



C26 Applications of a Convolutional Neural Network (CNN) for Automatic Classification of Outsole Features

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Learning Overview: After attending this presentation, attendees will be familiar with the ways that CNNs can be applied to classify forensic pattern evidence, specifically with shoe outsole features.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by introducing a powerful machine learning method to automatically classify shoe outsoles with the goal of improving the reliability of pattern evidence analysis. Results of this research can be used to automate and speed up shoe print database searches and provide valuable information about the relative frequency of specific characteristics found on outsoles within and across local populations.

The improvement of modern computing has led to the widespread implementation of machine learning, in which computers “learn” about data without being explicitly programmed. CNNs are a form of deep learning that mimics the human brain by using complex networks of hidden layers to learn patterns and make decisions about the contents of an image. For example, we may see an image that contains features such as “eyes” and “nose” and conclude that the image contains a “face.” Similarly, CNNs learn and combine local patterns in a set of training images to learn to detect the presence of a desired set of features in new images.

In forensic applications, images of shoe prints and outsoles are well-suited to classification using CNNs. This is because outsoles often contain distinct and well-defined shapes (e.g., circles, triangles, and text) that can be easily classified by a CNN. Once the shapes contained in a print are detected and classified, the resulting labels can be combined to determine the shoe’s category (e.g., athletic, formal) and brand, and labels for different outsoles can be compared to assess similarity between different designs.

A classification scheme was modified from sets of geometric features currently used by forensic footwear examiners, and thousands of outsole images were obtained and manually labeled according to the new scheme. These images were used to train a new classifier for the convolutional base of VGG16, a pre-trained CNN that is commonly adapted for novel image classification tasks.

One potential application of this new model is to automate and/or speed up database searches that examiners perform when searching for candidate shoe models which may match a questioned print. Another application, which is currently underway, is to collect a large amount of outsole data through sidewalk-embedded scanners, then utilize statistical methods to determine the relative frequency with which certain characteristics appear in shoes that are commonly worn within specific populations.

This presentation will include discussion of the process and challenges of developing a classification scheme and training a CNN for outsole recognition, summarize the performance of the current model, and present preliminary results for the determination of feature frequency in local populations.

Machine Learning, Shoe Outsole, Pattern Evidence