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2D Blood Trajectory Analysis Using Image Processing and Projectile Theory

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Abstract– **This latter is provided with the aim to contribute the in computational forensic, thus a new computation based on projectile motion and image processing is addressed. The proposed model helps to estimate weapon operation speed, angle of impact and projectile time. The proposed system is a semi-automatic model, which need some additional inputs during the computation. Thus the model can be described in three modules (1) applying edge detection technique for recovering ellipse from input image. (2) Accepting the user input using implemented image canvas (3) processing projectile motion equation on the basis of user input (4) conclude the results. in order to compute image edges canny edge detection is applied first, the recovered edge is used to compute the mean ellipse, and using a canvas the coordinate is provided by users. Based on user input the angle computed from ellipse is used for calculating the speed and flight time. In order to calculate the required parameters the projectile motion equation is used. Here the 9.8 m/s^{2} is used for gravitational force. The implementation of this simulation is performed using JAVA technology, the performance is evaluated in terms of processing time and memory requirement for collected sample images. The performance shows very fewer resources consuming technique for computing the facts. A classical model is also compared with this method to justify the solution. The observed solution improve the performance of existing approach. Finally some extension of the work is also suggested to improve the quality outcome.**

Keywords: Blood splatter analysis, projectile motion, and speed, angle of impact, time of flight, canny edge detection, simulation, and implementation.

I. INTRODUCTION

A number of real world domains are usages the services of computation. Basically the computation is the base of computers and their technologies [1] [2]. The computers are now in these days used for solving complex problems. In the similar ways the forensic science is a technique of computation and analysis by which the approximation about the conducted crime is analyzed [3]. This technology is helpful for finding, analyzing and recovering the evidences of the crime [4]. Therefore forensic science is a branch of science and technology which involve chemistry, physics, mathematics, biology and others for finding and evaluating the facts of crime. In critical cases where less and unclear facts and evidences are available then the help of forensics are used for rectifying the issues.

In this presented work the main area of investigation is forensic science where the efforts are placed for the blood strain trajectory analysis [5]. Basically, in a crime scene study blood strains are received and need to identify how and which directions the criminal conduct the crime, the blood trajectory analysis is a suitable technique for finding and collecting evidences. Additionally as the outcome it expected to process the image data using image processing and mathematical techniques for recovering the time of flight, speed of weapon and the angle of weapon operation. All these facts are helpful for crime scene analysis and re-creation of the crime scene. In addition of the aim is to use simple techniques and tools to reduce the computational efforts and time of processing the data. Therefore a new model for computing the blood strain trajectory is proposed, implemented and evaluated in this work.

II. RELATED WORK

This section reviews the recent literature and core contributions in the field of blood strain trajectory analysis.

MicroRNAs have attracted interest as a biomarker for forensic body fluid identification, since they not only show cell type but also exhibit a high intrinsic stability. ***Eva Sauer et al [6]*** aims to identify reliable miRNA markers for the identification of five forensically relevant body fluids and to establish an intuitive approach facilitating the determination of the origin.

A model predicting forward blood spatter patterns resulting from a round nose bullet gunshot is proposed by ***P. M. Comiskey et al [7]***. The chaotic disintegration of a blood layer located and aside of the bullet is considered. The size distribution of blood drops is determined, which allows for the prediction of a blood spatter ejected from the rear side of the target. Then, droplet trajectories are predicted accounting for gravity and air drag, The model predicts the number and area of individual stains, as well as the stain distribution as a function of distance. The predictions are compared with experimental data. The agreement between the predicted and experimentally measured parameters is found to be good.

The most commonly used trigonometric model is based on the linear movement of a blood drop, which disregards air resistance and gravitational force that affects mass points in an area of space. The aim of ***Richard Billich et al [8]*** is to map the flight trajectory of blood drops with the use of a firearm and evaluate the option of replacing the real world flight trajectory. A model was created to simulate the real world dispersion of blood. Samples with a volume of 100 ml were placed into a plastic bag and shot at. For the purpose of experiment was prepared wooden chamber. Plastic bags containing blood samples were hanged in the chamber and positioned into the chamber's center. Blood samples were shot at from a distance of two meters. Each shot was recorded by a high speed camera. Based on the physical and experimental models it was determined that the real flight trajectory may be defined by a parabolic technique. The parabolic approximation does not differ from the ballistic curve and real flight trajectories. From the progression of the curves capturing the flight of blood drops it was ascertained that for the purpose of using trigonometric models. The use of the parabolic approximation with distances of over 2 m leads to deviations of more than 3 mm. The outcome of comparisons shows that the real world flight trajectory differs very little from the ballistic curve and parabolic approximation. In crime reconstructions the angle of incidence of a blood drop impacting a horizontal surface plays an important role. The outcomes of the ballistic curve and the parabolic approximation are nearly identical.

