Innovative and Traditional Techniques in Crime Scene Reconstruction – a Case Study[1]

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This study presents the integration of traditional and contemporary methods in the domain of crime scene reconstruction, utilizing a homicide case as a practical illustration. The incident, dating back to the fall of 2021, involved the proprietor of a Hungarian distillery who caused the fatality of his employee during a dispute, employing both a stick and his bare hands as weapons. In the immediate aftermath of the crime, traditional methods of reconstruction were executed. Evidence of numerous hematomas on the victim's body was documented via meticulous close-up photography at the scene. During subsequent post-mortem examination, the size and shape of the hematomas were indistinguishable, yet the initial photographs facilitated pattern recognition that enabled an estimation of the number of strikes inflicted upon the victim. Additionally, a shoeprint detected on the victim's trousers was matched to the suspect's footwear, thereby corroborating the presence of a trampling event.

Modern techniques of reconstruction were later implemented. The crime scene was digitally rendered into a 3D model via photogrammetry, incorporating specific images from the original scene. The discovery and documentation of bloodstains informed subsequent bloodstain pattern analysis (BPA) conducted through the Hemospat software. The BPA yielded insights into the victim's movements during the altercation. These graphic findings were subsequently incorporated into the 3D model, offering a more comprehensive and visually compelling representation of the crime scene.

Through the synergy of conventional techniques such as pattern recognition and advanced approaches like BPA and photogrammetry, a comprehensive testing of the suspect's confession and a nuanced reconstruction of the incident were achieved. This integrative approach played a pivotal role in concluding the case as an intentional homicide.

Keywords: homicide, bloodstain pattern analysis, HemoSpat, photogrammetry, 3D modeling

I. Introduction

At the end of October 2021, the police received a report that there had been a fatal incident at a private distillery located in the outlying area of Pirtó village in Central Hungary. When the police arrived on the scene, they found the owner of the distillery, a neighbor, and members of

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a medical team in the boiler room. The doctor who was part of the medical team didn't rule out the possibility of foul play, as the deceased had multiple injuries consistent with physical assault. The police interviewed the distillery's owner, who was also the employer of the deceased. The man stated that in the late afternoon, as he was heading to the boiler room, he found his employee on the ground still showing signs of life. He called his neighbor for assistance. Upon arriving in the boiler room, the neighbor attempted to resuscitate the injured person, and immediately asked for help using an emergency call system, but they were unable to save him. Based on the gathered information, the authorities conducted a crime scene inspection and initiated an investigation due to suspicions of a criminal offense. Detailed photographs were taken during the post-mortem examination by the on-call doctor, showcasing the deceased's injuries and visible blood-like stains in the boiler room. The victim's clothing and a tool handle stained with what looked like blood were confiscated. Since it was not entirely clear at the time of inspection whether a homicide had taken place, latent blood testing and inspection of the owner's clothing were deferred to a later stage in the investigation.

In Hungary, any "non-natural" death is handled by the criminal police. A non-natural death includes deaths resulting from criminal acts, which trigger a criminal investigation. Other cases of non-natural death, referred to as exceptional deaths, include all suicides, fatal domestic accidents, deaths from unknown causes, deaths of detainees even if from natural causes, and deaths of persons with unknown identities even if from natural causes. In these cases, the criminal police initiate an administrative procedure. The administrative procedure is carried out in such a way that if suspicions of a crime against life arise later, the evidence obtained during the administrative process can be used in the criminal investigation. The administrative procedure involves crime scene investigation, post-mortem examinations, autopsies, witness interviews, data collection, etc. In criminal proceedings, the autopsy is performed by two medical experts, while in administrative proceedings it's done by one expert. Although legally one can forgo an autopsy in administrative proceedings if no further information is expected from it, in Hungary, autopsies are almost always conducted. If, during the administrative process, the pathologist performing the autopsy suspects crime, the autopsy is halted, and the police are informed.

A death resulting from an intentional crime can be classified as homicide under Hungarian law if the perpetrator intends to take a life or resigns themselves to the possibility of the death occurring. A crime beyond intentionality is treated more leniently under the law, occurring when the perpetrator intends only to assault the victim, but the victim subsequently dies from the injuries. In Hungarian law, this is not considered negligent homicide but is deemed more serious than negligent homicide and less severe than intentional homicide. Negligent homicide carries a sentence of 1-5 years of imprisonment, crimes beyond intentionality have a range of 2-8 years, while intentional homicide has a range of 5-15 years. There are multiple aggravating factors for intentional homicide; under one such qualification, the sentence can range between 10-20 years or even life imprisonment. Aggravating factors include premeditated homicide, base motives or objectives (like sexual assault), exceptional cruelty (which can be causing excessive suffering or excessively brutal acts dehumanizing the victim), killing a defenseless victim, killing a child under 14 years of age, killing multiple people, etc.

