

Chapter 1

Introduction

Blood pattern analysis (BPA) is an important section of forensic science. The main objective of the discipline is to analyse blood spatter patterns in order to reconstruct events and to determine the point of origin of the blood droplets.

Traditional techniques use software or physical strings to determine the region of origin by assuming it lies in the flight path intersection of various flight paths. A simple straight line trajectory holds for high velocity droplets. For medium and low velocities a non-linear trajectory is more accurate. An interdisciplinary approach is needed to determine cause and effect from a possible complex pattern of geometrical blood spatter. The most probable points of origin of the blood droplets are determined by mathematical modelling, using factors such as distance fallen, trajectory, angle of impact and volume of the fluid. This study will focus on the mathematical fundamentals of non-linear trajectories with the use of multi-target tracking.

In multi-target tracking the location of various targets can be provided with the use of a detector. The aim of multi-target tracking is to determine the trajectories of multi-targets over time and to solve the location of each target at every time instant.

Optimization methods such as the k -shortest path algorithm can be used to solve tracking problems. This study will focus on non-linear trajectories and the use of optimization methods to solve tracking problems.

1.1 Blood properties

Blood is a combination of suspended particles and liquid which act as a unit due to the force between the molecules. The platelets, white blood cells and red blood cells are all suspended particles, and together with the liquid form plasma (Sackheim & Schultz, 1977).

Surface tension has to be overcome by gravity force for a blood drop to fall from a blood source (Nordby, 2006). Furthermore a blood drop will not break up when it is in the air. When any blood source is struck with force, the blood will exit the source and, due to the surface tension the droplet will be a sphere while in the air. A greater force will resolve it in a perfect sphere, while with a smaller force the sphere will oscillate since there are also other forces acting on the droplet (Bevel & Gardner, 2008).

Due to gravity, any droplet in flight will accelerate until the terminal velocity is reached. This implies that at a certain acceleration the air resistance will result in a constant velocity. At terminal velocity the acceleration is zero, thus the weight of and drag of the droplet will be equal and the height fallen does not have any significant influence on the droplet's diameter.

1.2 Different types of bloodstains

Bloodstains are divided into three categories: passive, transferred and projected bloodstains (Nordby, 2006).

A passive bloodstain is formed by only the force of gravity acting on the droplet. Examples of these bloodstains are pools, drops or drips of blood (Nordby, 2006).

A transfer bloodstain occurs when a person who is bleeding comes into contact with an object and the blood is transferred to the object (Nordby, 2006).

A projected bloodstain originates when blood is forced to leave the blood source by an external force (Nordby, 2006). These types of bloodstains can be divided into three groups according to the velocity of the external force (Akin, 2004):

- Low velocity spatter results when the blood source is hit with a velocity of 5 ms^{-1} or less and the spatter has a diameter of 3 mm or more.
- Medium velocity spatter is observed when the blood source is hit with a velocity of between 5 ms^{-1} and 50 ms^{-1} and the spatter has a diameter between 1 mm and 3 mm.
- High velocity spatter is apparent when the blood source is hit with a velocity of 50 ms^{-1} and higher and the spatter has a diameter of 1 mm or less.

The distance fallen has no an influence on the degree of spatter of the droplet on impact with a surface, only the surface texture does. A droplet will not spatter and the surface tension will not rupture if a surface is clean and smooth. However, if the surface has porous, protruding fibres or is rough, the blood will spatter, since rupture of the surface tension will occur (Nordby, 2006).

The shape of the blood stain is circular if the angle of impact is 90 degrees. If the angle is less than 90 degrees it will have a tear drop shape. In the case of a tear drop shaped bloodstain the sharp point is in the direction of forward travel before hitting the surface and is known as a directional bloodstain (Wells, 2006) as illustrated in figure 1.1.

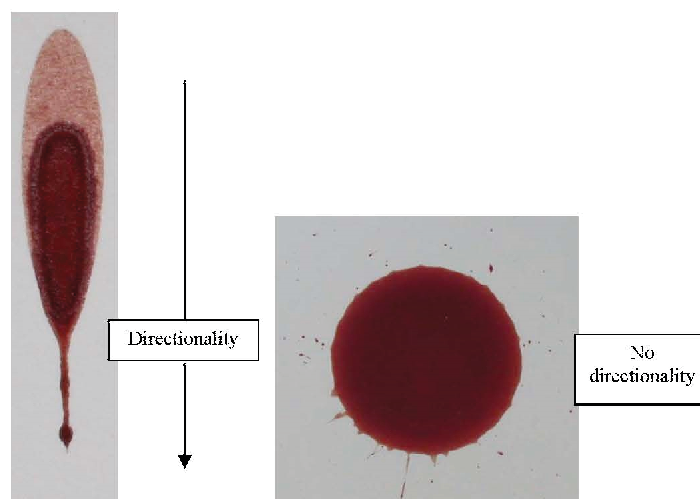


Figure 1.1: Directional and non-directional bloodstain (Wells, 2006)

At a crime scene the blood spatter analyst analyses the blood spatters to determine the point of origin, the movement of the blood, whether the victim came in contact with any object or victim and into which position the victim was before and during the crime (Bevel & Gardner 2008).

This interest of forensic experts, deriving the trajectories and origin of blood droplets from a particular spatter pattern, was the impetus for the investigation reported in this dissertation.