E57   3D Imaging Technology to Uncover Changes in Latent Fingerprint Topography in Four Dimensions

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After attending this presentation, attendees will be familiar with latent fingerprint degradation patterns and ridge topography changes in 3D, including a phenomenon known as ridge drift. Additionally, attendees will be introduced to the statistical methods used in the analysis of fingerprint aging under different environmental conditions.

This presentation will impact the forensic science community by demonstrating statistical evidence of fingerprint degradation patterns without sample manipulation.

Fingerprints have been used for identifying suspects and victims at crime scenes; however, the issue of "when" a latent fingerprint was deposited is a recurring concern in courts of law. Currently, there is no accepted methodology for estimating the time of deposition of a latent fingerprint. No method has yielded yet reliable results, neither has it been fully approved by the scientific community to be used in a court of law. To address this gap in forensic science knowledge, researchers have been studying visual methods to determine fingerprint age or to model fingerprint degradation patterns.[1] Estimation of the age of fingerprints could prove useful to crime scene investigations by excluding potential suspects if the estimated time of deposition is inconsistent with the time of the crime.

Previous studies have observed topographical changes and individual ridge movements as fingerprints aged, such as the discovery of ridge drift.[2] Other researchers, including Popov et al., have detected a "horizontal migration of components" of fingerprint ridges.[3] Dorakumbura et al. reported that individual fingerprint "droplets" vary in their adhesion to certain surfaces.[4] Merkel et al. demonstrated that 3D optical capturing devices could potentially solve the problem of determining fingerprint age.[5] In accordance with these and other previous research findings, this project investigates the causes of ridge drift that cannot be explained in 2D rendering of a fingerprint.

In 2D rendering, only the length and width of fingerprint ridges can be observed. In traditional analytical methods, fingerprints are usually manipulated using destructive or invasive procedures, such as powdering, exposure to reactive chemicals/metals, or swabbing. In this study, non-destructive 3D optical profilometry is used to examine the aging of a latent fingerprint without manipulating it. This imaging technology provides reliable information on the x, y, and z axes of fingerprint ridges. The ridge heights, widths, and lengths across a fingerprint are measured and analyzed over time using established statistical methods.

The experiment involved aging sebaceous-rich latent fingerprints from six donors (three males and three females) in various environmental conditions: "exposure to natural light" (direct sunlight and darkness); "substrate type" (glass and plastic); and "finger" (index and middle fingers). These were stored indoors and allowed to age. Exposure to light, temperature, and relative humidity were not controlled but monitored to closely mimic field conditions. Samples were randomly drawn over a period of three months and directly observed and captured using 3D imaging without any pre-treatment. The equipment used was a ZeScope™ Optical Profilometer from Zygo® Corp, which provided high-quality images and mathematical data in 3D space and time.

Over the course of the study, 1,296 fingerprint images and statistical data were collected for analysis. Each 3D fingerprint image was measured to acquire two metrics: Sa (average surface roughness) and Sq (standard deviation of the surface roughness). These values were aggregated to create a statistical model to explain the change in a fingerprint's Sa and Sq over time. Preliminary data demonstrated that both Sa and Sq measurements decreased over time, strongly suggesting that fingerprint ridges were also degrading in height.

This study proposes a methodology to track the physical changes in a latent fingerprint's ridge length, width, and height over time. This study provides evidence that degradation can be monitored and measured. Lastly, this study contributes to the ongoing research of determining the age of a fingerprint and provides a basis for future research.

Reference(s):
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