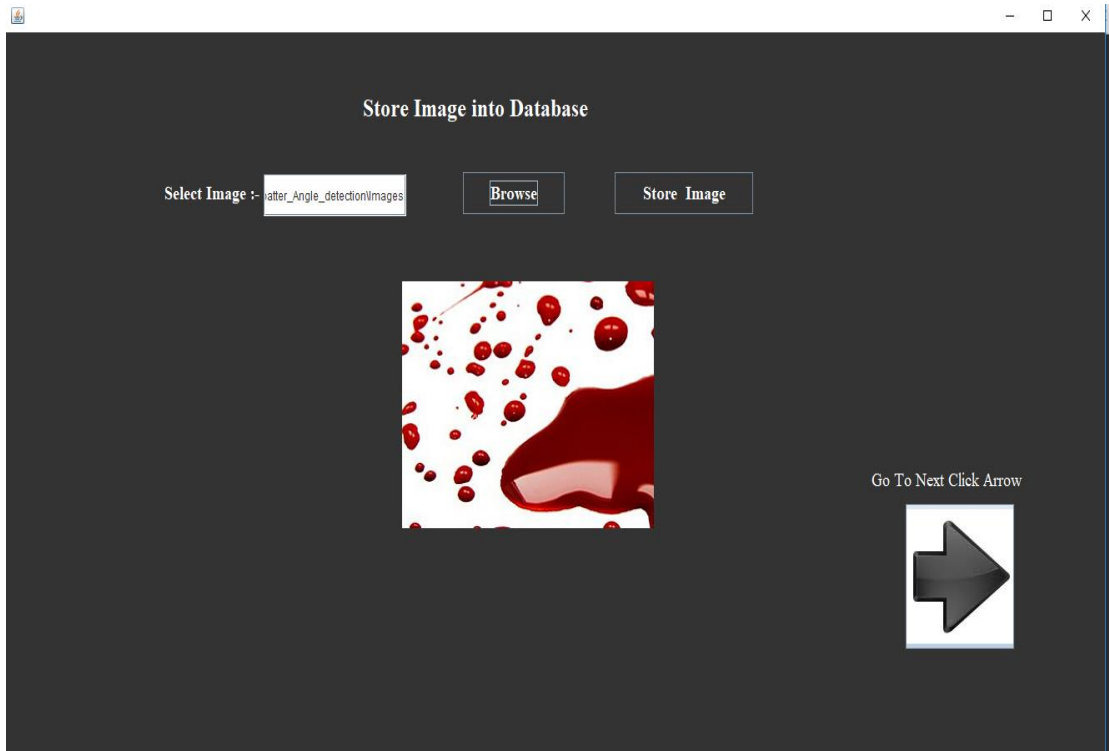
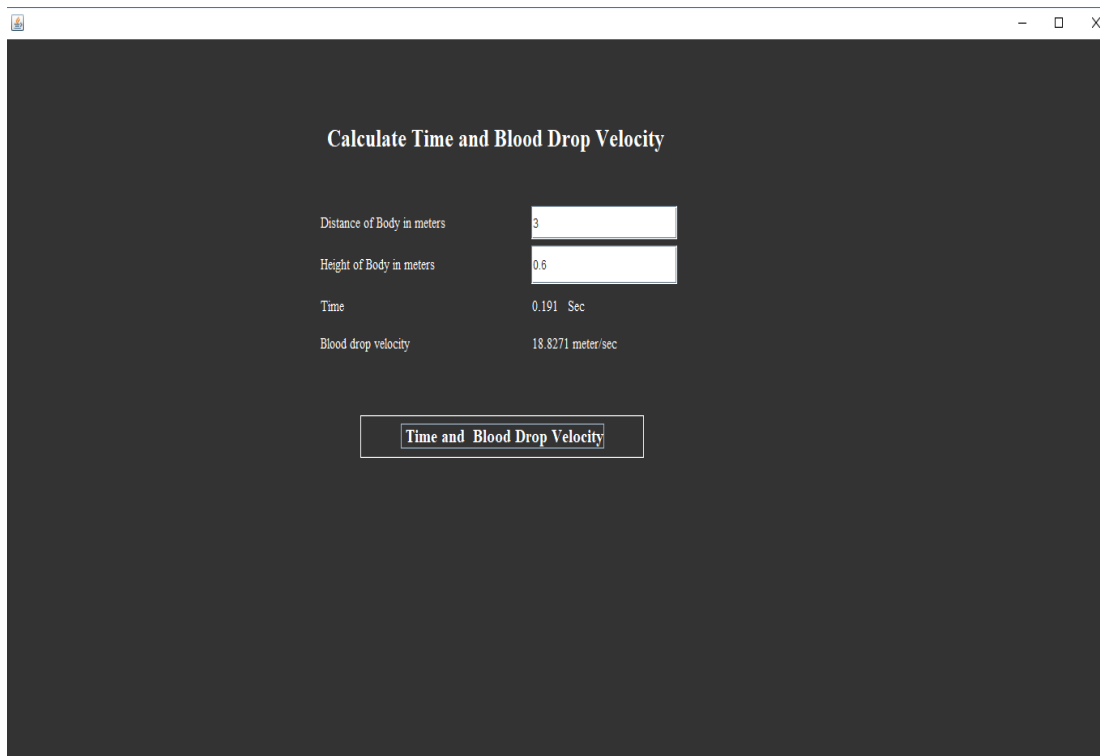**Figure 