Technical Note

The Use of HemoSpat To Include Bloodstains Located on Nonorthogonal Surfaces in Area-of-Origin Calculations

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Abstract: Determining the origin of impact patterns at crime scenes can be a challenge when there is limited or less-than-ideal information. This is made even more difficult if the analyst cannot incorporate data from nonorthogonal and orthogonal surfaces in the same analysis. Using HemoSpat software for impact pattern analysis allows analysts to remove several limitations, maximize the use of this information, and produce precise and reliable results.

Introduction

Forensic software offers an efficient method to assist the bloodstain pattern analyst with area-of-origin calculations for impact patterns [1]. Reynolds et al. have shown that using computer-fitted ellipses in these calculations is precise and reliable [2].

Impact patterns generated in the laboratory are created under controlled conditions. This allows an analyst to generate high-quality impact patterns with plenty of information for a directional analysis. Impact patterns at crime scenes, however,

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are usually not as pristine and often have limited information. In such cases, analysts may have only a few acceptable spatter stains for analysis. These stains can be on several surfaces, any of which may not be parallel to the XY, XZ, or YZ planes.

Historically, bloodstain pattern analysts using forensic software for area-of-origin calculations had to exclude nonorthogonal (angled) surfaces from their calculations. Analysts could not incorporate orthogonal and nonorthogonal surfaces at the same time in their analyses [3, 4].

This study will show the use of nonorthogonal surfaces in conjunction with standard room surfaces in an area-of-origin calculation using HemoSpat, a commercial software (FORident Software, Inc.) for impact pattern analysis.

Materials and Methods

This study describes the use of angled surfaces in area-of-origin calculations. As part of this study, a controlled bloodletting target area was created at the Ottawa Police Service bloodstain laboratory.

The target area was contained in a three-sided area that measured 1.51 m wide by 1.23 m long. The walls of the area were made of white melamine board. A small table measuring 0.55 m long x 0.55 m wide x 0.45 m high was placed on an angle in the corner nearest the origin (0, 0, 0) of the target area (Figure 1). All bloodstains measured for this study were located in the target area.

The source of blood for the impact was a small pool of blood (2 mL). This was positioned at X = 71.0 cm, Y = 98.0 cm, Z = 2.5 cm on a rubber hockey puck (Figure 1). A single blow from a hammer was delivered to the blood in the general direction of the origin. This allowed for the maximum dispersion of the blood on the table and walls (Figure 2).

Figure 1

The target area.

Figure 2

The target area after a single impact to the blood source.

Seventy-eight stains were chosen for analysis. Thirty-eight stains were located on eight different surfaces of the table and 40 stains were located on the three walls. Each stain was given a unique identifier, and a vertical reference line was drawn for each using a level. The stains were photographed using a Nikon D200 camera.

The position of the table and the table surfaces were measured according to the HemoSpat conventions for surface documentation. Eight surfaces were measured (Top, Bottom, Side 1, Side 2, Leg 2B, Leg 3A, Leg 3B, and Leg 4A) before the table was removed for analysis. The locations of the bloodstains on the table were measured relative to each surface's bottom left corner, according to HemoSpat's measuring convention (Figure 3). Table 1 lists the stains on the table and their corresponding surfaces.

Stain Number	Surface
1-3	Leg 3A
4-6	Leg 3B
7-9	Leg 2B
10-16	Side 2
17-24	Side 1
25-29	Top
30-36	Bottom
37-38	Leg 4A

Table 1

Bloodstains located on the table and their corresponding surface.

The locations of the bloodstains on the walls (left, front, and right) were measured relative to the room's origin (Figure 4). The origin was chosen as the corner formed by the left wall, the front wall, and the floor. Table 2 lists these stains and their corresponding surfaces.

Stain Number	Surface
39-48	Left Wall
49-68	Front Wall
69-78	Right Wall

Table 2

Bloodstains located on the walls and their corresponding surface.

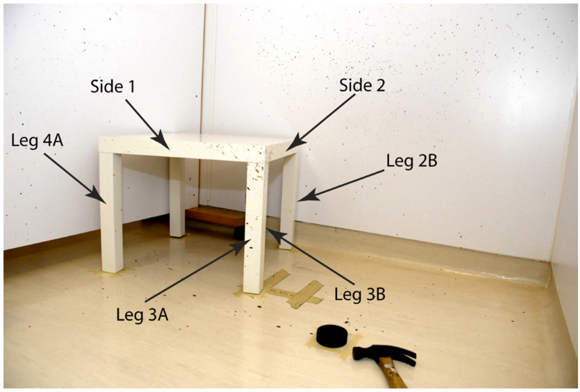

Figure 3

The table after the impact, with the legs and sides labeled.

