Application of Eye Tracking Technology for the Assessment of Forensic Fingerprint Examination

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Introduction

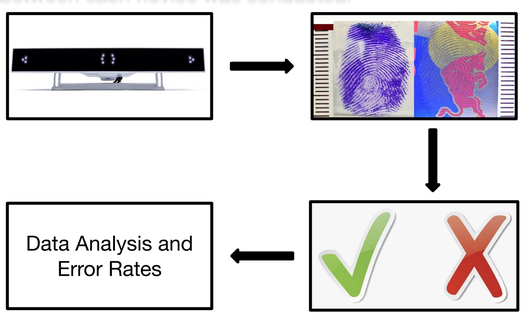
Fingerprint analysis has been used to help investigators solve crimes for more than a century. This analysis typically involves comparing latent fingerprints (fingerprints found at a crime scene) with known individual fingerprints to assess how similar they are. Trained latent fingerprint examiners will make an assessment by comparing details that include the shapes of the ridge lines that are formed and where the lines split or end. Often, latent prints are partial, smudged or distorted which makes the examiner determine if there is enough sufficient detail to make a comparison. Examiners typically follow an approach called the ACE-V methodology for Analysis, Comparison, Evaluation, and Verification [1][2]. The approach calls on examiners to make a series of subjective assessments. An examiner uses subjective judgment to select particular regions of a latent print for analysis.

In order to view or focus on an image in detail, gaze must be directed in a way that the image falls on the high acuity region of the eye [3][4][5]. Attention shifts between features are carried out using ballistic eye movements called saccades, in which the eye rapidly moves about three to four times per second [3][4][5][6]. The measurement of this process, therefore, provides a mechanism to quantify visual attention. Therefore, if an examiner's eye movements are followed, it is possible to follow the path of attention deployed by the observer which gives insight into what drew the observer's attention [7]. Eye trackers serve this purpose because they offer an objective view of overt human visual and attentional processes. Additionally, eye trackers offer a solution to gaze analysis that is unobtrusive to the participant, flexible in accommodating different persons, and recent development has yielded relatively inexpensive eye tracking systems [3]. Measurements taken from the eye tracker include reaction times (how quickly participants perform the action, on average), error rates (how many mistakes occurred, on average), and measures related to participants' eye movements (fixations, fixation durations) [8].

Without an understanding of how a latent fingerprint examiner views features within a pattern, there is no true way to assess the effectiveness or error rates of a resulting reasoning process. The purpose of this project is to contribute to the understanding of how fingerprint comparisons are completed, how pattern examinations are different between novices and experts, and which features within the fingerprint are most valuable to conclusion accuracy.

Methodology

The Gazepoint Eye Tracking and Biometrics UX Testing Kit is a computer-based eye tracking system that was used to analyze the gaze pattern of examiners. The eye tracker system was mounted below the monitor and measured the gaze toward a test stimulus on the screen. Patterns of interest were displayed on the screen closely replicating the current forensic process since comparisons are frequently made digitally. The participants conducted a standard forensic examination that encompassed both the initial analysis of the pattern and the feature comparison process made by the examiner. Once the examiner has completed their examination, they will be prompted for a conclusion regarding whether the two patterns are a match or a non-match. The data was then processed by a software which accompanied the eye tracking hardware to generate a heat map and a fixation map of participant areas of interest. Data analysis between each novice was conducted.



