

2018

A data set of bloodstain patterns for teaching and research in bloodstain pattern analysis: Impact beating spatters

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Abstract

This is a data set of 61 blood spatter patterns scanned at high resolution, generated by controlled impact events corresponding to forensic beating situations. The spatter patterns were realized with two test rigs, to vary the geometry and speed of the impact of a solid object on a blood source – a pool of blood. The resulting atomized blood droplets travelled a set distance towards a poster board sheet, creating a blood spatter. Fresh swine blood was used; its hematocrit and temperature were measured. Main parameters of the study were the impact velocity and the distance between blood source and target sheet, and several other parameters were explored in a less systematic way. This new and original data set is suitable for training or research purposes in the forensic discipline of bloodstain pattern analysis.

Disciplines

Databases and Information Systems | Design of Experiments and Sample Surveys | Forensic Science and Technology | Mechanical Engineering

Comments

This is a manuscript of the article Attinger, Daniel, Yu Liu, Tyler Bybee, and Kris De Brabanter. "A data set of bloodstain patterns for teaching and research in bloodstain pattern analysis: impact beating spatters." *Data in Brief* (2018). DOI: [10.1016/j.dib.2018.02.070](https://doi.org/10.1016/j.dib.2018.02.070). Posted with permission.

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ELSEVIER

Contents lists available at ScienceDirect

Data in Brief

journal homepage: www.elsevier.com/locate/dib

Data Article

A data set of bloodstain patterns for teaching and research in bloodstain pattern analysis: Impact beating spatters

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ARTICLE INFO

Article history:

Received 12 January 2018

Received in revised form

18 February 2018

Accepted 26 February 2018

ABSTRACT

This is a data set of 61 blood spatter patterns scanned at high resolution, generated by controlled impact events corresponding to forensic beating situations. The spatter patterns were realized with two test rigs, to vary the geometry and speed of the impact of a solid object on a blood source – a pool of blood. The resulting atomized blood droplets travelled a set distance towards a poster board sheet, creating a blood spatter. Fresh swine blood was used; its hematocrit and temperature were measured. Main parameters of the study were the impact velocity and the distance between blood source and target sheet, and several other parameters were explored in a less systematic way. This new and original data set is suitable for training or research purposes in the forensic discipline of bloodstain pattern analysis.

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Specifications Table

Subject area	Legal Medicine, Engineering
More specific subject area	Forensics – Bloodstain Pattern Analysis (BPA)

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<https://doi.org/10.1016/j.dib.2018.02.070>

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Please cite this article as: D. Attinger, et al., A data set of bloodstain patterns for teaching and research in bloodstain pattern analysis: Impact beating spatters, Data in Brief (2018), <https://doi.org/10.1016/j.dib.2018.02.070>

55	Type of data	<i>Images of 61 blood impact beating spatters, with text file describing the experimental conditions</i>
56		
57	How data was	<i>Blood atomized with custom test rigs, as described in the manuscript. Spatters</i>
58	acquired	<i>collected on poster board or butcher paper, and scanned with flatbed scanner A3</i>
59		<i>Epson Expression 11000XL</i>
60	Data format	<i>images scanned at 600 dot per inch (about 42.3 μm per pixel) and saved as.jpg</i>
61		<i>with minimum compression (10% compression max)</i>
62	Experimental	<i>Spatter images with dimensions of max 1.36 m \times 1.1 m, scanned in a piecewise</i>
63	factors	<i>manner and reassembled with image processing software</i>
64	Experimental	<i>Blood pool of ~ 1 mL volume on flat immobile surface impacted by either a</i>
65	features	<i>cylindrical rod or a flat surface; impact velocities between 2 m/s and 8 m/s; hor-</i>
66		<i>izontal distances between target and blood source from 30 cm and about 2 m; few</i>
67		<i>data items involve multiple impacts on same target, and impact on soaked foam</i>
68		<i>rather than pool</i>
69	Data source	<i>Ames, IA. Physical Targets have been preserved</i>
70	location	
71	Data accessibility	<i>Electronic data set is with this article, in two zip files of Supplementary material</i>

