C15 Curating Forensic Image Collection Using Machine Learning

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After attending this presentation, attendees will understand the opportunities afforded by machine learning for automatic classification or detection of forensically relevant features in images documenting human decomposition.

This presentation will impact the forensic science community by introducing new approaches to automate the annotation of digital collections and by discussing how this can transform research on human decomposition.

Some areas of forensic anthropology have accumulated large collections of digitized data. Despite the curation approaches of traditional collections that involve manual and painstaking labor analyzing individual samples, digital collections offer a tantalizing opportunity to automate some of the most tedious parts of curation work through the application of modern machine learning. These opportunities were investigated using a collection of one million photos documenting human decomposition collected at the Anthropology Research Facility (ARF) at the University of Tennessee, Knoxville. The research was conducted in stages, beginning with checking the feasibility of the approach and ending with object detection and classification.

Experiment 1 was conducted to verify the feasibility of using machine learning for images of human decomposition. While such tools are highly advanced in certain domains, for example, for recognizing faces of living individuals, they are not likely to work well on images depicting decomposing bodies. Image analysis algorithms that can detect forensically relevant features are not well known. The specific goal of this experiment was to accurately classify images annotated with tags indicating body parts by an expert. The expert used a web-based tool to interactively highlight an interesting forensic feature within an image and then provide a tag indicating body part (e.g., left foot) and a forensic feature (e.g., egg mass). A Convolutional Neural Network (CNN) structure was used to perform binary classification of these subimages based on body-part tags. A CNN structure was made of several convolutional layers, pooling layers, and dropout layers. In the model training, the loss metric, evaluation metric, and optimizer were binary cross entropy, accuracy, and Stochastic Gradient Descent (SGD), respectively. It was implemented using the sequential model in Keras, an open source deep learning Python library. Ten-fold cross-validation was used to avoid overfitting, measure performance, and select suitable parameters for training. The classification yielded high accuracy, for instance, 91.02% when classifying eye and left foot. For particularly challenging cases, such as eye versus mouth, it was lower at 62.43%. These results indicate that machine learning is capable of accurately classifying images with different shapes.

Experiment 2 was conducted to investigate the ability of machine learning algorithms to detect relevant features, such as body parts, in a full image that may include several (or none) of the body parts. This is a much harder (and more practical) problem, since the ability to automate the annotation of the body parts could be a powerful curation aid. Keypoint identification algorithms were used to discover areas of an image that represent certain high-level features (objects). Oriented Function Analysis System Technique (FAST) and Rotated BRIEF (ORB) algorithms from OpenCV were used. Keypoint approach is appealing because of its clear interpretation and extensive use in object detection. Meanwhile, it does not require that the input images have the same input size. The effectiveness of using keypoint approach was demonstrated by classifying annotated body parts with clustered keypoints. The k-medoids were used to cluster keypoints, some of which may be spurious as not all keypoints are necessarily representative of the classification label. To address that, each image was treated as a mixture of keypoint proportions within each cluster. With the labeled class, logistic regression was used to train the classifier. For example, when classifying eye and left foot with 100 clusters of useful keypoints, a high accuracy of 94.43% was reached. In more challenging cases, such as mouth versus eye, the number of useful keypoints in each image may be too small and not enough features will be detected. Overall, the approach works well if the image contains relevant features of the body parts. As further research, these algorithms will be applied to detect forensically relevant features, such as "larvae," "scavenging," and "marbling" and apply the approach to a large collection of images stored with the Forensic Anthropology Center. The results suggest clear avenues for further research toward automation of the curation for large collections of forensic images.

Human Decomposition, Image Analysis, Forensic Databases

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