The blood spatter analysis is the process which relies on the expertise of the forensic. The human intervention also creates the problem of errors and misjudgments. Use of image processing to the whole will deal with automation of removing human factor. The proposed method, by ***Abhijit Shinde et al [9]*** takes the image from blood spatter and reconstructs the blood source. The methodology uses the Otsu's method for thresholding and Hough transform for edge detection.

A mechanical device that uses gravitational and spring compression to create spatter patterns is presented and discussed by ***Theresa Stotesbury et al [10]***. The device uses either two or four springs in parallel to create seventeen reproducible impact velocities. The impactor is held at several known spring extensions. Trigger inputs to the high-speed video camera allow the user to control the magnet's release while capturing video footage. A polycarbonate base is used to allow for simultaneous monitoring of the side and bottom views. Twenty-four patterns were created. Area of origin estimations fell within an acceptable range, distribution analysis for the use in research. This work provides a framework for interested in developing a robust impact device.

Aisling A. Galligan et al [11] Forensic pathologists who autopsy the victims of gun violence are often called upon to answer questions in both criminal and civil proceedings. In this case report of an officer-involved shooting incident, the statement of the police officer appeared to be in direct contradiction to the statements of other eyewitnesses, and the final resting position of the body. Trajectory analysis of two gunshot wound pathways was performed to assess the veracity of the officer's statement and forensic animation used to create exhibit.

This is a data set of blood spatter patterns scanned at high resolution, generated by ***Daniel Attinger et al [12]***. The spatter patterns were generated with a rifle with varying ammunition. The resulting atomized blood droplets travelled opposite to the bullet direction, generating a gunshot back spatter. Fresh blood was used; The main parameters of the study were the bullet shape, size and speed, and the distance. Several other parameters were explored. This new and original data set is suitable for training or research purposes.

Theresa Stotesbury et al [13] explores the crown formation dynamics of blunt force impact. Three weapons –a hammer, a baseball bat, and a metal bar – were used. Impact velocity was controlled using a impact device. High-speed videos were collected and analyzed with motion tracking. Interestingly, crowns were not observed to form in seven out of nine trials. The widths and heights where observable crowns formed were measured and ranged. Bloodied material type was observed to influence the size and shape of the crown; Three unusual cases of rim instability were observed. The work supports the idea of formation dynamics caused by blunt force impact. Observable crowns can form with a range of geometries and subsequently produce.

A technique of calculating the origin of blood and trails formed that could give impact directions and positions had been presented by ***Shahid Iqbal et al [14].*** The size, volume of droppers, and spikes around the stain border relayed on droplet impact velocity and droplet diameter, it was not unusual to find bloodstain patterns, and through proper interpretation. Precise measurements and digital camerawork might estimate the free height of passive droplets, the features related to the effect of the surface, and the intensity involve. Four diverged forms of stains were made and human blood with heparin as an anti-coagulant was taken. Pipette and precision syringe were applied for blood splashing. All volumes were cycled for successively for five times to make four kinds of contact stains and spatter stains on different surfaces.

Kristina Pokupcic [15] discussed about Blood is one of the most important biological traces that are found on crime scene. It contains valuable information, and considered to be an important forensic tool. Analysis of different aspects of bloodstains can contribute to clarify the circumstances. Such crucial information can point criminal investigation and help solve the crime. It can also help with legal determination of criminal offense. It is important to determine the sequence of events. Analysis of different aspects of bloodstains includes methods from natural sciences, methods in molecular biology and from mathematics, physics and chemistry. Knowledge enables interpretation of results and makes it possible to get closer to the truth. After determining that blood by using serological tests, DNA profiles which account for the donors of different bloodstains. To answers about sequence of events and mechanisms specific groups of bloodstains on the crime scene, investigation is pointed.