Results

Fixation Map

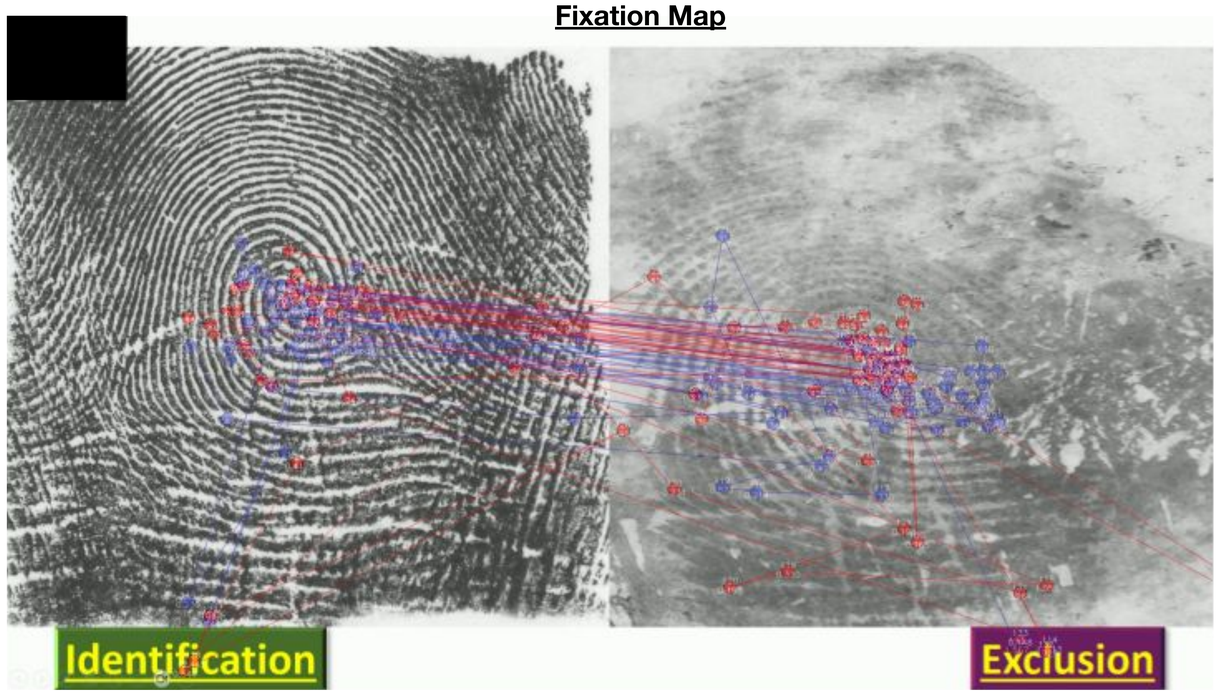


Figure 1: The duration each fixation point novice 1 (blue) and novice 2 (red) looked at when comparing a latent fingerprint (developed with SPR) to a known fingerprint.

Heat Maps

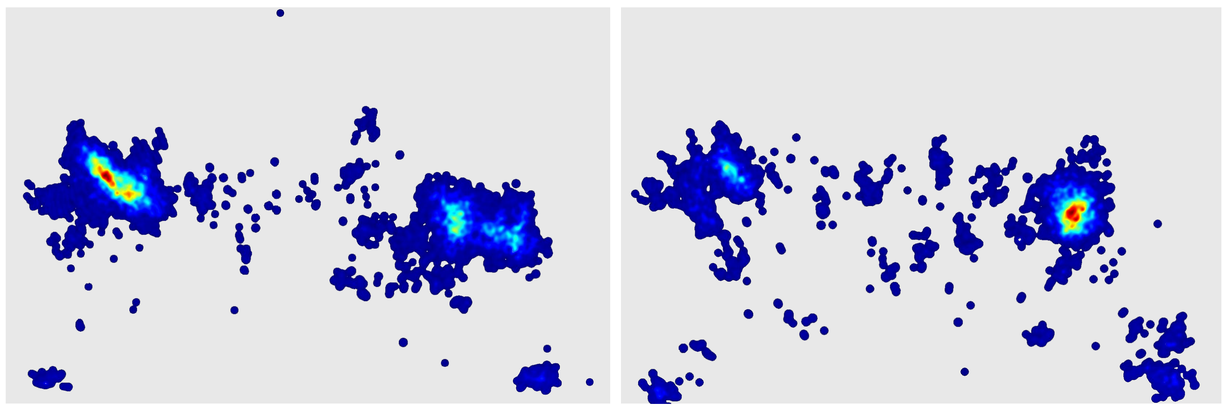


Figure 2: The areas novice 1 (left) and novice 2 (right) heavily used for coming to their comparison conclusion (red) compared to the areas least used for comparison conclusion (dark blue).