Value of the data

- The data set can be used by researchers to test crime scene reconstruction models [1–3]. Briefly, these models pursue two purposes. First, they classify patterns with respect to their generation mechanism (e.g. beating vs. shooting [4]). Second, they determine the region of origin of the blood spatter [5,6]. Recently, the US National Academies emphasized [7] the need to develop more accurate bloodstain pattern analysis methods, with stronger fluid dynamics foundations. Accessibility to large amounts of bloodstain patterns produced under controlled conditions is thus important for the development of the needed science base [3,7–9]. The data in this manuscript addresses the above issues by systematically documenting the experimental conditions.
- The data helps dissemination of blood spatters for teaching and instructional purposes. Indeed, production and transport of blood spatters is cumbersome. A large space, the size of a habitation room, is needed to create a realistic blood spatter; and care should be taken to have a reproducible and realistic generation mechanism, be it a beating or a gunshot. Blood sourcing and handling is not trivial either. Human blood for instance needs to be used under strict safety conditions because of the risk of blood-borne diseases and pathogens. Since travelling across borders is common for BPA instructors, both alternatives of travelling with blood spatters through customs or having the blood spatters prepared at the site and time of the workshop involve logistic efforts and safety risks. This database provides provide BPA instructors with a safe set of spatters ready to be printed for their classes.
- This data set is new and original, and has not been published elsewhere.
- The experimental design and methods described in this manuscript can be readily reproduced and used to create additional blood spatters.

1. Data

Blood spatters are a subset of bloodstain patterns, with stains generated by drops gone airborne [1–3] before hitting the surface of a solid object called the target. Impact spatters are spatters where blood is atomized by a force applied impulsively to the blood source [2]. Those features of atomization and airborne transport are rarely observable in a crime scene, and distinguish spatters from other bloodstain patterns, such as transfers where stains are produced by contact between the blood source and the target.

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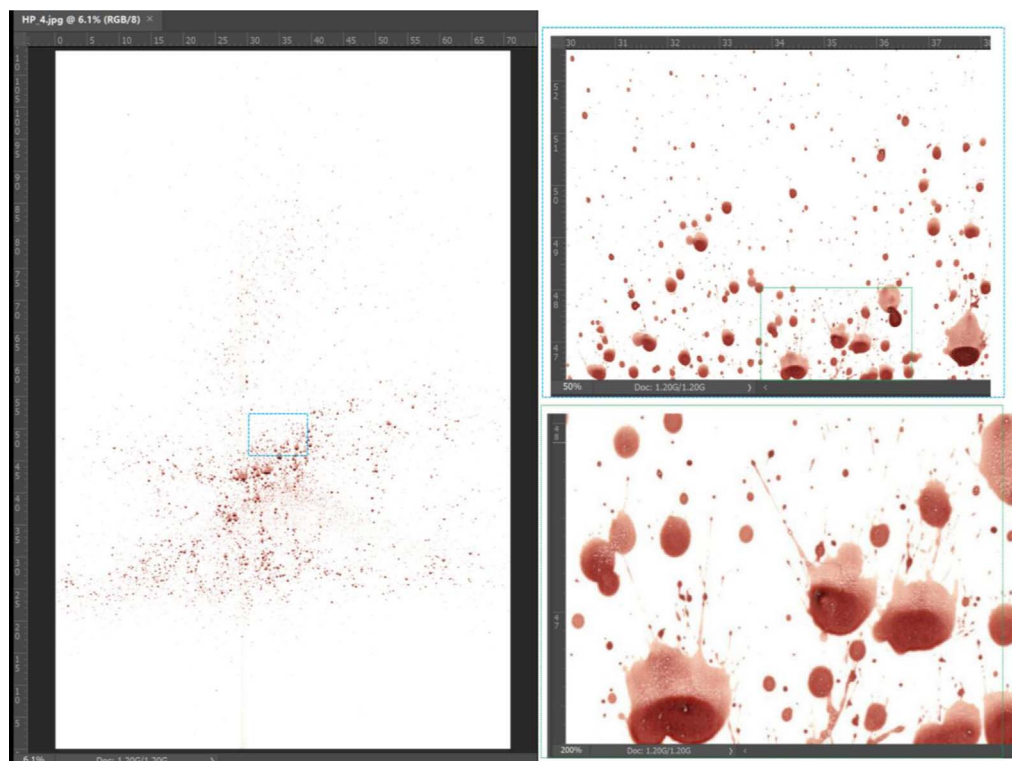


Fig. 1. Example of blood spatter HP_4, with scale (in cm) indicated on the inset edges. The size of the target poster board is 70×110 cm, left. The high resolution of the stain edges is well visible. Image segmentation software such as the one used in [9] can count and measure more than 36,000 individual spots in the image, within a few minutes of processing time.