III. PROPOSED WORK

The Forensic science is a technology that helps to explore the criminal activities. Therefore, using these approaches implementation of law becomes feasible. The forensic science involves different branch of science for finding resolution of legal disputes. In the broadest sense, forensic science is a technology that is used for resolution of legal issues. In this context in a violent crime where the blood strains are generated need to be analyze. In this situation an expert is employed for approximating the position, angle, speed of weapon operated. Additionally a number of different techniques are available that are claim to provide the accurate details about the crime scene. In this chapter the proposed methodology for blood strain analysis is presented which is helpful for exploring the facts about the crime scene.

A. System overview

Forensic science is a branch of science. That branch is used for analysis of crime scene. Therefore a number of techniques and concepts i.e. chemistry, physics, engineering and others are used for discovering the facts and information to reconstruct the actual happening of crime. Therefore these techniques are helpful for solving the various serious offences. In different kinds of fact collection and exploration of crime for finding the evidence it is required to analyze the various available evidences in crime spots. Among various kinds of evidences the blood strains in crime spot is an essential fact for crime scene analysis.

The blood strain analysis for a crime scene is helpful for discovering the different facts such as angle of weapon operated, type of weapon used, speed and timing. In this work the main objective is to analyze the blood splatter for identifying the facts of angle and the speed of weapon. Therefore the proposed work involves the techniques of image processing, projectile and impact of gravity for accurate estimation of the required facts. Thus an improved technique for blood strain analysis is described. Additionally the efforts are placed for recovering the different information such as angle and velocity of operated weapon. The proposed technique is not completely automated it needs some additional inputs for finding accurate information. Using the user input and the blood spot samples a mathematical model is introduced in this work. The samples are basically images based thus image processing is also included. This next section provides a basic understanding about the proposed work the detailed modeling of the proposed system is demonstrated in next section.

B. Methodology

The proposed blood strain analysis technique involves some of the assumptions which are described here first. In further the proposed technique is explained with their essential components and functional points of view.

a. Blood spots

In this work the two major kinds of blood spots are considered. Both the manners of blood spots are demonstrated in figure 3.1 and figure 3.2. Among them the figure 3.1 shows the simple drop of blood and it is not scattered in any direction (random pattern). Therefore, it is assumed that the drop comes at 90^0 angle. Therefore that blood drop creates a circle.

Figure 3.1 blood spot for vertical positions

On the other hand the blood spots demonstrated in figure 3.2 shows that blood is scattered in a specific angle. It means the blood is appeared in a particular angle from surface and create an ellipse. Thus these two kinds of blood spot are used for the experimentation and proposed system design.

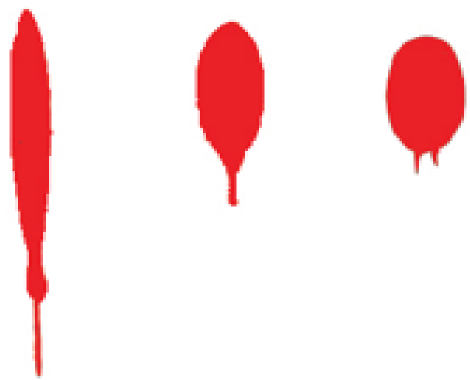

Figure 3.2 blood spot with angle

b. Angle and speed

In order to involve the assumption of angle and speed we have to consider first about the projectile motion. The figure 3.3 shows the basic overview about the projectile motion. Where a person is standing up on a particular height and throws an object in two scenarios. In first scenario the object is just dropped at a particular height, thus angle of projectile motion is 90^o. Additionally in next scenario the object is thrown away with some efforts then the projectile motion having some angle from the contact surface. In the similar manner if we consider the same example with the blood strain creation according to figure 3.3. The reason of developed blood spots, when a drop of blood travel from position 0 to 1, then the angle of drop is 90*, this event create the blood spot as given in figure 3.1, means it create a simple circle. On the other hand when some force and angle is produced in blood drop then the blood drop is traveled a relative distance therefore it's path way is 0-2. This scenario develops the blood spot as given in figure 3.2. By using these two assumptions of the proposed system is modeled using the concepts of three domain of science and technology i.e. image processing, projectile motion and simple mathematical models.

