INSIGHTS

An Algorithm to Compare Two-Dimensional Footwear Outsole Images Using Maximum Cliques and Speeded Up Robust Features

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Publication Date: 21 Feb. 2020 | **Link:** forensicstats.link/FootwearAlgorithm-DOI

OVERVIEW

Footwear impression researchers sought to increase the accuracy and reliability of impression image matching. They developed and tested a statistical algorithm to quantify and score the degree of similarity between a questioned outsole impression and a reference impression obtained from either a suspect or a known database. The resulting algorithm proved to work well, even with partial and partial-quality images.

THE GOALS

1. Develop a semi-automated approach that:
   - Compares impression evidence imagery with putative suspect or database images.
   - Calculates a score to quantify the degree of similarity (or correspondence) between the images.
   - Lowers human error and bias in current practice.
2. Create a method to obtain a similarity score for a pair of impressions which can be used to assess the probative value of the evidence.

Key Definitions:

Graph Theory: Study of graphs made up of vertices connected by edges

Clique: A subset of vertices with edges linking symmetrically, where every two disinct vertices are adjacent

Maximum Clique: Clique that includes the larges possible number of vertices

APPROACH AND METHODOLOGY

This algorithm focuses on the similarity between two outsole images and relies on the concept of *maximum clique*. Local maximum cliques can be used to find corresponding positions in the two images so that they can be aligned.

Rotation and translation don't affect a maximum clique — it depends on the pairwise distances between nodes on the graph.

So — although outsole pattern images may be translated, rotated and subjected to noise and other loss of information — the geometrical relationships between the points that constitute the pattern will not change much.

In this study, researchers developed a publicly available and usable database of 2D outsole impressions. Then the researchers used data from a KNM™ (knowledge navigator model) database.

CONTACT

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KEY TAKEAWAYS FOR PRACTITIONERS

No. 1: With this new comparison learning algorithm, practitioners can align images using features chosen as areas of interest and calculate a similarity score more objectively.

No. 2: The proposed pattern-matching algorithm can work with partial images or images of variable quality by partially aligning patterns to quantify degrees of similarity between two impressions.

No. 3: While this study focuses on footwear evidence, this algorithm has potential applications for other situations of pattern comparison, like:

- latent prints
- surveillance photos
- handwriting
- tire treads and more.

No. 4: The algorithm can distinguish impressions made by different shoes — even when shoes share class characteristics including degree of wear.

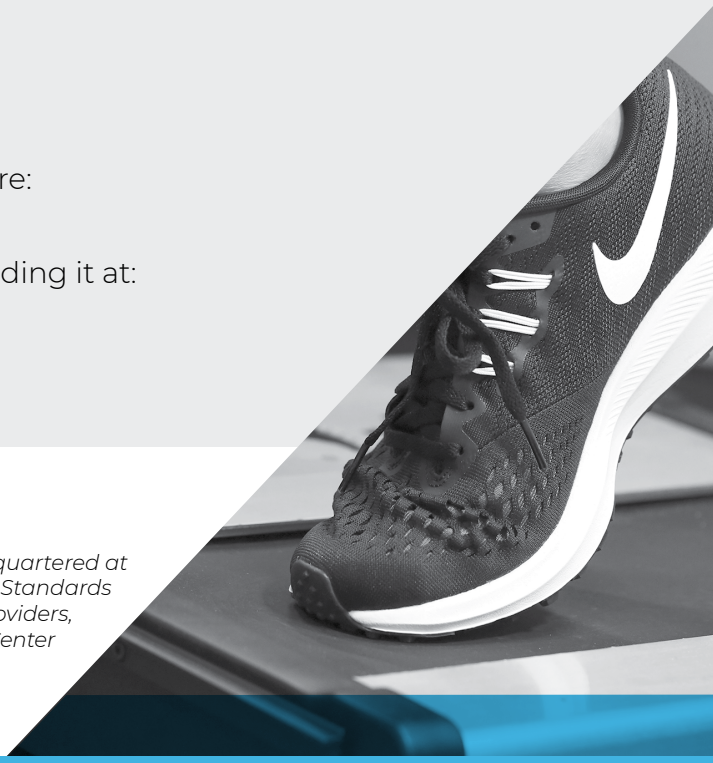
SEE THE ALGORITHM IN ACTION

Researcher Dr. Soyoung Park demonstrates the team's novel algorithm in a CSAFE webinar. The method is promising, because it appears to correctly determine, with high probability, whether two images have a common or a different source, at least for the shoes on which they have experimented. Access it here: forensicstats.link/Footwear-Algorithm-Webinar-Soyoung-Park.

NEXT STEPS

Access the full research study to learn more: forensicstats.link/FootwearAlgorithm.

Explore and try the algorithm by downloading it at: forensicstats.link/ShoeprintR.



FUNDING

csafe
Center for Statistics and Applications in Forensic Evidence

CSAFE is a publicly funded organization headquartered at Iowa State University. The National Institute of Standards and Technology (NIST) is one of the center's providers, supporting CSAFE as a nationally recognized Center of Excellence in Forensic Sciences, NIST Award # 70NANB15H176.