B173 A Comparison of 2D Footwear Images Using Maximum Clique (MC) and Speeded-Up Robust Features (SURFs)

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Learning Overview: The goal of this presentation is to introduce an objective, accurate, and reliable approach to quantify the similarity between two outsole impressions.

Impact on the Forensic Science Community: Footwear impressions are commonly found in crime scenes, but examiners lack objective approaches to analyze and interpret the evidence. This presentation will impact the forensic science community by presenting an algorithm to quantify the similarity between two impressions and enable calculation of the probative value of footwear impressions in real casework that would have a big impact among footwear examiners.

Footwear examiners are tasked with determining whether the suspect's shoe could have left the print at the crime scene. Current practice relies on the visual comparison of the two impressions and a subjective assessment of their similarity, perhaps with the aid of a catalog of outsole patterns with brand and model information.

Footwear evidence are found in about a third of all crime scenes.[1] However, footwear impressions are rarely introduced as evidence in criminal proceedings. This may be because accurate, reliable, and validated methods to quantify the similarity between two outsole impressions have yet to be proposed, and therefore, examiners are limited in the type of conclusions they can make.

A new method called Maximum Clique, Comparison, Speeded-Up Robust Features (MC-COMP-SURF) that quantifies the similarity between two outsole impressions is proposed. The method compares a full or partial image of a shoe impression (Q) from an unknown source to an impression (K) from a known reference shoe, using 2D images of the impressions. MC-COMP-SURF relies on robust features on each impression and aligns them using MC.[2] MC arises from graph theory and can be used to assess the property of geometrical congruence in the outsole patterns. An advantage of the MC method is its invariance to rotation and translation. A disadvantage is that for large images, the method can be computationally intensive and time consuming. After aligning features in Q and K, it is possible to define multiple similarity features and combine them into a univariate similarity score using a Random Forest (RF). The approach that outputs an RF score from MC-COMP-SURF is denoted RF-SURF.

A large experimental database of 2D outsole images was built by researchers in the Center for Statistics and Applications in Forensic Evidence (CSAFE). One hundred sixty participants were allocated a new pair of athletic shoes of one of two brands and sizes 8, 8.5, 10, 10.5. Each shoe from each pair was imaged four times right after purchase and about every eight weeks on three additional occasions, during which time study participants wore the shoes. The algorithms discussed in this presentation were constructed and tested using a subset of the data consisting of shoes with the same class characteristics and similar degree of wear that are difficult to tell apart. RF-SURF outperformed other methods in the literature, including Phase-Only Correlation (POC) and MC-COMP-edge in the sense of minimizing classification error into the same or different shoe classes.[3,4]

The algorithm was also tested in more realistic scenarios with partial, degraded, and smudged images from the questioned impression. Images obtained from Q were degraded sequentially, resulting in images of decreasing clarity. The same algorithms were used to quantify the similarity between degraded images from Q and a high-quality image of K. Results suggested that the comparison algorithm based on SURF is robust to some forms of image degradation; at all levels of degradation, MC-COMP-SURF outperformed all other methods in terms of classification accuracy.

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Footwear Impressions, Similarity Score, Source

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