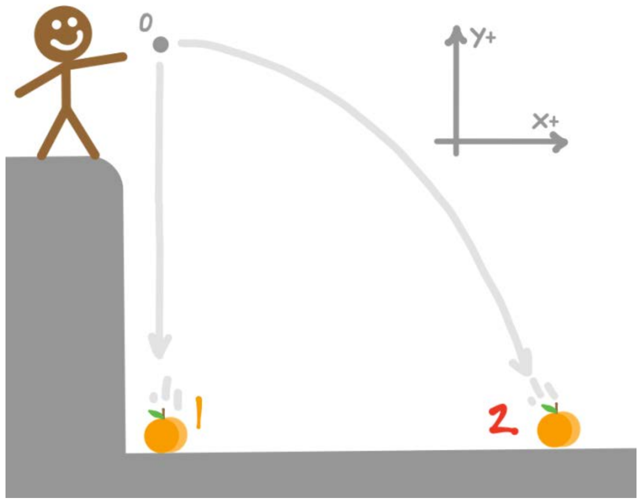

Figure 3.3 angle and speed

C. Proposed system

The proposed computational model for the blood strain analysis and facts recovery are demonstrated in figure 3.4. Additionally the used functional components are also explained that are used for intermediate computation for the proposed system architecture. This section provides are explanation of the proposed system.

Blood strain samples: That is the initial input for the system. That is a provision by which the input blood strain images are provided as input. After that the information is processed for finding the required facts. That is basically user input of the blood spot samples in form of the digital image. The digital images are composed with help of pixels (numerical values). These different values (0-255) are used to represent the real world objects. Using the input image the angle and speed of weapon is calculated. But the captured images that contain the blood strains, are not always much clear therefore to find the significant information for input image the features of the input images are extracted. Thus the next step is the feature extraction from the input image.

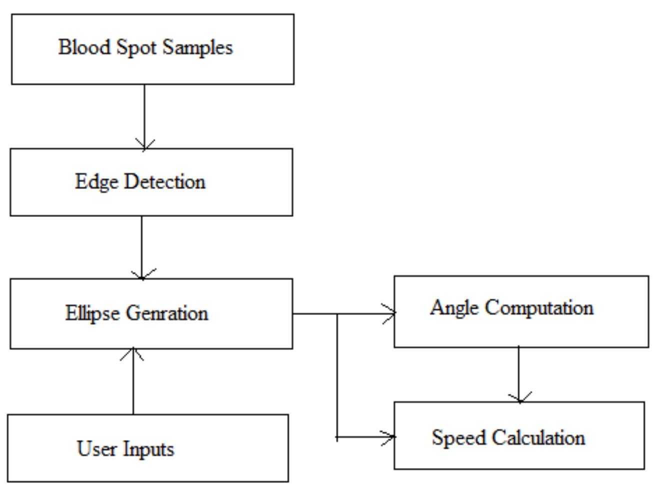

Figure 3.4 proposed blood strain analysis model

Edge detection: basically for extracting the essential information there are various kinds of feature extraction techniques are available such as color features, edge feature, and texture features. In this work the edge features are considered for work. The edges of the images are used to represent the objects in an image. Therefore the edge detection technique is needs to be implementing for identifying the objects in given sample image. In this context the proposed work include the canny edge detection technique. The canny edge feature extraction method is deals in five key phases namely smoothing (noise reduction), finding gradients (marking), non-maximum suppression (optimization), double thresholding (evaluation), and edge tracking (finalization).

Smoothing is the first step of edge detection in canny edge detector approach. Basically it is assumed that when an image capturing device is used then it always affected with some small amount of noise. The noise content in image can affect the accurate extraction of edges. Thus the filters are applied to reduce the noise. The process of noise removal is indication of smoothing of the image. In second phase it finds gradients. For understanding with simplicity it is the preparation of edge identification. So, the edge strength is computed. Here, we can use any distance measurement technique. There are two distance functions 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, first equation shows Euclidean distance and second is Manhattan distance. Where, Grx and Gry are used to denote the gradients of x and y coordinates. Figure 3.5 shows the two steps of canny edge detection, first describes smooth image and next is edge's strength.