In cases where the victim dies as a result of physical force or blunt trauma, it's essential to clarify the intent and the aggravating factors. Often, the acts involve beatings, leading to various non-immediately fatal injuries. However, frequent assaults can raise suspicions of murderous intent. Prolonged assault can suggest particularly cruel intent or suggest a crime against a defenseless person. The punishment can vary widely, from two years to life imprisonment, and depends solely on what can be proven. In most cases of death resulting from beatings, the perpetrator will admit to the intention to harm but not to the intention to cause death.

Regarding the fatal incident at the Pirtó distillery, the autopsy was conducted by experts from the Hungarian Institute for Forensic Sciences (HIFS). During the post-mortem examination and autopsy, numerous external and internal injuries were noted. The victim had injuries on their nose, the left side of the head, arms, upper, and lower body, which could result from hits, kicks, and assaults with a rod-like object. From the waist downwards, traces of instrumental impact were visible on the victim's back during the post-mortem examination, but these marks were not discernible during the autopsy. The investigating authority ensured an expert examination combined with an additional inspection for the appointed trace expert to examine the suspicious blood stains in the boiler room and reconstruct the mechanism of the victim's injuries. The goal was to combine traditional forensic investigative methods with the latest technical advancements and expert techniques to better substantiate data influencing the qualifying circumstances and to either prove or rule out the fact of intentionality.

II. Method

A 3D photogrammetry

In the context of a forensic scientist on-scene examination, a three-dimensional capture of the crime scene was carried out using 3D photogrammetry. Photogrammetry is a three-dimensional imaging process in which specialized imaging software determines the approximate three-dimensional structure of objects based on photographs taken from various viewpoints using mathematical methods. The basis of the photogrammetric three-dimensional model is a series of photographs that systematically scan the area or object to be captured in such a way that every detail becomes visible in different shots. The consecutive elements of the photo series must overlap with each other by at least 50-70%[6].

The photo series was created under poor lighting conditions. The equipment used included a Canon EOS 6D camera, a Canon EF 24-70 mm f/4L IS USM lens, and a Canon Speedlite 430EX II flash. To expedite the process, a tripod was not used; instead, high sensitivity settings (ISO 1000-2000), relatively wide or moderately narrow aperture settings (f/5-f/9), flash and lamp lighting were employed to allow for handheld shooting with manageable shutter speeds (1/25-1/60s) while using a 24mm focal length. A total of 511 Canon Raw 2 (CR2) format photos were taken in a room with complex geometry containing numerous objects, and the photo capture process took approximately 45 minutes.

As part of the expert examination, additional metric photos were taken of visible, unwashed bloodstains, and the remnants of washed bloodstains were visualized and photographed using luminol.

The CR2 format photos were converted into JPG files using Adobe Photoshop Lightroom CC (Version 2015.12), and the three-dimensional model was created using RealityCapture (Version 1.2.0.16813) photogrammetry software. During the reconstruction of the three-dimensional model, relevant photos from the primer crime scene investigation were also used (a total of 32 photos). Due to the use of crime scene photos, the individual adhesive labeling numbers indicating bloodstains on the three-dimensional model appear partially transparent, which were used by the examination committee during the scene investigation. The three-dimensional model created from the scene detail is dimensioned based on on-site measurements and approximately reflects real-world dimensions.

[6] Metzger Máté, Ujvári Zsolt, Gárdonyi Gergely, 'Forensic Application of Photogrammetry: Reconstruction of crime scenes, corpses, and object is three dimensions. [A fotogrammetria kriminalisztikai célú alkalmazása: helyszínek, holttestek, tárgyak rekonstrukciója három dimenzióban. In Hungarian]'*Belügyi Szemle*, 2020/11., 57-70. DOI: 10.38146/BSZ.2020.11.4

B Bloodstain pattern analysis and HemoSpat

Bloodstain pattern analysis (BPA) infers what happened, the sequence of events, the number of events, and the timeframe of the events from the shape characteristics of blood found at a crime scene, the characteristics of blood droplets, and the distribution of multiple droplets. It may reveal the relative positions of the involved parties and their movement in space.[7]