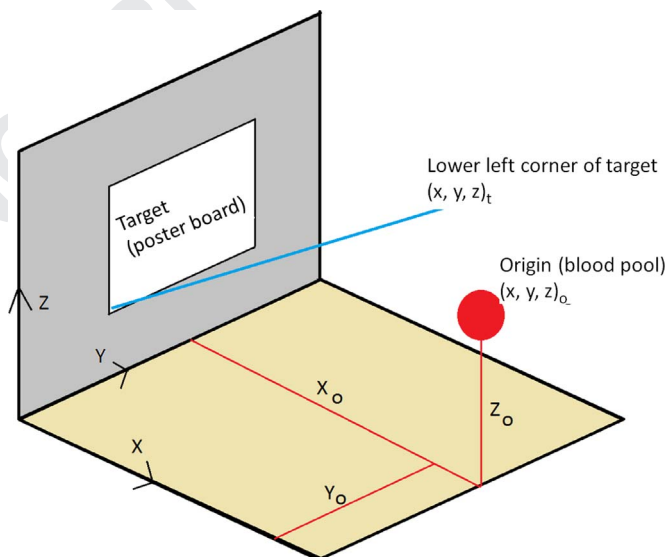


Fig. 2. Coordinate system used in the experiments.

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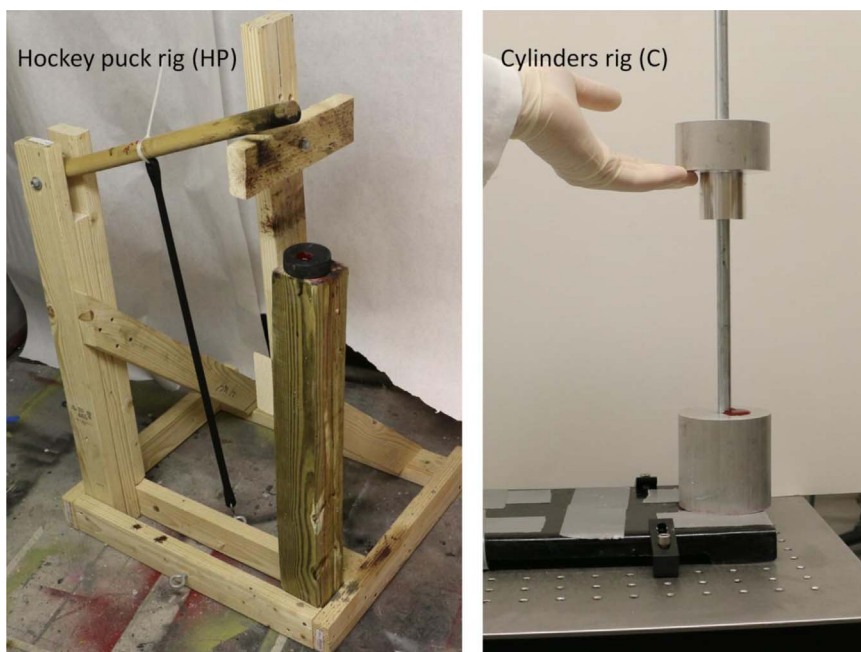


Fig. 4. Two test rigs were designed to generate the impact beating blood spatters. Left, a dowel hits a hockey puck where the blood is located. Right is a sliding cylinder device that squeezes the blood between two flat surfaces. In both devices, the initial position of the impactor controls the impact velocity. For scale information, the bottom cylinder on the right is about same diameter as a hockey puck, 7.6 cm.

Table 2

Measurement of the velocities in experiments, from high-speed movies analysis.

Velocity, m/s	Experiment
2.4 ± 0.1	Cylinder, 30 cm height
3.4 ± 0.1	Cylinder, 60 cm height
5.2 ± 0.2	Rod, dowel position #1
6.6 ± 0.2	Rod, dowel position #2
7.8 ± 0.2	Rod, dowel position #3

the velocity of the impact that atomized the blood, and the distance between blood source and spatter target.

2. Experimental design, materials and methods

Two tests rigs were used to create the impact blood spatters, as shown in Fig. 4. In the first rig (dowel and hockey puck, named 'HP#'), blood is rapidly squeezed between a cylindrical wood dowel (rod) and a flat surface. The dowel rotates by the force of a rubber bungee, and hits a hockey puck where the blood is located. Before impact, a rotating wood slab holds the dowel under tension, at an initial angle controlled by a set of discrete dowel holes around which the slab is free to rotate. That initial position is reported as the dowel height station and numbered 1–3 (3 corresponding to the highest height and tension used in this data set). In the second rig, that with cylinders, named 'C#', blood is squeezed between two flat surfaces. The immobile bottom cylinder is 7.7 cm in diameter. The

top cylinder is 3.8 cm in diameter, and able to freely fall along a vertical guide rod from a pre-set height.