4.2 Browsing Image**
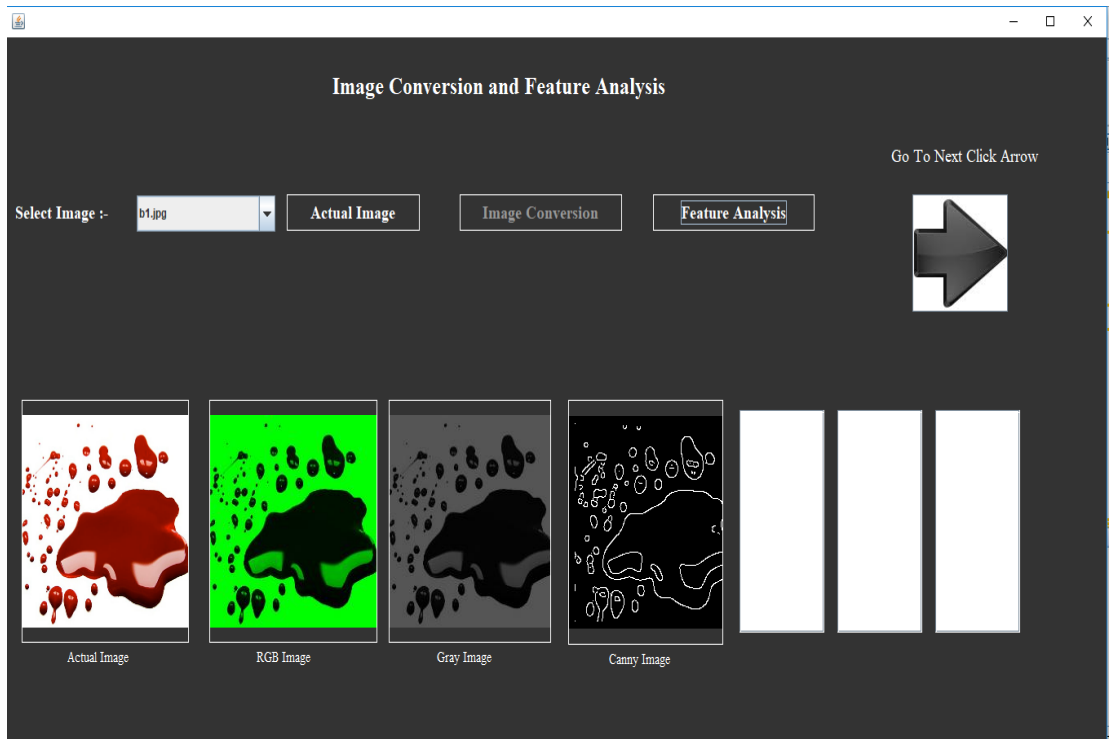
Figure 4.3 Image Conversion

