The Effect of Weight on the Placement of RACS in 2D Outsole Images

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Project Rationale & Goals

- Footwear evidence is often overlooked, perhaps because we lack methods to analyze it. In response, we have developed computational tools to quantify the similarity between two outsole images. The tools rely on our ability to align images using “interesting” pixels such as those associated with RACs (Randomly Acquired Characteristics). We explore whether the relative location of pixels varies with the weight of the wearer and whether the weight effect depends on the instrument that captures the outsole impressions.

Materials & Methods

- Materials

  - Nine pairs of second-hand shoes (various brands)

  - Weight dumbbells

  - Puncturing devices

  - Everspry Outsole Scanner (EverOS)

  - BVDA Sole Print Impression Pad (BVDA pad)

- Method

  - Data Collection: To capture accurate results on the wear and tear of shoes found at a crime scenes, we used shoes found at the thrift store. Shoes were cleaned to remove any debris that might be found on the outsoles as to not interfere with the images captured. The RACs were created on 8 sections that divide shoe outsoles using three puncturing devices. The three devices included a heavy-duty leather hole puncher, a pin, and box cutters that create a circle shaped pattern, a dot, and an irregular line, respectively.

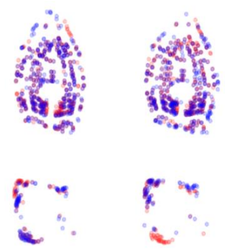
  - Data Analysis: To align the matched pair images, we extracted SURF (Speeded up Robust Features) points and aligned them using ICP (Iterative closest point) algorithm in MATLAB. Images were also analyzed by side-by-side comparison looking for color concentration differences and visibility of RACs by weight differences.

Discussion

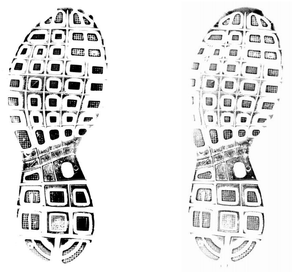
- The data shows weight as a factor in accurately capturing RACs on shoe impressions.
- The BVDA Sole Print Impression Pad does a better capturing outsole images in regard to the location and intensity of the RACs.
- The weight effect on the degree of alignment is inconclusive when using ICP algorithm based on SURF points, indicating that aligning the outsole images from the same shoe was not significantly affected by different weights for some shoes.
- The location and visibility of RACs are dependent on the weight the subject was wearing.
- The difference between the 3D scanner and 2D scanner come down to how color intensity can be interpreted. The Everspry Outsole scanner masked RACs when a darker color (on a greyscale) was present. The darker color is caused by the pressure sensed by the machine and the variability in outsole depth.

- Impression of shoe 1 (left side) using BVDA pad: the image on the right was by a person, and the image on the left was with added 55lb to the person.

- Impression of shoe 1 (left side) using EverOS : the image on the right was by a person, and the image on the left was with added 55lb to the person.

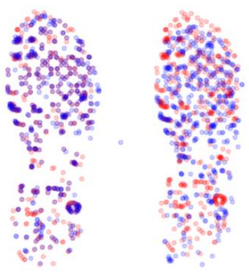


- Alignment of shoe 1 (right side) : SURF points from shoe 1 without extra weight is colored in red in both figures. Blue dots on the left, and right figures indicate the same shoe without extra weight, and with extra 55lb, respectively.



- Impression of shoe 4 (left side) using BVDA pad: the image on the right was by a person, and the image on the left was with added 55lb to the person.

- Impression of shoe 4 (left side) using EverOS : the image on the right was by a person, and the image on the left was with added 55lb to the person.



- Alignment of shoe 4 (right side) : SURF points from shoe 4 without extra weight is colored in red in both figures. Blue dots on the left, and right figures indicate the same shoe without extra weight, and with extra 55lb, respectively.

Future Direction

- We will continue to develop computational tools to quantify the weight effects on the shoe outsole with RACs.
- The relationship between the position of RACs over eight sections, and their expression will be explored by different weights.
- The difference in size and shape of RACs by various weights will be studied.

Acknowledgments

- Speir, J., Richetelli, N., Fagert, M., Hite, M. and Bodziak, W., 2016. Quantifying randomly acquired characteristics on outsoles in terms of shape and position. *Forensic Science International*, 266, pp.399-411.

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