LouisSaveinDupuisJournalofMultidisciplinaryResearch2024,3:154-158 Doi.: 10.21839/lsdjmr.2024.v3.121

ResearchArticle

MATHEMATICS IN FORENSIC SCIENCE

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Abstract

One of the most crucial methods for detecting crimes is quickly emerging to be mathematics. The significance of mathematics in forensic science is covered in the project's first chapter. Talk about the various areas of mathematics that are utilized in criminal investigations, such as probability, trigonometry, measures, proportion, and calculus. The Pythagoras theorem, trigonometric functions, and other trigonometric techniques in forensic science are covered in the second chapter. Discuss the many kinds of blood spatter, find the area of convergence and the angle at which the blood spatter impacts, and calculate the height of the blood fall using trigonometry. The use of differential equations to determine the estimated time of death is covered in the third chapter.

Key words*: Estimating a person's time of death using Newton's law of cooling and examples.*

Introduction

Any scientific field that examines crime scene evidence for a court of law is known as forensic science. In order to examine the evidence from crime scenes, forensic scientists are well-versed in mathematical ideas and equations, which are employed in all branches of research. Gathering measurements and recording evidence are the primary tasks of crime scene investigators. Forensic scientists use the data to calculate and ascertain the facts of a crime. Proof of what happened during a crime can be shown in data numbers thanks to math.

The court wonders if forensic evidence analysis is impossible without mathematical knowledge. One concerns the importance of evidence as an expert witness and in relation to the crime. Such a task should be able to be handled by the forensic scientist. Both types and the weight that the court should assign to each may be made easier by methods based on Bayesian statistics that use probabilistic arguments. The expert witness must have a solid grasp of the fundamental mathematical and statistical techniques used in forensic science in order to prepare the discussions and presentation of any quantitative data in the report that is given to the court with the rigor and clarity that are required.

The Determination of the Estimated Time of Death Using Differential Equations

Calculus in Forensic Science

Blood stain pattern analysis is a technique used by forensic analysts to reconstruct the crime scene. As it happens, the direction in which the blood was used to hurt the victim can be determined by both the position of the blood's landing and the shape of the blood on the landing surface. Every day, forensic technologists and medical examiners utilize a different type of calculus to determine a victim's time of death.

The corpse begins to decay during the three phases of death that a victim goes through. The rate at which the body cools after death is known as Alger mortis. Analysis employs mathematical concepts to determine the victim's position, the scene of the bloodshed, and even the kind of weapon or impact that injured the victim. Weapons can occasionally even disclose a criminal's mindset.

Alger mortis is used to estimate the time of death; moreover, Newton's rule of cooling can be utilized to ascertain the time of death if the body is found just a few hours after death

$\frac{dT}{dt}$=K$(T - T_0)$

Where T is the temperature of the object,T_0 is the temperature of the surroundings.

The rate at which the temperature T(t) changes in a cooling body is directly proportional to the temperature difference between the body and the temperature T's of the surrounding medium.

Newton's law of cooling modeled as first order initial value problem

$$\frac{dT}{dt} = K(T - T_s)$$

$$\mathrm{T}(0) = T_0$$

T_0 is the initial temperature of the body and K is the constant of proportionality If T_s is constant via method of separation of variables

$$\frac{1}{(T - T_s)}\,dt = K\,dt$$

Integrating both sides

$$\int \frac{1}{(T - T_s)} = \int K\,dt$$

$$\log(T - T_s) = Kt + c$$

$$(T - T_s) = e^{Kt+c}$$

$$T(t) = T_s + e^{Kt+c}$$

Applying the initial condition

$$T(0) = T_s + ce^0$$

$$c = T_0 - T_s$$

Hence $T(t) = T_s + T_0 - T_s e^{Kt}$

If $K > 0$ $\lim_{t\to\infty} e^{Kt} = 0$

Therefore, $\lim_{t\to\infty} T(t) = T_s$ and the temperature of the body approaches that of its surroundings.

Trigonometry in Blood Splatter

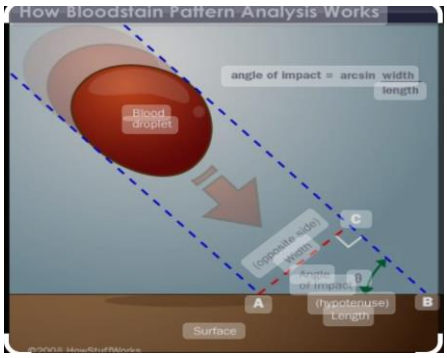
In forensic science, we may need to interpret data arising from measurements made at a crime scene, such as in blood pattern analysis or bullet ricochet, or investigate cases of forensic relevance, such as the trajectory of a rifle bullet or a suspicious death resulting from a fall from a tall building. Trigonometry is the mathematical analysis of problems involving angles, frequently using trigonometric functions like sine, cosines, and tangent. In all of these

investigations, we need to understand the fundamentals of trigonometry.

Trigonometry has a special place in the hearts of blood spatter analysts, who use the known identities and trigonometric functions to determine the angle of impact that is, the angle at which the person was struck and the angle at which the blood fell and use the angle impact to determine a person's height.

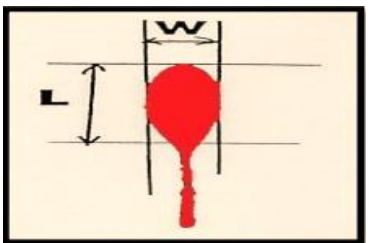
Blood Spatter

There are various varieties of blood spatter, which are defined by the distribution of the blood, the shape of the droplets when they hit a surface, and the angle of impact. Because each person's blood composition varies in proportion, blood is not uniform. Because the many organs have varying ratios, volatility is expected within the individual as a result of these different proportions.