In this case, the *expiration pattern* was one of the relevant trace types.[8] This pattern occurs when blood exits under pressure from the mouth or nose. It typically consists of small blood droplets, sometimes with observable air bubbles at their center. Another relevant trace type was the *swipe pattern*, which happens when a bloody object touches a surface and then moves across it.[9] Its significance lies in the fact that the direction of the smear can usually be precisely determined, and in cases with overlapping traces, the order of their formation can also be ascertained. The *impact pattern* is a crucial trace type, which is created when blood splatters due to physical force, commonly seen in unarmed or weaponized assaults.[10] Its immense significance lies in the fact that, once the blood droplets land on a surface, one can calculate the angle of impact (the sine of the angle of impact is the ratio of the droplet's length to its width). Furthermore, the droplet's long axis indicates the *area of convergence*, from which the *area of origin* in space can be determined when the angle of impact is known. The term *pool* refers to when a significant amount of blood accumulates due to gravity.[11] Typically on the floor, this occurs when bleeding happens over a relatively extended period. The *transfer stain* is also crucial, which is the contact of a bloody object with a surface; it differs from the swipe pattern in that the bloody object does not move across the surface.[12] Its significance lies in the fact that the original bloody object's outlines and patterns are often clearly visible when observing the transfer stain.

Using processed crime scene photos, the *FORident HemoSpat v11.1* software automatically calculates the angle of impact.[13] By processing multiple droplets, the area of origin can be determined with the software's help. The result can be exported in graphic format, and the exported file can be embedded into three-dimensional image files.

The investigative authority provided the pattern evidence expert with the case's documentation and the original complete attire of both the victim and the perpetrator. Based on the information in the documentation and the suspect's testimonies, the pattern evidence expert established scenarios that could be corroborated or refuted through expert examination of the submitted evidence and crime scene clues and traces.

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[8] Stuart H James et al, *Principles of Bloodstain Pattern Analysis. Theory and Practice* (Boca Raton: CRC Press, 2005) 160; Tom Bevel and Ross M Gardner: *Bloodstain Pattern Analysis with an Introduction to Crime Scene Reconstruction* (Boca Raton: CRC Press, 2008) 225; William G Eckert, *Introduction to Forensic Sciences* (Boca Raton: CRC Press, 1997) 197

[9] Stuart, *Principles*, 89; Bevel and Gardner, *Bloodstain Pattern Analysis*, 59; William G Eckert and Stuart H James, *Interpretation of Bloodstain Evidence at Crime Scenes* (Boca Raton: CRC Press, 1998) 306

[10] Stuart, *Principles*, 119; Bevel and Gardner, *Bloodstain Pattern Analysis*, 41; Eckert, *Introduction*, 196

[11] Stuart, *Principles*, 87; Bevel and Gardner, *Bloodstain Pattern Analysis*, 61; Eckert, *Introduction*, 188

[12] Stuart, *Principles*, 88; Bevel and Gardner, *Bloodstain Pattern Analysis*, 61; Eckert and Stuart, *Interpretation*, 50

[13] https://hemospat.com/#/0

C Mark examiner's methods

The mark examiner visually examined various residue smears (e.g., blood-like stains, dust smears) on the clothing items, inferring their formation mechanisms from their morphological properties.

Based on the size and shape characteristics of the visually observed footwear mark fragment on the victim's trousers, a preliminary selection was made among the available footwear. The sole of the suspect's right shoe showed size and shape similarities with the imprint fragment. Thus, using an ink method, a test imprint was made with it. Metric photographs of the imprint fragment and the test imprint were enlarged to the same scale and superimposed on each other using a superposition method.

III. Results and discussion

The scene of the crime was the distillery's boiler and the "L"-shaped room surrounding it. During an expert review held a week after the crime, we found several small blood drops on the boiler's front and side panels, as well as on the wall next to the boiler. However, the distillery owner, who was still at large, destroyed some of the blood-suspicious contaminants in the days following the investigated event. A secondary inspection allowed us to also conduct latent blood trace research on the concrete floor. To carefully assess the blood traces on-site, we conducted measurements, used Luminol blood trace research, and photographed the location using photogrammetry.

From the photos taken using the photogrammetry method, we created a 3D model, into which we successfully integrated those metric photos taken during the previous scene examination, showing all the blood-suspicious contaminants. This provided a virtual 3D representation of the original scene for the expert examination.