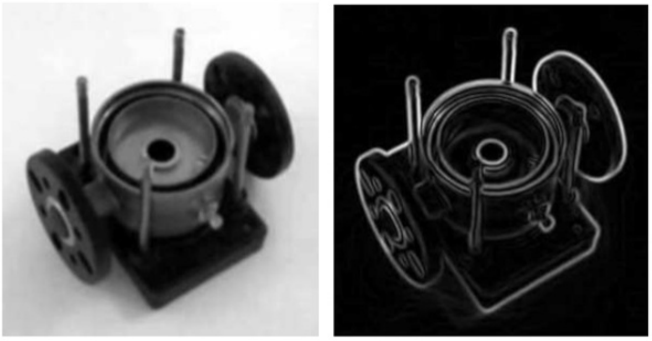

Figure 3.5 smoothing and gradient

But to improve the edges, that are not clearer enough we have to compute direction of edges θ using the below function.

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

The next step is non-maximum suppression. That is used to restructure "blurred" edges into "sharp" edges. Thus entire local maxima are being preserved and other image contents are removed. So, first gradient image is rotated on direction 45◦ and 8-connected neighbor points are used. Secondly strength of the edges is validated. The edge strength is used to define the pixel's orientations in positive and negative directions. Finally, when target pixel's edge magnitude is higher than preserved pixels then it is kept safe else removed.

The fourth step is known as double thresholding. Here, the preserved pixels in last step are labeled with the estimated strength, where almost are probably true edges. But some of them are affected by noise. Thus to differentiate between both a threshold scheme is used. The thresholding helps to classify edge strengths in stronger and week edges, to keep safe. Therefore, when the pixels strength is higher than the threshold is labeled as strong edges else it is labeled as weaker edges. The final step is known as edge tracking. The strong edges are directly included as final edge. And from weak edges only those edges are keep safe that have a connection with the strong edges. Thus to recovering the edges from image Edge tracking is essential. Using BLOB-analysis, pixels are classified for connected BLOB's. Thus pixels with direct connection with 8 neighbors are keeping preserved.

Ellipse generation: the edge detection techniques help to recover the edges/ curves/ shapes in the original images. Additionally remove the other non essential data. Therefore from the input images the only shape information remains and the information such as color and other are removed. In this case the image edge that contains blood spot as elliptical structures is extracted to be used with next phase for computing the angle and speed of weapon.

User input: in order to accurate analysis of speed and angle of weapon operation we need some additional information about the crime facts.

1. Height of body where the attack is done
2. Distance among both the points blood spot and body position

These two basic inputs are helping us to accurate evaluation of the required facts.

Angle computation: to compute the angle a basic idea is demonstrated in figure 3.6. The implementation of this technique is possible in 3D environment or real world scenarios. But the available samples of blood strains are based on 2D. Thus we use the technique as given in figure 3.7.

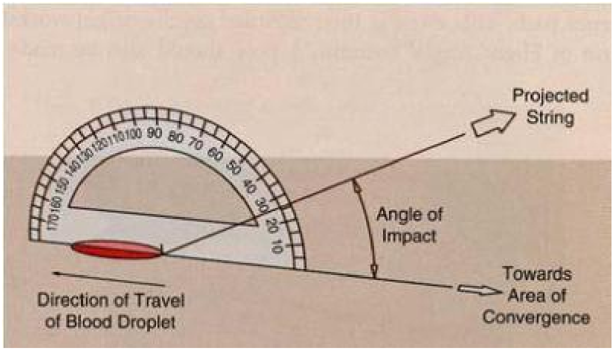

Figure 3.6 angle calculation

By using the 2D model we prepare a geometric configuration of system. Thus it is assumed that the image contains multiple blood drops. Therefore an average point is concluded. This is a line which follows the average point of the entire ellipse as shown in figure 3.7. Thus an image canvas is developed which contains an imaginary line which is passes through the combined ellipse. Here a directional input is required which passes through the ellipse outer line. The length of line is such that it crosses the imaginary line.