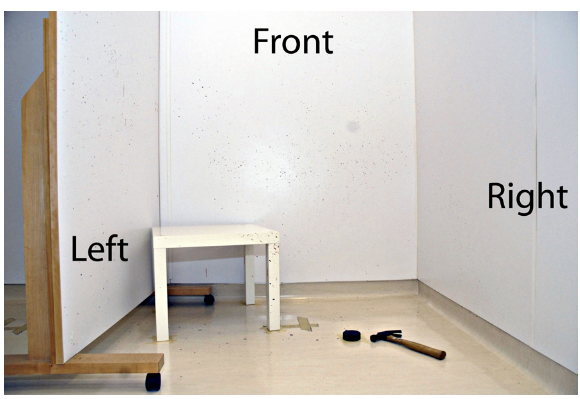

Figure 4

The left, front, and right walls of the target area.

Surface information, stain images, and stain locations were entered into HemoSpat version 1.2 for analysis. Each stain image was analyzed to identify the vertical reference angle, scale, and the bloodstain ellipse. From this, HemoSpat calculated all angles and the origin for the pattern.

Three different area-of-origin calculations were completed using the same data set: one using only the stains from the table, one using only the stains from the walls, and one using all the selected stains. This was done to examine the use of nonorthogonal surfaces separately and in conjunction with standard room surfaces in an area-of-origin calculation.

Results

Area-of-origin calculations were completed using just the stains from the table, just the stains from the walls, and all the stains. The results from the three calculations are given in Table 3.

	X/cm	Y/cm	Z_{max}/cm
Known	71.0	98.0	2.5
Calculated origin based on stains from the table	68.4 ± 3.2	91.4 ± 9.5	11.7
Calculated origin based on stains from the walls	72.0 ± 7.3	100.0 ± 6.4	18.9
Calculated origin based on all stains	70.0 ± 8.4	97.8 ± 8.3	17.6

Table 3

Known position of the blood source and the origin values calculated by HemoSpat.

Discussion

The area of origin can give a general location [5] or relative posture [6] of a bleeding victim who has received a blow. In the literature, there are several limits used for area-of-origin calculations. These include a tennis ball, a grapefruit, a soccer ball, and a basketball [7, 8]. The limit of 30.5 cm [9] was chosen as a comparison criterion because it was a defined measurement that incorporated all of these illustrations.

The results of the study are presented using three sets of data to calculate the area of origin. The use of just the stains from the table, just the stains from the walls, and all the stains will be discussed. There was excellent agreement between the three area-of-origin calculations and the known position of the source.

Stains from the Table

There were 38 stains on the table that were documented. The stains were chosen because of their size, shape, and location. There was some difficulty with stain selection on the table because of the nature of the target material.

The legs were constructed of a pressed wood core covered with a thick-coated paper. Although the legs were white and provided an excellent contrast with the blood, there was a problem with the bloodstains flaking away. It appeared that the larger the stain size, the more prone it was to flaking (Figure 5).

The top and sides of the table were also constructed of a pressed wood core with a white melamine-like surface. Again, this provided a surface that had excellent contrast with the blood. Some stains also flaked off this surface material, but not as many compared to the legs.

The bottom of the table was a finished face of the wood core. This surface was a more natural wood color and provided good contrast with the blood. The problem with this surface was that there was some absorption of the blood. This was not consistent across the entire surface.

Despite the challenges the different surfaces presented, there were enough stains present that were suitable for analysis.

The area of origin calculated using just the stains from the table differed from the known origin by 2.6 cm on the X axis, 6.6 cm on the Y axis, and 9.2 cm on the Z axis. Figure 6 shows the top view of the stains from the table.

The area of convergence calculated for the stains from the table was located between the table and the actual source. Aside from the arguments for analyst error, there are other possible explanations for the discrepancy.

One possible explanation involved the placement of the source. The source was close to the ground. This did not allow some of the calculated paths to pass through the general source location [10]. The paths may have been "cut" short when they hit the floor, thus moving the calculated origin away from the known origin.

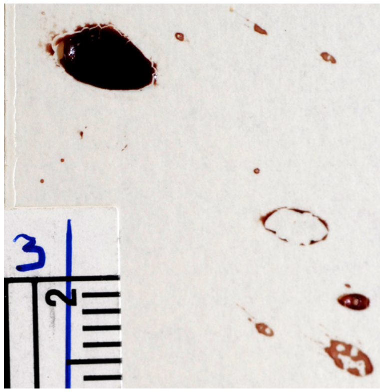

Figure 5

Flaked stains on the table legs.

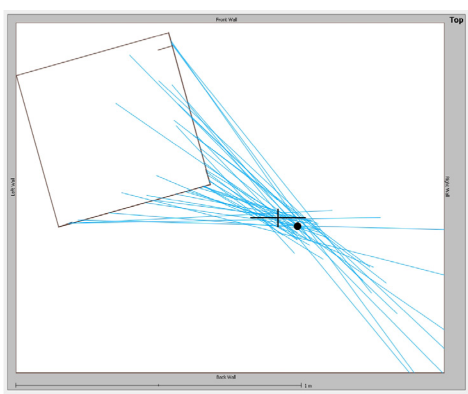

Figure 6

Screen shot of the top view of the stains from the table and the calculated origin. The black dot was added to show the approximate location of the known origin.