The blood stains found on the boiler's front wall in size and distribution were typical of an impact pattern. We documented their exact location in photographs and measured the distance of the drops from the concrete floor and the sidewall. Subsequently, by inputting the data into the HemoSpat software, we obtained three different areas of origin that suggested an assault in front of the boiler's front panel. Considering the victim's height, the area of origin corresponded to the slightly stooped head of the victim. The isolated impact pattern suggested at least one additional, fourth assault. We integrated the exported graphics from the HemoSpat software into the 3D model, making visible the victim's four reconstructed head positions in the 3D space, where injuries were sustained leading to an impact pattern on the boiler's vertical surface (see Picture 1).

Picture 1: The boiler with blood stains[14]

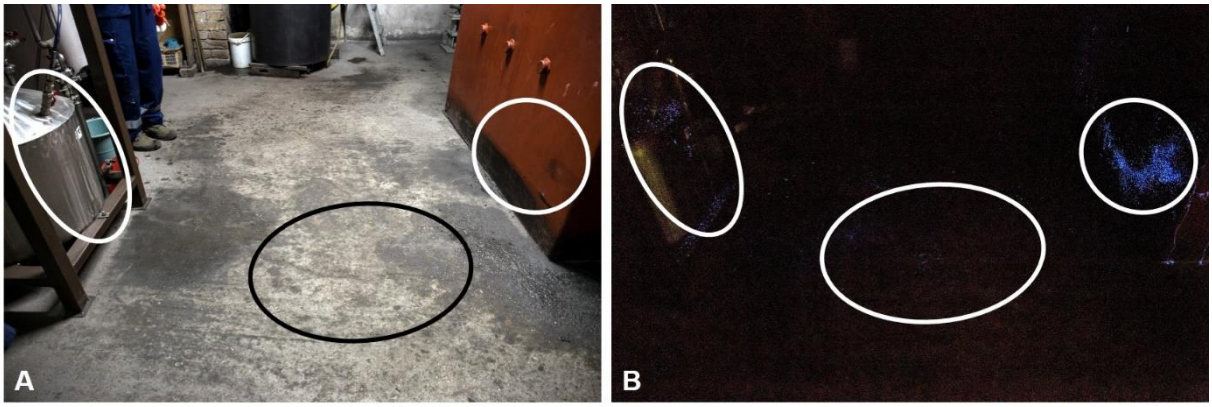
A: To the right of the entrance to the boiler house, there's a boiler where blood stains of an "impact pattern" type can be seen on its front wall. During the on-site examination, significant groups of traces were marked with metric arrows. B: During the expert examination, we measured the distance of the visible blood stains on the front wall from the wall and the concrete floor, and fed this data into the HemoSpat software. The results were integrated into the 3D model in vector format. The intersection points of the vectors show the spatial position of the injured person's bleeding head injuries, which we marked with colored circling. B-C: Blood stains wiped off by the owner of the distillery became visible on the entrance opening and the side wall of the boiler after integrating the inspection images into the 3D model (areas circled with dotted lines). We marked the blood traces, which were of the "expiration pattern" and "swipe pattern" type, close to ground level on the boiler's side wall with framing and circling. D-E: On the side wall of the boiler, the "expiration patterns" marked with green circling and the "swipe pattern" marked with white framing can be seen in detail.

For other impact patterns on the room's vertical surfaces, we could not make similar precise measurements as the owner washed most of the boiler's sidewall and the surfaces of the entrance's sidewalls. Based on the metric onsite photos integrated into the 3D model, additional

[14] Source: Pictures taken by Zsolt Ujvári.

assaults, either with bare hands or using tools, and of medium velocity, likely affected the victim standing near the entrance and in front of the boiler's sidewall. Extremely elongated impact patterns are observed on the wall plane perpendicular to the boiler's front wall, indicating the blood source was very close to the wall. This is typical when the blood source hits the wall or a bloody body part strikes the wall, where in this case, the wall was the entrance. These traces also start from a height corresponding to the victim's head.
On the opposite door's glass insert to the boiler's front wall, an expiration pattern was visible at about face height considering the victim's height, confirming that the victim was still standing when blood from the respiratory tract got onto the vertical surface. Considering the victim's bleeding injuries, these trace groups could have formed, for example, as a result of a nasal injury when the victim coughed or sneezed while standing in front of the door.
Near the ground level below the mentioned impact patterns on the boiler's sidewall, another expiration pattern was observed. This group of blood traces confirmed that blood was exiting from the victim's airways when they were lying down, and their head was close to the boiler's sidewall. We found two swipe patterns in opposite directions here, suggesting the victim was moving back and forth while lying on the ground. Although it's generally possible to determine the sequence of trace groups, we couldn't determine the sequence between the expiration pattern and the swipe patterns here. This could be because the boiler wall was still hot when the blood reached its surface, and the traces burned onto it (see Picture 1 C-E).
These ground-level traces closely relate to the transfer stain or pool observed on the concrete floor made visible with Luminol during the secondary inspection, and the impact patterns visible on the surface of the tank opposite the boiler (see Picture 2).