In the hockey puck rig, the impact contact occurs along a line; in the cylinders rig, across the flat surface of the top cylinder. The measured impact velocities are reported in Table 2. On both rigs, the pool of blood has approximate volume of 1 mL blood, and thickness of 1 mm. To ensure reproducible surface and wettability conditions, the impacting surfaces were rinsed with isopropanol, then deionized water, and dried before each trial. In selected experiments, a soaked polyurethane foam was used instead of a blood pool.

The experiments were performed in a closed room (159.2 cm × 249.8 cm × 242.6 cm), where the air was quiescent. Room temperature and relative humidity were measured with a Mannix PTH8708 temperature-humidity pen.

The experiments utilized ethically-sourced swine blood with heparin to prevent coagulation. The blood was drawn less than 48 h prior to any experiment. The blood was placed on a rocker and was at room temperature. Hematocrit was measured with a dedicated centrifugation device (STI, Hemata-Stat-II).

The choice of swine blood can be explained as a compromise between safety and relevance to BPA in a public university laboratory. Indeed, human blood is a biohazard, requiring extensive testing and handling precautions to avoid risks of HIV (human immunodeficiency virus) and hepatitis B & C, which can be deadly if untreated. Artificial blood is still in a development phase, and it is not clear if it will ever be able to match all the complex - and still partly unknown [15]- characteristics of actual blood [3]. Among animal blood, swine blood is the closest to human blood in terms of comparable physical properties [16], such as hematocrit range, shear viscosity of whole blood and plasma, erythrocyte aggregation behavior. Since swine blood has not been associated with risks of HIV or hepatitis B, it is a safer substitute to human blood. Thus, swine blood was drawn from healthy pigs screened for zoonotic diseases at the Ames USDA facilities. Blood was stored refrigerated when not in use and allowed to reach room temperature before use. Personal protection for biohazard including coveralls, gloves, face shield, surgical mask, goggles, were used while producing spatters, and gloves while manipulating dried spatters during e.g. scanning.

Most blood spatters were generated on a target made with flat poster board sheets (UCreate, Walmart Inc., 22 in × 28 in) taped together. The smooth side of the sheet was typically used. Few experiments were made on the rougher side of the same sheets, and other on less expensive butcher paper. Targets of large sizes (up to 136 × 110 cm) were assembled by taping together the back of two or four poster board sheets with masking tape. An optical profilometer Zygo Newview 6300 measured the roughness of the target, with results reported in Table 1. Spreading correlations, which link drop sizes, stain sizes and impact velocities together, have been characterized on those substrates according to the methods in [10]. Note that Table 3 of [10] reporting values of roughness for a range of substrates, has a typo for the roughness, mentioning [mm] instead of the correct magnitude in [μm].

The spatters were scanned at 600DPI (dots per inch) on a flatbed scanner (Epson Expression 11000XL), which is slightly better than what has been obtained with high-end photography [4], and allows to have a clear definition of the edges of most stains. The use of a scanner avoids issues of parallax, which are often present on crime scene photographs. The spatters were scanned in a piecewise manner, by cutting the tape joining the poster board sheets, because the maximum scanning area of the scanner was A3 (297 × 420 mm), significantly smaller than the largest target posters (1360 × 1100 mm). Poster board sheets were never cut in that process. Scans were assembled using image processing software Adobe Photoshop®, and saved as high-quality jpg. A sticker was placed at the center of each sheet, to allow precise assembly of the scans. Photoshop was used to remove marks that were not stains, such as sticker, tape, or pencil marks.

Acknowledgements

The authors acknowledge financial support from the US National Institute of Justice (Grant no. NIJ 2014-DN-BX-K036). This work was partially funded by the Center for Statistics and Applications in Forensic Evidence (CSAFE) through Cooperative Agreement No. 70NANB15H176 between NIST and

Iowa State University, which includes activities carried out at Carnegie Mellon University, University of California Irvine, and University of Virginia. We acknowledge the contribution of John Polansky for the construction of the hockey puck test rig and the production of some spatters, useful discussions with William Ristenpart, Craig Moore; Alex Yarin; advice of Herb McDonnell to build the cylinders test rig; and the roughness measurements by Ashraf Bastawros and Bishoy Dawood.

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332 **Q3** Transparency document. Supplementary material

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Transparency document associated with this article can be found in the online version at <https://doi.org/10.1016/j.dib.2018.02.070>.

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338 **Appendix A. Supplementary material**

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Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.dib.2018.02.070>.

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345 **References**

346 **Q3**

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