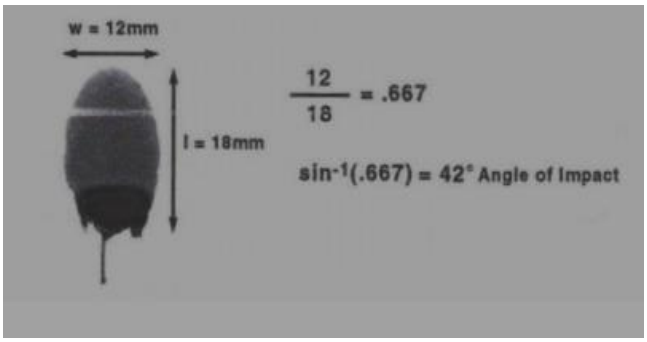
Angle of Impact

In order to determine the angle of impact, we measure the width and length of the blood stain, being careful not to measure the tail. For example, if my arms were bleeding and I held it straight out, the angle would be 90 degrees when we calculate the angle of impact.



Since the tail is a result of both the weapon's force and gravity, we do not quantify it. The smaller the angle of impact, the bigger the tail should be.

Sine of impact angle = width of bloodstain/ length of bloodstain



Determining Height

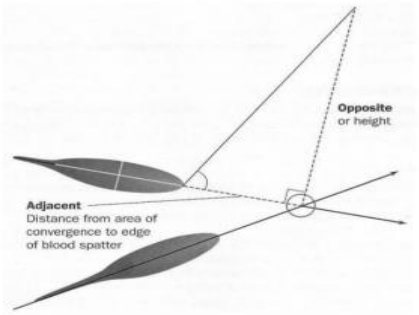
Determining the height at which the blood fell is crucial because it indicates the height from where the drop came, and by knowing the victim's height, we can infer that either the victim or the offender is the source of the blood mark.

Height = tangent of the angle × distance

Tangent of the angle of impact

=opposite/adjacent

= height /distance



Police Mathematics

To solve crimes, police officers employ mathematics on a daily basis. It is the responsibility of police officers to investigate the crime or accident site. On the work, they explain data that must be saved for information using math. For instance, skid marks from a speeding vehicle. Statistics, probability, and wavelets can all be used to store and evaluate data. Prime numbers and encryption can be used to send it safely. Police must first identify the information that lies behind the data, though. To determine what occurred and who was responsible, they must examine all of the evidence that was left at the crime scene and proceed backwards.

The officer must solve an inverse problem in order to determine the speed of the vehicle at the scene. Mathematical detective problems are called inverse problems. Trying to determine an object's shape based simply on its shadows is an example of an inverse issue. Also, a day in the life of a police officer.

Along with other elements like braking force, road friction, and collisions with other cars, the car's speed is what causes the imprints. Police officers must enter a formula to determine who is at responsibility for the collision in the absence of any witnesses at the scene. The officer's task is to determine whether or not the vehicle was speeding at the time of the collision. The police officer only knows that the car was damaged, that there were witnesses, and that the car had skid marks on it. Examining the skid marks can aid in reconstructing the collision.

Probability in Solving Crimes

Based on Rossmo's formula, Kim Rossmo claims that his research produced a new criminal investigation technique known as geographic profiling. His formula seeks to identify the potential residence of the criminal. Studies show that offenders tend to perform their crimes in locations that are neither too near nor too far from their homes. We can locate a range of potential sites.

In the diagram, the green spots highlight where the crimes have been done. The area called "HOT ZONE" is the area with the highest probability where the criminal resides.

$$p_{i,j} = k \sum_{n=1}^{(\text{total crimes})} \left[\underbrace{\frac{\phi_{ij}}{(|X_i - x_n| + |Y_j - y_n|)^f}}_{1^{\text{st}}\text{ term}} + \underbrace{\frac{(1-\phi_{ij})(B^{g-f})}{(2B - |X_i - x_n| - |Y_j - y_n|)^g}}_{2^{\text{nd}}\text{ term}} \right],$$

$$\text{where: } \phi_{ij} = \begin{cases} 1, & \text{if } (|X_i - x_n| + |Y_j - y_n|) > B \\ 0, & \text{else} \end{cases}$$

He uses the following formula

We divide the area into grids and the equation shows the probability in a particular grid

The first term essentially the denominator, measures the distance from the point of crime till the grid.

Higher the Distance → Higher the Denominator → Higher the Probability of the Grid Being the Residence Area of the Criminal

The second term essentially the denominator, subtracts the distance from a buffer zone

All of the other variables in the equation remain constant.

Higher The Distance → Lower The Denominator → Smaller The Probability Of The Grid Being The Residence Area Of The Criminal.

Both these terms help balance the distance from being too close or too far from the crime scene. When we add these, we can make the HOT ZONE

Conclusion

Forensic science is mostly used by law enforcement to look into crimes like theft and murder. The army also uses the forensic science procedures to analyse weaponry, high explosives, etc.

The development of identifying forensics has increased the significance of mathematics in the administration of justice, and its impact is still seen in matters of judgment and proof. Take statistics (evidence), for instance. One of the most crucial methods for detecting crimes is quickly emerging to be mathematics.

A variety of techniques, including probability and statistics, are now available to assist, whereas in the past a Sherlock Holmes would have to be satisfied with a magnifying glass or a jury with gut instinct and logical reasoning. Today, expert conclusions on mathematics are left behind.

Reference

Essential mathematics and statistics for forensic science; CRIAG ADAM