Picture 2: The crime scene before and after using Luminol [15]



A: On the right side of the photo, there is a silver-colored tank, and on the left side, the side wall of the boiler can be seen. Bloodstains (impact pattern, expiration pattern, swipe pattern) were visible on their vertical surfaces. There were no blood traces on the intermediate concrete floor. B: Using Luminol, transfer stains or pools originating from the victim's head injuries also became visible on the concrete floor.

Blood traces, due to gravity, from the bleeding injuries to the victim's head were visible on the victim's clothing. The front of the perpetrator's coat showed an expiration pattern mixed with bloody saliva. According to the perpetrator's later confession, this could have formed when he moved the still-living victim before asking for help from a neighbor. On the side of his footwear, we found swipe patterns that indicated kicking the bloody body surfaces.
The deceased's clothing was covered in various material contaminants, whose morphological properties also supported the distillery owner's statement that after the assault, he dragged the victim by their armpits to a sitting position near the entrance (see Picture 3A). Additionally,

[15] Source: Pictures taken by Zsolt Ujvári

during the forensic examination, a shoe impression was discovered on the left calf area of the victim's trousers, which had been preserved in its original state. Subsequent comparative analysis revealed that it originated from the sole of the perpetrator's right footwear (see Picture 3). Thus, the perpetrator stepped on the lower leg of the victim already lying prone.

Picture 3: The trousers of the victim and test imprint of the perpetrator's right footwear[16]

A: The backside of the victim's trousers can be seen. We marked with dotted framing the dust smudges that could originate from moving the body. B: A footwear imprint fragment can be seen on the left calf of the trousers. C: A test imprint made with an ink method from the walking surface of the perpetrator's right footwear. Images B and C are magnified to the same scale

Photographs from the death examination and the forensic examination of the confiscated, blood-stained tool handle quantified the number of tool-induced impacts on the victim's lower body, which the forensic pathologists couldn't determine during the autopsy. There were also injuries on the upper body indicative of a tool-related assault, but the properties of the trace-forming tool weren't reflected, and quantification wasn't possible. The perpetrator struck the victim's buttocks, thighs, and calves with a rod-like rigid object at least 28 times.

IV. Conclusion

The results of the investigations and the conclusions drawn from them, including the most likely version of events, were presented by experts at the criminal trial using visual documentation and a 3D model. With the projected 3D model in the courtroom, participants of the trial got a precise picture of where the victim and their assailant moved from and to during the examined incident, and what actions might have taken place at specific points in space. The experts, based on an assessment of bloodstains and physical evidence on site, and statements made in the

[16] Source: Pictures taken by Zsolt Ujvári.

perpetrator's testimonies, concluded that the owner of the distillery repeatedly punched his employee near the entrance of the boiler room, then in front of the boiler's front wall. As a result, the victim's nose might have been broken. The scuffle between the two continued in front of the boiler's side wall, and then the victim ended up lying face down on the concrete floor. At this point, the assailant grabbed a tool and spanked his victim with a wooden tool handle, then kicked and stomped on him multiple times. After realizing something was wrong, he dragged the victim to the entrance and called his neighbor for help. The defendant, who fully confessed, raised no objections to the expert findings, did not dispute the accuracy of the reconstruction, and the expert examination confirmed his final testimony in many ways. The only disagreement he had with the reconstruction was about the position of the victim lying on the ground. The bloodstains noticed near the ground level on the side wall of the boiler were intended to position only the victim's head; it couldn't precisely determine where the victim's other, non-bleeding body parts were located in the available space. The exact position of the victim's body has no effect on the events, the assault, the sequence, and the timing.
Therefore, the forensic medical findings and the bloodstain analysis-based trace expertise confirmed that the victim was assaulted while standing, then lying down, thus establishing the qualification of particular cruelty. The 67-year-old defendant was sentenced by the Kecskemét Court to 15 years in prison and a 10-year ban from public affairs, without the possibility of parole, for the crime of murder committed with particular cruelty.[17]

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