Figure 4.4 Image Feature Extraction

Figure 4.5 Angle Computation

Figure 4.6 Time and Speed

CHAPTER-5

Results Analysis

This segment gives the assessment of results to support the proposed research targets. In this unique circumstance, tests are led on an alternate arrangement of blood splatters, and in view of the trial dataset, the exhibition is estimated. Thus, the estimated performance indicators are explained and their interpretation is also discussed in this chapter.
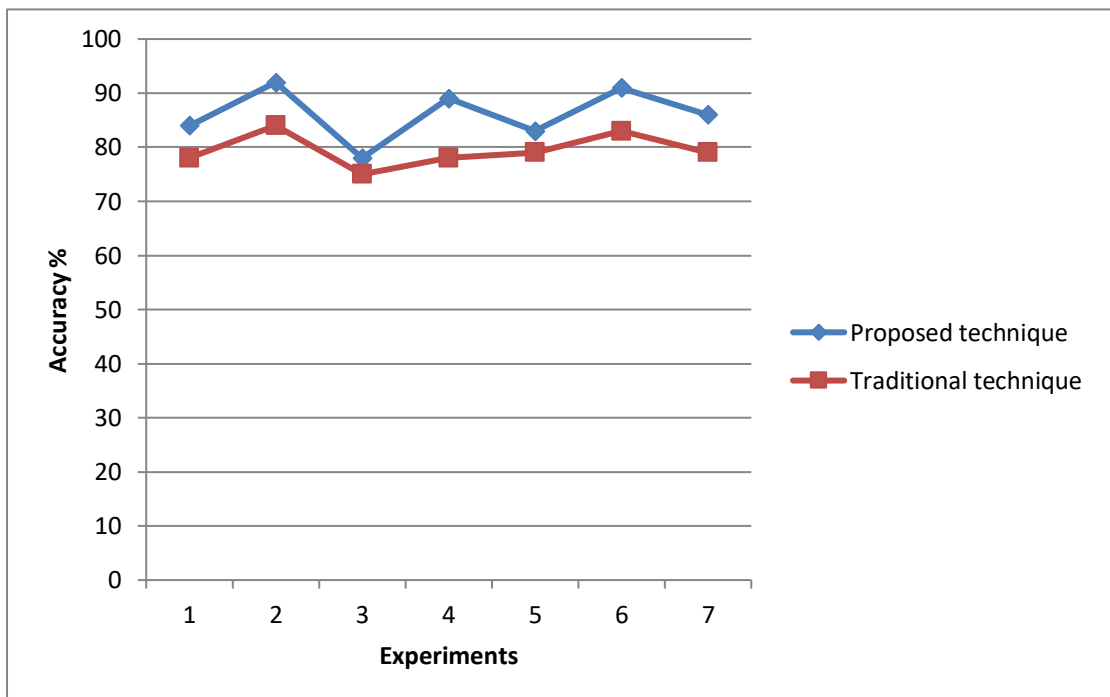
5.1 Accuracy

The aim of experiment is to accurately identify the angle of impact, thus for that purpose we have measured the accuracy of the implemented model. Additionally a comparison with the similar blood splatter analysis model is also given. The accuracy indicates the correctness of the measurement technique. In order to measure the correctness of the estimation we utilized the following equation:

$$accuracy(\%) = \frac{computed\ angle}{actual\ angle} X100$$

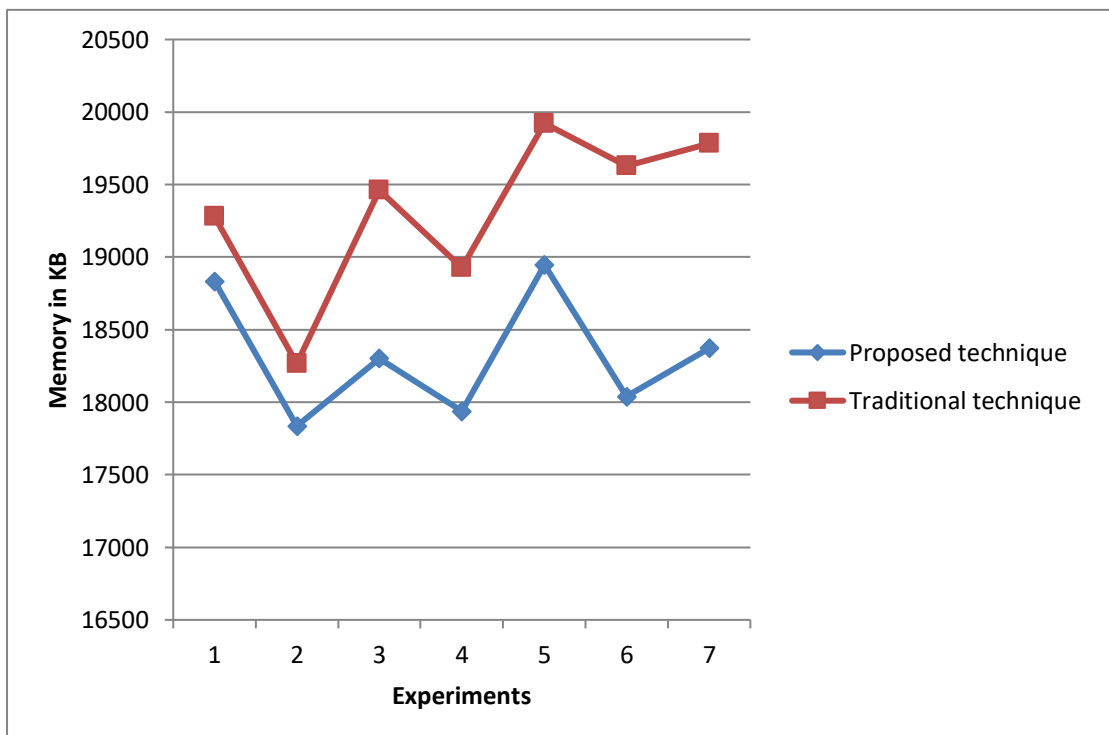| Experiments	Proposed Technique	Traditional Technique
1	84	78
2	92	84
3	78	75
4	89	78
5	83	79
6	91	83
7	86	79

Table 5.1 Accuracy Percentage

Figure 5.1 Accuracy

The figure 5.1 and table 5.1 demonstrate the measured accuracy of blood splatter analysis models i.e. traditional and proposed. We have conducted a number of experiments and among most accurate consequences are reported in this section. Here the accuracy is measured in terms of percentage (%) values. The observation of both the technique's performance values are described in table 5.1 and their line graph is demonstrated in figure 5.1. According to the prepared graph the Y axis shows the accuracy of both models and the X axis shows the number of time the observations made. According to the findings, we can say the proposed technique is useful for accurately measuring the essential facts of crime scene such as precise time, speed, and point of activity.

5.2 Memory Usage

The total amount of main memory utilized among the assigned part of memory is known as the memory utilization of algorithms. The memory is an essential performance measurement for studying the efficiency of an algorithm that indicate how much memory an algorithm required for processing the information. In JAVA technology the memory is calculated using the following equation:

$$memory consumed = total assigned - total free space$$

Figure 5.2 Memory Usages

54

| Experiments	Proposed Technique	Traditional Technique
1	18833	19282
2	17836	18266
3	18301	19462
4	17937	18927
5	18946	19922
6	18039	19629
7	18372	19783

Table 5.2 Memory Usages

For measuring the efficiency and computational cost of a contributed algorithm the time and memory is frequently utilized parameter. The describe technique of the proposed blood spot examination is revealed in figure 5.2 and table 5.2. The measurement of memory utilization is provided in terms of KB (kilobytes). Here the table 5.2 demonstrate the observations made during the execution of the proposed method additionally we also draw a line graph using the same values as given in table 5.2, the figure 5.2 provides the required line graph. In this figure 5.2, Y-axis describes the utilized memory and X-axis shows the number of different experimental observations. According to the measured and observed results we can say the proposed technique is more memory efficient than the traditional blood spot investigation technique.