Stains from the Walls

There were 40 stains on the walls that were documented. The stains were chosen because of their size, shape, and location.

The blow that created the pattern was struck on an angle in the general direction of the origin of the target area (0,0,0). As previously indicated, this was done to maximize the dispersion of the blood on the table and walls. In doing so, there was a void created on the left wall and front wall that essentially eliminated a large number of potentially high-quality stains (Figure 7).

It is known that the top-down view (X-Y plane) of a reconstruction provides the best method of calculating the area of convergence and that any calculation of the height component of the area of origin is an upper limit [11]. The area or origin that was calculated using just the stains from the walls differed from the known origin by 7.3 cm on the X axis, 6.4 cm on the Y axis, and 18.9 cm on the Z axis. Figure 8 shows the top view of the stains from the walls.

As expected, the calculated Z value from the walls was higher than the known origin. James et al. discussed how the distance from the area of convergence may affect the height calculation [12]. The farther a blood drop travels, the more its path will assume a parabolic arc. Using a straight line to approximate its path will force the line higher than the actual trajectory.

It is possible that the Z value that was calculated using the stains from the walls was affected by the distance the blood had to travel. This could contribute to the 7.2 cm difference in the Z value that was calculated from the stains on the walls and the Z value that was calculated from the stains on the table. It follows that this would also affect the Z value calculation involving all of the stains.

Although the calculated Z value was higher than that calculated using just the stains from the table, it still fell within an acceptable range.

All of the Stains

The use of all of the stains in the area-of-origin calculation produced excellent results. The values differed from the known origin by 1.0 cm on the X-axis, 0.2 cm on the Y-axis, and 15.1 cm on the Z-axis. Figure 9 shows the top view of all of the stains.

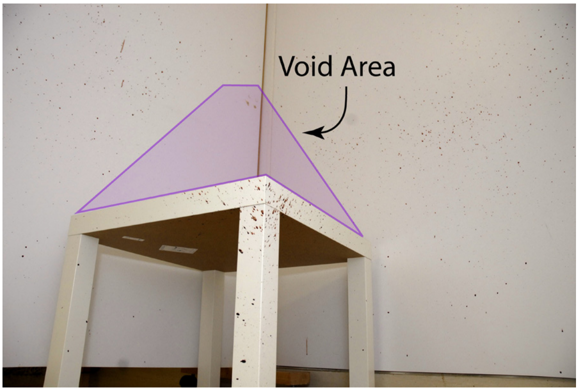

Figure 7

An image marked with the void above the table on the left and front walls.

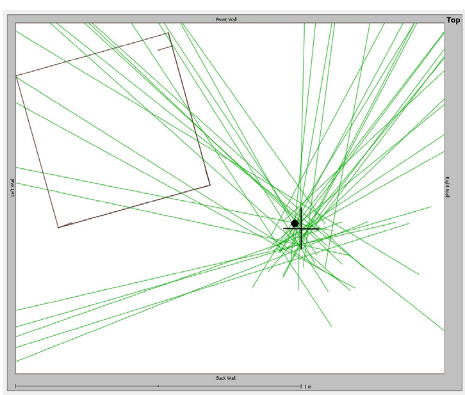

Figure 8

Screen shot of the top view of the stains from the walls and the calculated origin. The black dot was added to show the approximate location of the known origin.

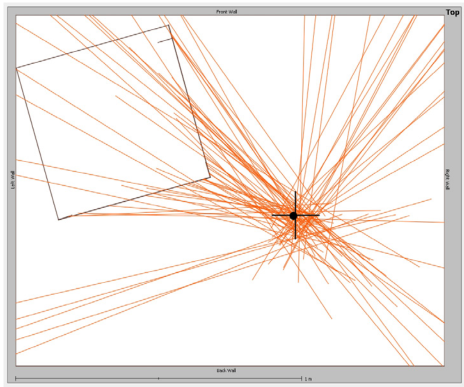

Figure 9

Screen shot of the top view of all of the stains and the calculated origin. The black dot was added to show the approximate location of the known origin.

Conclusion

The use of forensic software in area-of-origin calculations using nonorthogonal surfaces can greatly assist the bloodstain pattern analyst.

This study demonstrated that calculations using bloodstains located on both nonorthogonal and on orthogonal surfaces were possible and presented excellent results. When all the data was used, the calculation of the convergence was within 1 cm of the source and the maximum height was within 15.1 cm.

The task of analyzing bloodstains on nonorthogonal surfaces is made easier by using the HemoSpat software. This allows the analyst to remove objects from the scene, analyse them in a controlled and safe environment, and incorporate the data in an area-of-origin calculation.

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