In this context, that crossing point is assumed here as the first coordinate of two or more lines, this point is denoted here as (x_1, y_1). The two other coordinates of the lines is given as (x_2, y_1) and (x_2, y_2). Therefore we have two set of coordinates which are representing two different lines which are crossing each other in an angle. This angle can be recognized as the angle of impact. To calculate the angle between two straight lines first we compute the slops S:

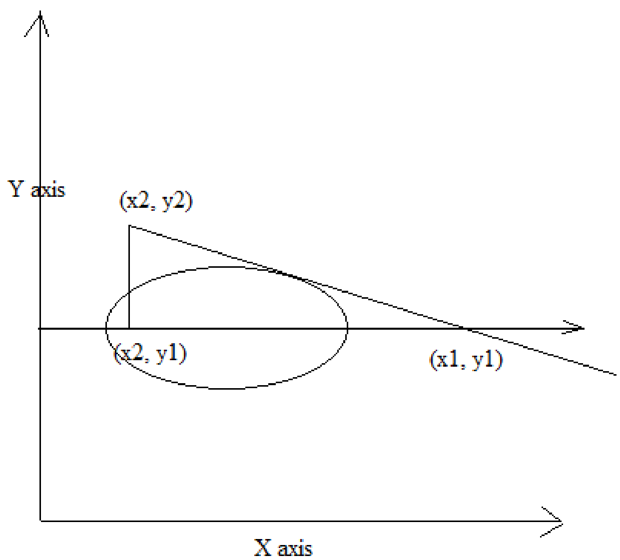

Figure 3.7 proposed geometry of angle estimation

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 our required angle of impact which is required to find. In next section the speed and time is computed.

Speed calculation:

The speed of an object can be calculated using the Newton's law, but the blood splatter follows the projectile motion. Therefore in order to compute speed of the weapon the equation of projectile is helpful. The projectile equation is given as:

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

Where S_y is the speed to be computed for horizontal direction, $u_y = u\ sin\theta$ and $u_x = u\ cos\theta$, the u is initial object speed, g is the gravitational force 9.8 m/s^2, and t is the time of travel, and h_0 is the height.

Here we have the value of h_0 as user input, that is denoted in further computation using h_1. Additionally we have the value of horizontal distance between body position and blood splatters. In order to compute horizontal distance in this scenario we can use the formula of horizontal range as:

$$S_x = u_x t$$

Thus

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

Where t is the time of flight, which is similar in both the ends thus the

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

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

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 u is the speed of the weapon operation.

Thus the system computes all the three target outcomes angle of impact, flight time and the speed.

D. Proposed Algorithm

The proposed work is aimed to compute the essential facts for recreation of crime scenes. In this context some essential parameters are obtained. The required process for obtaining the significant parameters the used process is described using the table 3.1. The algorithm provides the details about the input of the system and obtained values after completion of the required process.

Input: blood splatter image I_b, two coordinate A, B, height of body H

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

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

IV. RESULT ANALYSIS

This section provides the evaluation of results for justifying the proposed research objectives. In this context experiments are conducted on different set of blood splatters and based on the experimental dataset the performance measured. The obtained observations of the performance of the system are given using performance factors.

A. Accuracy

The accuracy of the proposed system is measured by validation technique. In this context some images and relevant Meta data is collected that provides the angle of drops and the images of the blood drops. Using the calculated values and the predefined values the ratio of success is measured in terms of accuracy. The following equation is being used for that purpose.

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

Experiments	Proposed technique	Traditional technique
1	84	78
2	92	84
3	78	75

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4	89	78
5	83	79
6	91	83
7	86	79

