B69 The Repeatability of Ridge Width Measurements for Latent Fingermark Aging Studies

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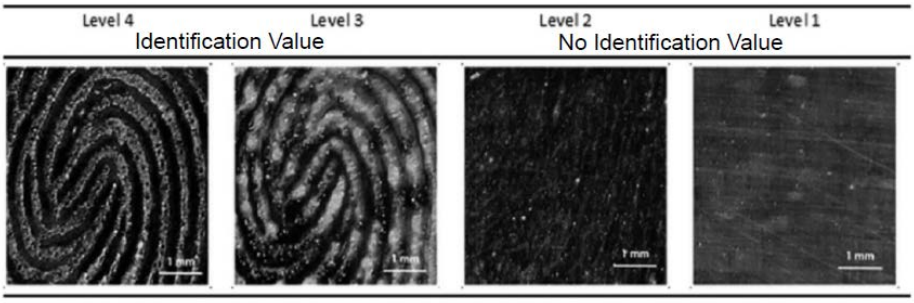
Learning Overview: After attending this presentation, attendees will learn about the reliability of manually-collected measurements of latent fingermarks' ridge widths. Additionally, they will be introduced to the statistical methods used in the analysis.

Impact on the Forensic Science Community: This presentation will impact the scientific community by demonstrating the robustness of the method used to measure topographical features with the goals to introduce automation in the future and use ridge widths as a parameter to estimate degradation patterns over time.

Fingermark identifications and analyses have been performed for over 100 years and are still a valuable forensic tool. However, the issue of when a latent fingermark was left behind is a recurring concern in the criminal justice system. Currently, there are no standards for estimating the time of deposition of a latent fingermark. To address this challenging matter, researchers have been seeking visual ways to model natural degradation patterns under the effect of different environmental conditions.[1-4] A reliable, portable, and inexpensive method to reveal the age of fingermarks could prove useful to crime scene investigations as it would exclude potential suspects if the estimated time of deposition is inconsistent with the commission of the crime. According to past research, changes in fingermark ridge widths over time could be used as a possible parameter to model the natural aging process of latent fingermarks.[5,6]

The purpose of this project was to statistically analyze the consistency of ridge width measurements across examiners obtained from different types of fingermark imprints. Measuring ridge widths manually, in the absence of an automated tool, is a highly subjective process. Therefore, determining the deviation of measurements on the same exact fingermarks becomes crucial. Repeatability, precision, and accuracy of each examiner was established.

The experiment involved testing the repeatability of measurements within and across four independent examiners. These consisted of three trained students and one expert. Intra- and inter-variability was statistically examined on fresh latent fingermarks powdered with titanium dioxide and carbon black, as well as on inked prints (flat and rolled) of the same fingers. A total of 90 fingermarks were examined using digital imaging software from 10 different donors. A statistical randomization schema for sample analysis was designed that resulted in a simplified version of data collection and a systematic approach to every measurement. Data was collected in three random rounds for each image. An examination of the quality of fingermarks [Fig. 1] was performed to evaluate how it could influence the accuracy of ridge width measurements, as shown:



[1] Categories of latent fingermark quality defined as a function of "levels of ridge detail"

For image quality, attribute agreement analysis was performed to confirm the agreement of examiners with themselves (intra-variability) and with each other (inter-variability). A method that is often used in agreement analysis where ratings are ordinal calculates Fleiss' Kappa, which tests for significance of intra- and inter-variability using asymptotic normal theory. Results suggested that examiners agreed with themselves and with each other. This suggests that intra-variability was not significant. Further, Fleiss Kappa statistics were calculated to confirm the agreement among examiners for each quality level. In this data set, examiners rated the prints at levels 3 and 4 (none were rated at 1 or 2). Results implied that the examiners agreed with each other for the quality level.

