D1 The Application of Optical Coherence Tomography (OCT) in the Detection of Latent Fingerprints

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Learning Overview: The goals of this presentation are to show how to: (1) detect latent fingerprints hidden beneath adhesive tape, and (2) separate overlapped fingerprints by a novel forensic imaging technique, OCT.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by introducing a novel forensic imaging technique, OCT, into the detection of latent fingerprints, which enables obtaining cross-sectional structure while being non-invasive, *in situ*, high resolution, and high speed. OCT may become a reliable guide and complementary method in forensic investigation.

Fingerprints are usually covered by a certain non-transparent material at a crime scene, which leads to difficulties in detecting and matching the fingerprint. For example, the fingerprint can be deposited unintentionally on the sticky side of adhesive tape by the suspect in various criminal cases, including rape, murder, kidnapping, and explosives.[1] However, the adhesive tapes found at crime scenes are often stuck together or attached to a certain substrate. Consequently, the latent fingerprints are sandwiched between two strips of adhesive tapes or between the tape and the substrate, making the prints difficult to detect and visualize. Traditional treatments, such as mechanical separation, steam heat, chemicals, liquid nitrogen, and freezing with refrigeration, would more or less affect the physical condition of tapes, contaminate the biological evidence, and eventually may adversely affect the accuracy of identification.[2-4] In addition, latent overlapped fingerprints are frequently encountered in latent fingerprints lifted from crime scenes, which are difficult to separate and match by fingerprint matchers.[5] A few methods have been proposed to separate overlapped fingerprints, but these methods are not accurate and reliable enough.[6] It is desired to develop a non-invasive and high-resolution subsurface imaging method to reduce the labor of fingerprint examiners.

OCT is an optical imaging technique that is new in forensics and performs high-resolution, cross-sectional tomographic imaging of the internal microstructure in materials and biologic systems by measuring backscattered or back-reflected light.[7-8] In the first part of this presentation, a custom-built OCT system was employed to detect and visualize the latent fingerprints that were deposited on the boundary of adhesive-substrate *in-situ*, without any pre-treatments, such as unraveling or chemical processing, preserving the integrity of tape evidence. Three most commonly used types of adhesive tapes (i.e., electrical tapes, box-sealing tapes, and Scotch® tapes, were chosen, and nine different samples were prepared for obtaining the internal fingerprints. The OCT system employed a broadband, super-luminescent diode as a light source centered at 832nm with the Full Width Half Maximum (FWHM) bandwidth of 60.4nm. The system was tested to achieve ~6μm resolution and the maximum imaging speed of 70 kHz A-line rate that equals to 43fps. For 3D image acquisition, single Axial scan (A-scan) acquisition was combined with 2D lateral scanning mechanism. A hand-held probe was designed to realize portable and flexible scanning across an area of the samples. The *en face* (transverse section) images of each sample at the subsurface layer of the latent fingerprints were presented. The results demonstrated that OCT can rapidly detect and recover precision images of latent fingerprints hidden beneath adhesive tapes while maintaining the original physical and chemical state of the sample.

In the second part of this presentation, the same OCT system was adopted to separate four overlapped fingerprints, which were deposited on the slide glasses oriented at 0°, 90°, 180°, and 270°. 3D OCT reconstructions were implemented and *en face* images of the fingerprints at each subsurface layer was extracted from the 3D OCT dataset. The individual fingerprints were successfully recovered in high resolution due to the tomographic ability of OCT. The results show that OCT provides a reliable guide and complementary method to separate overlapped fingerprints in a non-destructive and fast detection manner.

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