Table 4.1 accuracy %

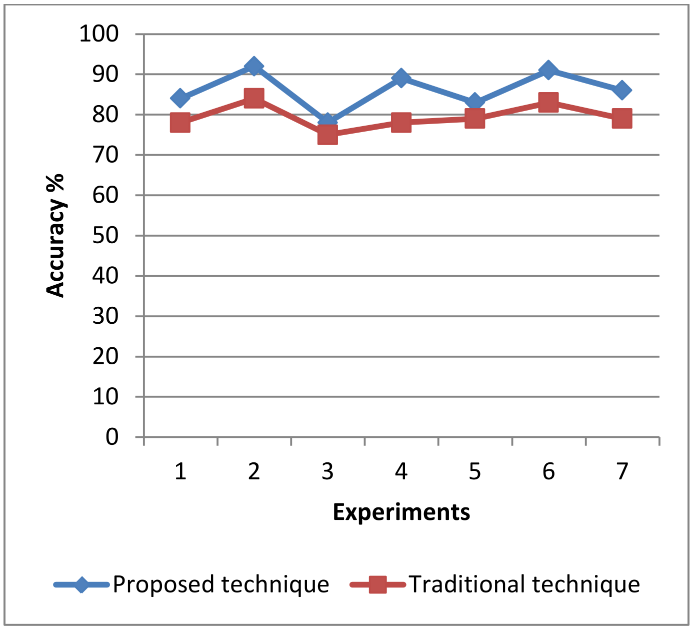

Figure 4.1 accuracy

The performance of the proposed blood trajectory computational system is demonstrated in figure 4.1 and table 4.1. In each experiment the different image of same size is used, additionally the performance is measured in terms of percentage (%) accuracy. The table 4.1 contains the observed values during different experiments and their line graph representation is demonstrated in the figure 4.1. The conducted experiments are reported in X axis and the Y axis show the percentage accuracy obtained for the particular experiment. According to the observations we concluded that the precise inputs can helpful for measuring accurate time, speed and angle of operation.

B. Memory Usage

The memory usages of an algorithm can be termed as the memory consumption or the space complexity of algorithm. That replicate the amount of main memory resource is consumed during the processing of the data using the algorithm. That can be calculated using the following formula according to the JAVA technology.

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

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 4.2 memory usages

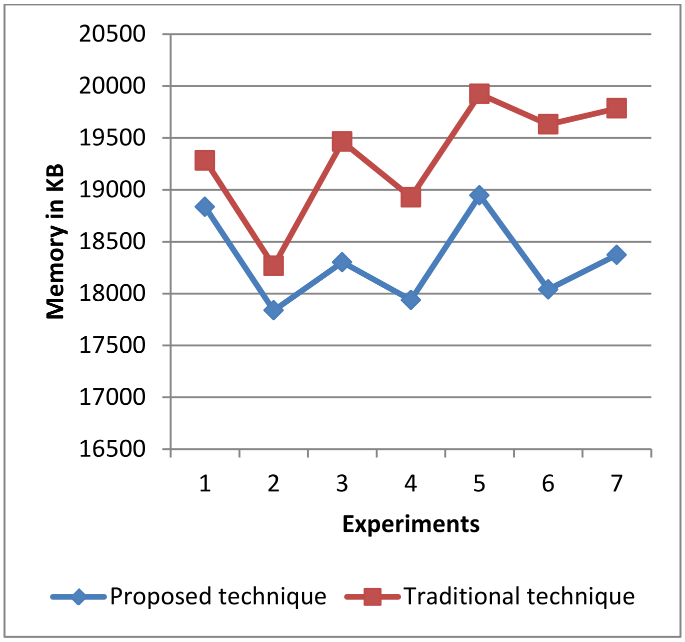

Figure 4.2 memory usages

The memory usages or space complexity of the proposed blood trajectory analysis technique for computing the weapon speed, angle and trajectory time is evaluated in terms of memory usages and reported in figure 4.2 and table 4.2. The calculated memory usages are demonstrated here in terms of KB (kilobytes). The table 4.2 stores the obtained memory usages of the system and the graphical (line graph) representation is given in figure 4.2. According to the line graph X axis represents the experiments and observations and the Y axis shows the relevant memory usages of the algorithm. The performance obtained described us the memory usages of the system is depends on the size of image produced as input for the experiments.

C. Time Requirements

The time requirements of the proposed system are also known as the time complexity or time usages of the system. That is the total amount of time which is consumed for processing the data. Therefore the sum of all the process time is described here as the time requirements of the algorithm. That is calculated here in the following manner.