6.3   Time Requirements

Traditionally measurement of information processing time is an essential parameter to know the efficiency of the implemented system. In this section we are calculating the time consumed for identifying the forensic information from processing

of the input image. It is the amount of time which is used by the algorithm for uncovering the crime scene facts. In order to approximate the time requirements of the proposed forensic image processing tool we utilize the following equation:

$$time\ consumed = algorithm\ end\ time - start\ time$$
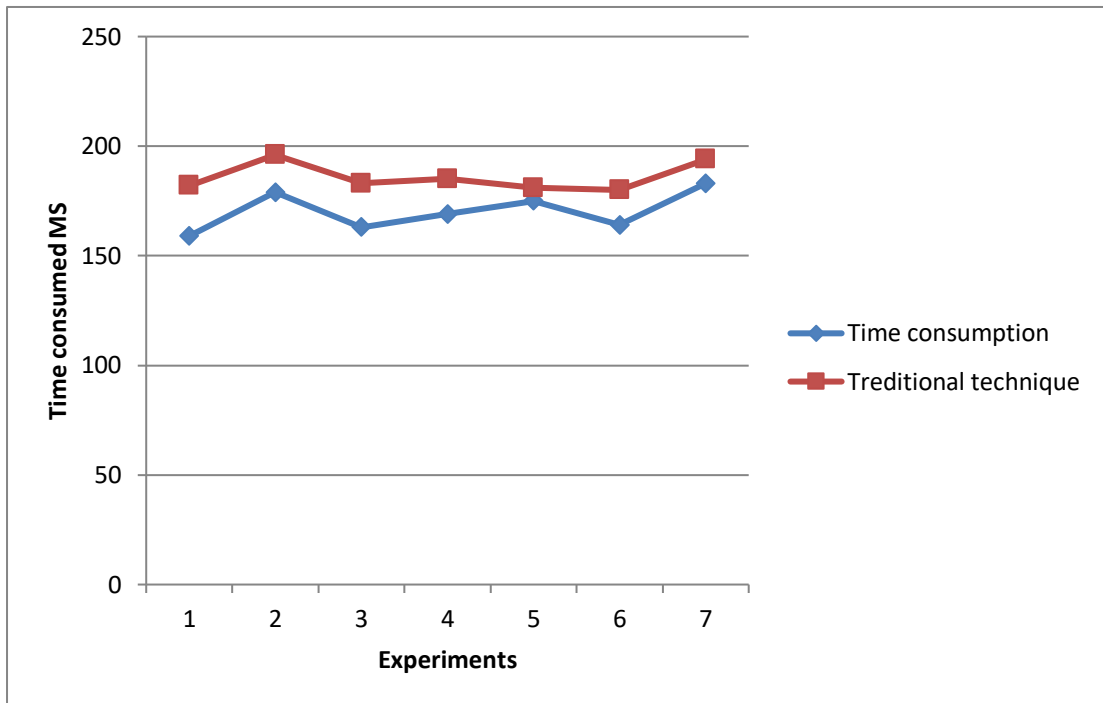
Figure 5.3 Time Requirements

In order to uncover the criminal facts from the input image of crime scene is measured here as the time requirement of the proposed model. The time of crime scene image analysis is given in figure 5.3 and table 5.3. The implemented technique requires very less time to calculate the required factors thus we calculate it in terms of milliseconds (MS). In the demonstrated diagram of the time requirements the X-axis include the number of observations made and the Y-axis shows the factor estimation time. Additionally, the observed time of the calculation is explained in table 5.3 according to the experiments carried out. The figure 5.3 is a line graph representation of the values reported in table 5.3. According to the evaluation of the proposed and a similar traditional model we found the proposed technique utilizes less amount of time as compared to classical blood splatter analysis model.