For the actual ridge width data, 30 points of measurement were distributed over 6 regions away from any identifiable minutiae [Fig. 2]. The same exact points were measured for all different types of prints. These points were cross-sections of ridges measured in pixels.

Fig. 2. Example of an inked fingermark image depicting the 30-point measurement distributed over 6 regions

Statistical analysis [Fig. 3] revealed that there were no significant differences within and across examiners (i.e., intra- and inter- variability). Thus, there was a consensus of measurement accuracy and precision among them proving the consistency and reproducibility of the method used. However, data consistently revealed ridge width differences between the latent and inked groups, and within the inked subgroups (flat vs rolled). These differences could be explained by the nature of the fingermarks themselves (latent vs. visible) and the deposition method for the inked prints (plain static vs. rolling motion). No significant differences were detected between the white and black powdered subgroups.

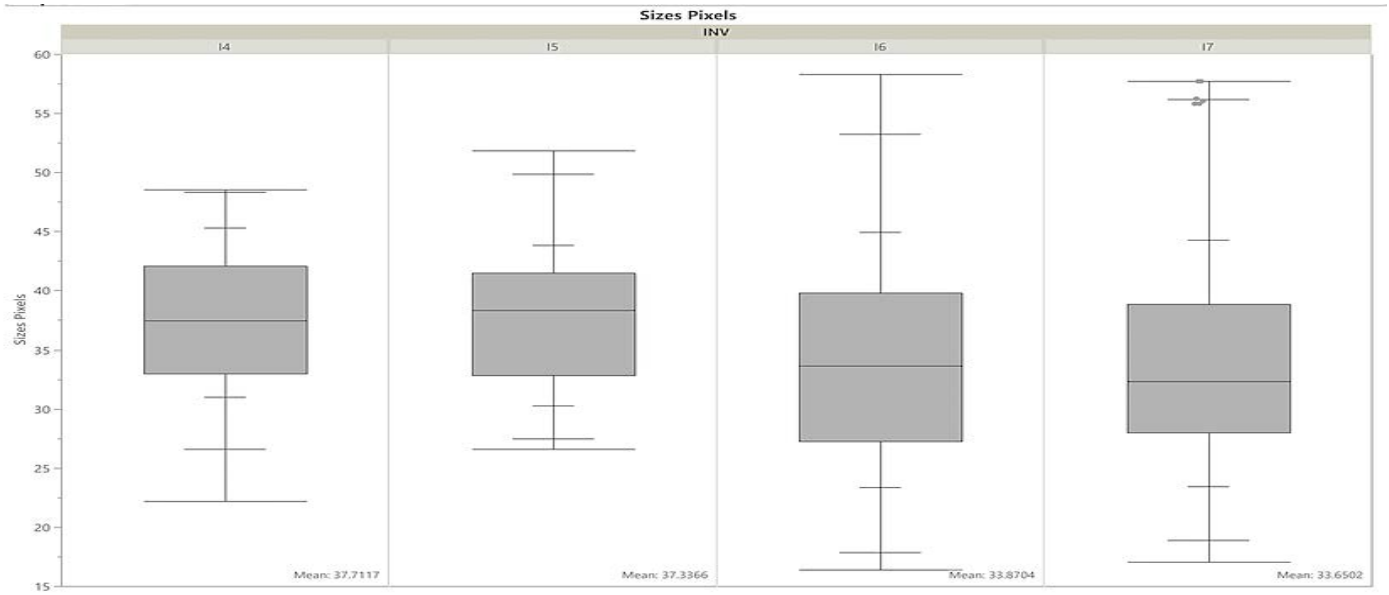


Fig. 3. Boxplot of overall raw data (ridge widths in pixels) per examiner.

This research provides evidence that changes in ridge width as result of natural degradation over time could be measured in a consistent manner. It contributes to the ongoing search for an inexpensive visual method for estimating the age of latent fingermarks and provides a basis for future research and automation for the analysis of topographical features.

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Ridge Width, Morphometrics, Degradation