$$time\ consumed = algorithm\ end\ time - start\ time$$

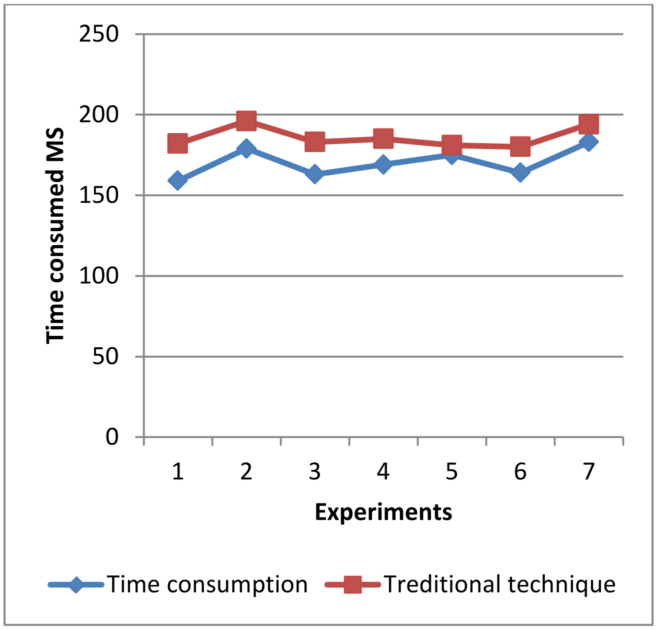

Figure 4.3 time requirements

The time requirements of the proposed blood splatter trajectory analysis system is reported in figure 4.3 and table 4.3. The time requirement of the proposed system is measured here in terms of milliseconds (MS). The Y axis contains the values of the time requirements additionally the corresponding the experiment numbers are reported in X axis. These values are obtained from experiments and reported using the table 4.3. The line graph of the system performance is given in figure 4.3. According to the time consumption the similar amount of time is required for processing the data, but it is slightly depends on the dimensions of image pixels.

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 4.3 time requirements

IV. CONCLUSION

This section provides the summary of the entire work performed for accurate blood strain analysis. The experimental observations are described here in terms of conclusion and the future work is also reported.

A. Conclusion

Forensic science is also known as criminalistics. That is the application of science to criminal and civil laws, mainly on the criminal side during criminal investigation. It is governed by the legal standards of admissible evidence and criminal procedure.

Forensic scientists collect, preserve, and analyze scientific evidence during investigation. On the other hand some of them visit crime scene to collect the evidences. The laboratory of forensic testifies as expert witnesses in both criminal and civil cases and work for prosecution or the defense. Forensic science is a combination of two Latin words: forensic and science. The forensic, relates to a discussion or examination in public. Science is derived from the Latin word for 'knowledge' and is today closely to the scientific method. Thus, forensic science can be use of the scientific methods and processes in crime solving.

The aim of the proposed work is to investigate and design a blood strain analysis technique. The proposed work aimed to prepare a simple model which accepts the blood strain image as input, and produces the values (predictive) of angle of impact, speed of movement (i.e. criminal weapon), and time of flight. In this context by using the techniques of image processing and classical physics a new model is proposed in this work. The proposed model is not fully automatically it accepts some additional inputs for recovering the required facts form the crime scene. In this context first the image high level features are recovered thus the LBP (local binary pattern), canny edge detection technique and the grid color movement analysis is performed on image. These methods are applied on image to recover the edge, texture and the color distribution in the image. After feature extraction the obtained features are represented using the image. This image is further used for accepting the user input and produces the factors using the projectile based formulation.

The implementation of the proposed technique is performed using the JAVA technology and using the NetBeans IDE. Additionally to store the performance calculated for the system is preserved in the MySql database. The measured performance of the system is summarized in terms of mean values. These values are demonstrated in table 5.1.

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 5.1 performance summary

According to the obtained and described outcomes of the proposed blood strain analysis of the system is acceptable for real world use. That produces accurate and efficient outcomes for finding the required facts of evidence. But we identify some of the limitations of the proposed work. This is needed to be simplifying in further research.

B. Future Work

The proposed work is motivated for understanding the potential of forensic science and the techniques. Additionally we want to learn the use of scientific techniques for solving the complicated crime. That played an essential roles when the criminal cases are much complex. Thus by motivation of contribution in forensic a blood strain analysis technique is developed. In order to enhance that technique more precisely the following future extensions are suggested.

1. Human input for drawing the line can impact the performance of the existing system thus in near future the model is modified to align the obtained blood spots in a given image
2. The proposed technique is currently only helpful when the victim is in static position when the attack happen, in near future the mobility is also considered for system design
3. The proposed technique is suitable for vertical position analysis (standing or sitting positions), it is need to be develop for the horizontal position (sleeping position).

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