A27 A Geometric Morphometric Approach to Fingerprint Analysis

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After attending this presentation, attendees will learn about efforts utilizing geometric morphometric tools for the spatial analysis of fingerprints to determine fingerprint uniqueness.

This presentation will impact the forensic science community by adding an assessment of this spatial analytical approach and the establishment of a statistical basis for determining fingerprint uniqueness.

Geometric morphometrics, a spatial statistical modeling method, is useful for quantitatively studying biological shape variation. Geometric morphometric analyses include methods from multivariate statistics, non-Euclidean geometry, biometrics, and digital graphics that preserve biomathematical aspects of the objects being analyzed. Furthermore, morphometrics includes a collection of readily available statistical tools (e.g., NTSYSpc and R). Within the forensic science community, forensic anthropology has led the way in exploring the applicability of geometric morphometric techniques. Examples include analyzing mandibular morphology and craniofacial landmarks, performing a three-dimensional virtual reconstruction of a fragmented cranium, and estimating pediatric skeletal age.

For this study, a sample of fingerprints taken from the Oregon population have been utilized for geometric morphometric analyses including characterization, pattern recognition, and probabilistic modeling (i.e., determining the areas where differences are concentrated among friction ridge contours) in an effort to fully ascertain the relevance and efficacy of this spatial approach to resolving fingerprint uniqueness. Procedures for the selection of landmarks (e.g., specific minutiae primarily associated with deltas and cores), the superimposition of fingerprint images (i.e., Procrustes), the visualization of shape change (i.e., thin-plate spline), the ordination of superimposition data (i.e., principle components analysis), and the application of multivariate statistics were established.

A comparison of typical approaches for conducting geometric morphometrics with employment of a geographic information system (GIS) to emulate morphometric techniques is also presented. GIS is a collection of hardware and software components that integrate digital map elements with relational database functionality. The strength of GIS lies in its inherent ability to integrate, store, edit, and analyze spatial features and relationships, as well as the query and display of spatial information. These systems include traditional mapping capabilities (e.g., land surveying and aerial photography) and provide users with tools to interactively search and analyze any spatial information, including fingerprint space. GIS is increasingly being applied to the analysis of the positions, patterns, and relationships between objects located in a defined space. These objects include discrete entities expressed as points, lines, or polygons. Collections of objects in a defined space may be linked or associated with one another geometrically or by functional associations. GIS-based spatial analysis is very similar in concept and scope to graph theory in discrete mathematics. Techniques in spatial analyses include data modeling, image processing, grid algebra, surface analysis, and network analysis and visualization. The GIS-based tools available for spatial analysis have grown exponentially in recent years, all driven by the practical need to understand, predict, and model relationships between objects located in space. Our geometric morphometric procedures were emulated in GIS which was initially developed for meeting other objectives associated with ongoing fingerprint research being conducted in our laboratory. The impetus for this comparison of geometric morphometric techniques using a GIS platform included minimizing data handling and increasing overall efficiency in spatial analysis.

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