A63 Geographic Information Systems and Spatial Analysis – Part 2: A Monte Carlo Approach to Estimating Probabilities for Latent Print Identification

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After attending this presentation, attendees will understand the use of Geographic Information Systems as a means to quantify fingerprints and evaluate fingerprints.

This presentation will impact the forensic science community by addressing issues raised by the NAS report to apply a scientific approach to fingerprint analysis. The probabilities being produced are addressing the uniqueness of fingerprints.

A Geographic Information System (GIS) is a collection of hardware and software components that integrate digital map elements with relational database functionality. GIS data are typically captured in the form of either raster grids (e.g., pixels) or vector features (e.g., points, lines, and polygons) with points in space using x, y and sometimes z coordinate values. GIS allows for the placement of spatially rich objects, such as fingerprints, in a shared spatial environment, and allows for comparisons among the objects. For this study, approximately 950 fingerprint images from digits one, two, six, and seven were geo-referenced by placing the core at 100mm in Cartesian coordinate graph space consequently positioning every print in positive graph space. Fingerprint parameters including minutiae type placement, direction, and the spatial relationship of minutiae were quantified and were used to evaluate the uniqueness of fingerprint regions. The distances and directions between minutiae and between core and minutiae were calculated. In addition, a Monte Carlo simulation, more specifically a bootstrapping simulation, was used to estimate the probabilities of occurrence of different spatial configurations of minutiae within print types. These probabilities were created first for a reduced model of position only (x,y) with a margin of error (±0.32 mm) placed around each minutiae position, and then for models of increased information and complexity. The simulations consisted of *n* minutiae randomly selected from a specific fingerprint region. The selected minutiae were then used to query our database for fingerprints with the same minutiae configuration. This procedure was iterated 1,000 times to obtain a distribution of false matches. This procedure was performed on nine predefined, overlapping regions of a fingerprint that represent the entirety of a fingerprint. These regions were defined in such a manner as to reduce any artificial boundary effects created by the boxes. For every fingerprint used in this procedure, nine separate probabilities were obtained. The simulations were run on 50 randomly chosen fingerprint images per pattern type (right slant loops, left slant loops, whorls, arches) for a total of 300 fingerprint images sampled and 50,000 iterations performed per region within a pattern type and for the number of minutiae chosen. These results were then used to analyze whether different regions have a lower chance of false matching. Simulations were performed with three, five, seven, and nine minutiae chosen. As anticipated, as the number of minutiae selected increases, the chance of obtaining a false positive decreases. The overall means for all regions and print types were x-bar_3=0.16, x-bar_5= 0.000714, x-bar_7= 0.000005, x-bar_9=0.00. In addition, our simulations showed that the area above the core has a lower probability of matching anything not itself. The probability of false positives drastically decreased as more information, such as minutiae type and direction, was added to the model. Model simulations were performed both within print type and among all print types, and the findings for both approaches are similar. The research described addresses issues raised by the NAS report by applying a scientific approach to fingerprint analysis. The probabilities being produced are addressing the uniqueness of fingerprints.

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Fingerprints, Statistics, GIS

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