Experiments	Proposed Technique	Traditional Technique
1	159	182
2	179	196
3	163	183
4	169	185
5	175	181
6	164	180
7	183	194

Table 5.3 Time Requirements

CHAPTER-6

Conclusion and Future Work

This segment gives a rundown of the exploration work described in this document. The aim of automated blood splatter analysis tool design has been accomplished successfully and some of the limitations are remains to fix, thus the future extension plan has also been discussed.

6.1   Conclusion

Maintaining the low and internal safety of country is the primary aim of the governments. Therefore various rules and regulations are developed for securing their people. But, sometimes crimes are happen in various mysterious circumstances, thus to discover the facts of crime the forensic science is used. That is a group of multiple subjects of science. That is the used for implementing the law, discovering the crimal facts, finding the answers about the crime happening and also used to prove the crime. It is administered by the lawful principles of permissible proof and criminal technique. Criminological researchers gather, safeguard, and dissect logical proof during an examination. Then, the collected information and obtained digital facts are utilized for recreation of the crime locations. Additionally, this provides the strong evidence for cross verifying the statements given by victim or culprit. Forensic science word is combination of two Latin words: legal and science. Therefore, we can say that is the domain of scientific study where we work and discover facts and figures for low enforcement. Subsequently, measurable science can involve logical techniques and cycles of wrongdoing addressing.

The proposed work is keenly interested to examine and offer a blood stain investigation method, which is efficient and less computationally complex. This model will accept the raw blood spot images and analyze it in order to recover the key information for the crime scene like the point of impact, speed of weapon operation, and projectile analysis for calculating the time of blood drop flight. In this context, we are utilizing the classical physics concept with the image processing for recovering and identifying the essential insights. The proposed model isn't completely programmed it acknowledges a few extra contributions for recuperating the necessary realities from the crime location. In this setting first, the picture's undeniable level highlights are

recuperated accordingly the LBP (nearby double example), vigilant edge location procedure, and network variety development examination is performed on the picture. These techniques are applied to the picture for extracting the low level features like edge, color, and texture. These processes of feature measurement will helpful to describe the essential elements from the input image for analysis. Additionally, the recovered information requires fewer amounts of time and memory for processing the image information in complex crime scene analysis.

In order to implement the required blood splatter analysis tool we utilize the JAVA technology. Additionally the NetBeans integrated development environment (IDE) is used for writing and executing code. Finally, to store the determined performance factors we utilize the MySQL database. By using the experimental analysis we calculate the performance matrix which is described in table 6.1.

S. No.	Performance parameters	Proposed technique	Traditional model
1	Accuracy	86.14	79.42
2	Utilized memory	18323	19324
3	Computational time	17028	185.85

Table 6.1 Performance Review

As indicated by the accomplished and depicted results of the proposed blood stain investigation the framework is OK for true use. That produces precise and proficient results for tracking down the expected realities of proof. In any case, we distinguish a portion of the limits of the proposed work. This is required to have been improved on in the additional examination.

6.2   Future Work

The proposed work is propelled by grasping the capability of scientific science and its procedures. Also, we need to gain proficiency with the utilization of logical procedures for tackling confounded wrongdoings. That assumed a fundamental part when criminal cases are considerably more mind-boggling. In this manner, by the inspiration of commitment to legal sciences a blood smudge examination strategy is

created. To upgrade that strategy all the more definitively the accompanying future augmentations are proposed.

1. Human contribution to defining the boundary can influence the exhibition of the current framework consequently in not so distant future therefore it is required to make improvements on the contributed technique according to adaptation of future requirements.

2. The introduced method is developed by assuming the victim is in static position but in real scenarios it not always happen thus we need to incorporate the dynamicity of victim in future extension

3. The introduced technique for blood splatter analysis is focused on vertical position examination (standing or sitting positions), it will need to extend for the horizontal position too.