Development of an Intelligent Forensic System For Hair Analysis and Comparison*

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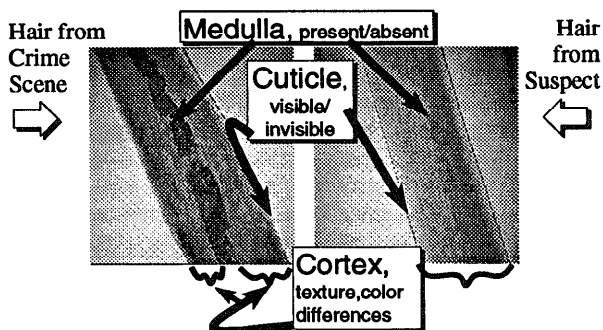Colorado School of Mines
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Figure 1: Microscopic images from two different hairs

The Problem: An important forensic task is to analyze and compare hair evidence in criminal cases. A forensic expert compares sets of hair images from a crime scene to a set from a suspect. Under a microscope, hairs are fairly distinctive, as shown in Figure 1. The *medulla*, which runs along the center of the hair, can take on a variety of different shapes. The *cortex* material outside the medulla has different textures and colors. The *cuticle*, which is located on the exterior of the hair, can be either visible or invisible.

Forensic analysis is a tedious procedure. The forensic expert must manually compare hundreds of hair samples to determine whether or not two sets of samples came from the same person.

The Solution: Neural networks have been used for several problems involving interpretation of images. In forensic hair analysis, a neural network can be used as a preprocessor to extract important features from a microscopic image of a hair. This can facilitate the comparison process.

Project Description: This project explores the automation of hair analysis. We are working with the Colorado Bureau of Investigation to develop a system to aid in the hair comparison process. Our system will take as input a microscopic image of hair and produce classification decisions about features like visibility of the cuticle, presence or absence of a medulla, and cortical texture and color.

The database for this project contains 725 microscopic hair images from 8 different people. To gather the images, a color video camera was connected to a microscope. The video images were sent to a computer-based image viewer. The image was finally captured using a frame-grabber and saved as a TIFF graphic file. 600 of the images were taken from 3 people corresponding to "suspect" hairs. 125 images were taken from 5 people corresponding to "crime scene" hairs.

Each image was segmented into a number of pieces appropriate for classification of different features. We used a variety of image processing techniques to enhance this information in advance of neural network classification. Statistical tests will be used to determine the degree of match between the resulting collection of hair feature vectors.

Analysis of Results: An important issue in the automation of any task used in criminal investigations is the reliability and understandability of the resulting system. To address this concern, we are doing rigorous empirical analysis of our networks. In addition, we are developing methods to facilitate explanation of a neural network's behavior.

One way to better describe the internal decision process of a neural network is to interpret hidden unit hyperplanes as a decision tree. Each node of the decision tree represents a decision made at a particular point of the classification process. The leaves represent a classification choice. This method provides both a graphical and more readily interpretable description of the means by which the neural network classification is made.