OSAC RESEARCH NEEDS ASSESSMENT FORM

Title of research need: Comparison Algorithms for Footwear Forensics

Describe the need: Comparison of footwear impressions is necessary for many tasks in footwear forensics, including comparison of crime scene and test impressions for evidence evaluation, as well as intelligence gathering such as database lookup for make/model determination, linking crime scenes to previous arrestee shoes through database search, and crime scene linking. (All of these capabilities are necessary for a National Footwear Database). Although some of the comparisons can be done manually, algorithms could help speed up intelligence gathering, enable a larger number of comparisons, and provide a quantitative basis for evidence evaluation. For 2D impressions, existing comparison algorithms in these applications have limited performance because features in impressions are often partial, occluded, overlaid on top of one another, smeared, noisy, distorted, of low contrast or occur on a cluttered or highly structured background. No algorithm has been shown capable of performing near the level of expert examiners. Therefore, more research needs to be done in the development of new algorithms, evaluation of existing algorithms, and development of methodology for testing and evaluating such algorithms.

Keyword(s): Footwear, Algorithms, Comparison, Pattern Matching, Intelligence Gathering, Evidence Evaluation

Submitting subcommittee(s): Footwear & Tire **Date Approved:** October 24, 2022

Background Information:

1. Does this research need address a gap(s) in a current or planned standard? (ex.: Field identification system for on scene opioid detection and confirmation)

2. Are you aware of any ongoing research that may address this research need that has not yet been published (e.g., research presented in conference proceedings, studies that you or a colleague have participated in but have yet to be published)?

Gautham Venkatasubramanian, Vighnesh Hegde, Sarala Padi, Hari Iyer, Martin Herman. "Comparing footwear impressions that are close non-matches using correlation-based approaches." Journal of Forensic Sciences 66:3 (2021) 890-909. doi.org/10.1111/1556-4029.14658.

3. Key bibliographic references relating to this research need: (ex.: Toll, L., Standifer, K. M., Massotte, D., eds. (2019). Current Topics in Opioid Research. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-88963-180-3)

- Nicole Richetelli, Mackenzie C. Lee, Carteen A. Lasky, Madison E. Gump, Jacqueline A. Speir. "Classification of footwear outsole patterns using Fourier transform and local interest points." Forensic Science International 275 (2017) 102-109.
- Adam Kortylewski. "Model-based Image Analysis for Forensic Shoe Print Recognition." PhD Thesis, University of Basel, 2017.
- Bailey Kong, James Supancic III, Deva Ramanan, Charles C. Fowlkes. "Cross-Domain Image Matching with Deep Feature Maps." International Journal of Computer Vision (2019) 1-13.
- Soyoung Park. "Learning algorithms for forensic science applications." PhD Thesis, Iowa State University, 2018.
- Soyoung Park, Alicia Carriquiry. "The effect of image descriptors on the performance of classifiers of footwear outsole image pairs." Forensic Science International 331 (2022) 111126. doi.org/10.1016/j.forsciint.2021.111126
- Junjian Cui, Xiaorui Zhao, Nini Liu, Sergey Morgachev, Daixi Li,M.Eng. "Robust Shoeprint Retrieval Method Based on Local-to-Global Feature Matching for Real Crime Scenes." Journal of Forensic Sciences, March 2019, Vol. 64, No. 2., 422-430.

4. Review the annual operational/research needs published by the National Institute of Justice (NIJ) at https://nij.ojp.gov/topics/articles/forensic-science-research-and-development-technology-working-group-operational#latest? Is your research need identified by NIJ?

Yes.

5. In what ways would the research results improve current laboratory capabilities?

This research could result in faster, more extensive and more reliable intelligence gathering. In addition, it could help examiners in performing more reliable evidence evaluation that can be justified quantitatively.

6. In what ways would the research results improve understanding of the scientific basis for the subcommittee(s)?

The results of this research could provide a quantitative basis for intelligence gathering, one that's based on algorithms and data. In addition, it could provide an objective, quantitative, demonstrable, data-driven basis for evidence evaluation rather than the subjective methods upon which current evidence evaluation is based.

7. In what ways would the research results improve services to the criminal justice system?

The ability to improve the reliability, speed and variety of intelligence gathering could greatly help in identifying potential suspects and solving more cases. The ability to perform reliable, quantitative evidence evaluation may directly impact the degree of confidence of the footwear examiner's opinion presented in court. It could also be used in formulating a statistical basis for opinions, such as developing a likelihood ratio.

8. Status assessment (I, II, III, or IV): II

	Major gap in current knowledge	Minor gap in current knowledge
No or limited current research is being conducted	I	III
Existing current research is being conducted	II	IV

This research need has been identified by one or more subcommittees of OSAC and is being provided as an informational resource to the community.