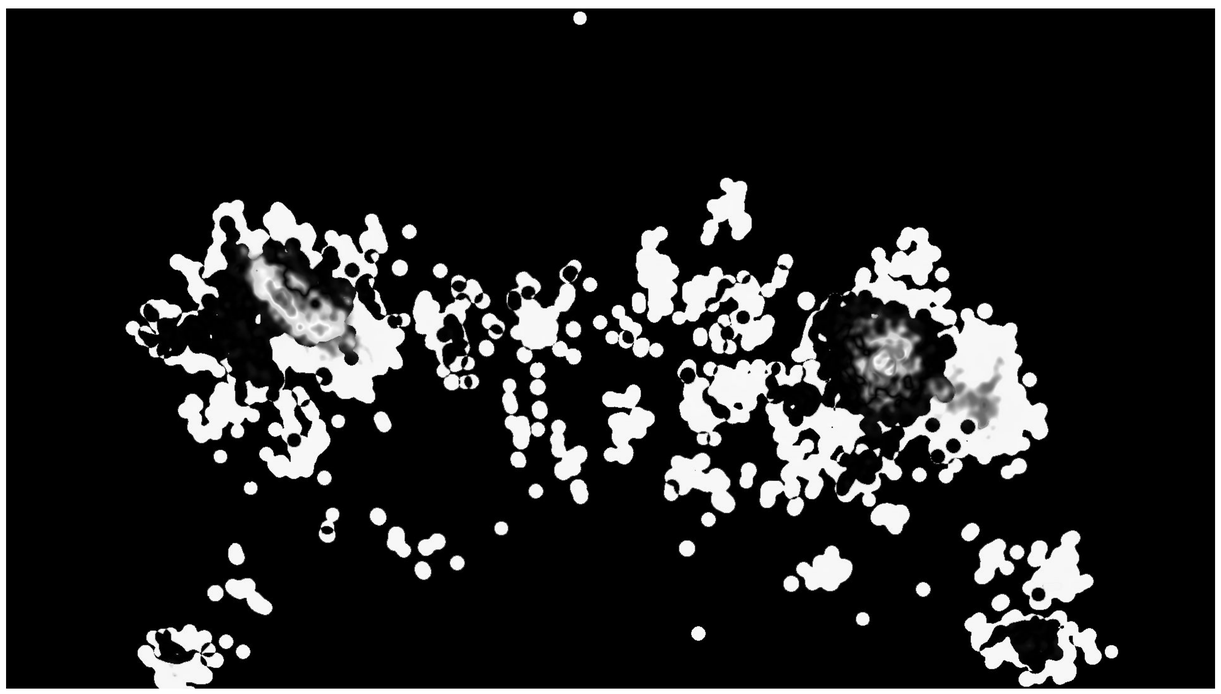


Figure 3: Difference map between novice 1 and novice 2. Areas of white indicate highest normalized differences between the participants and areas of black indicate no difference between participant gaze.

Conclusions

- The significations of fixation and fixation durations
  - Small overlay of the same fixations between novices **(Figure 1 and 3)**
  - An average of 16 minutes for novices to compare 10 latent fingerprints in which the level of difficulty gets harder
    - For a novice to complete one comparison, it took and average of 92.644 seconds
    - Novices' comparisons times varied depending on the development used (powder was the shortest and wetwop was the longest)
  - More research should be completed with more novices to pinpoint what minutiae is most used when coming to fingerprint comparison conclusions
- False negatives and false positives were calculated
  - 0.5% of the conclusions were false positives; whereas 1.7% of the conclusions were false negatives
  - Novices, on average, lean 20% of the time inconclusive
  - On a comparison in which 50% came to the wrong conclusion, a high confident average of 4.8 was calculated (on a scale of 1-6, 6 being very confident)

Deliverables

- Imaged and scanned fingerprints of different developmental techniques
- Analysis of fixation and fixation durations
- Recommendations for the implementation of the developed methodology within forensic crime lab trainings

Future Directions

- Continue fingerprint examination using Gazepoint
  - Analysis fixation points experts use when comparing latent fingerprints
  - Compare expert data to novice data
- Yearly retests of novice and experts to determine consistency rate
  - Leads to challenges in fingerprint analysis
- Continue Gazepoint analysis for other forensic science disciplines

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Acknowledgements

- Dr. Jamie Spaulding, Department of Criminal Justice and Forensic Science at Hamline University, for research support
- SCUR Program and Professor Sharon Preves and Professor Leif Hembre for funding and research support
- Undergraduate forensic science students at Hamline University for their willingness to participate in this study, enabling data collection for novice latent fingerprint examiners