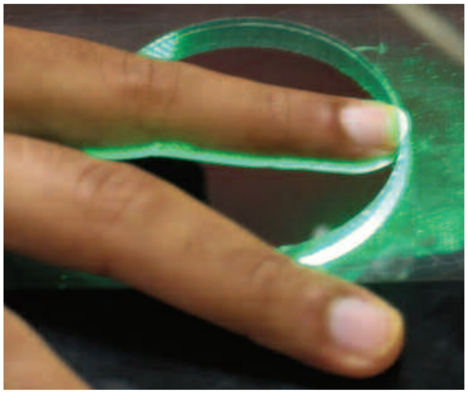

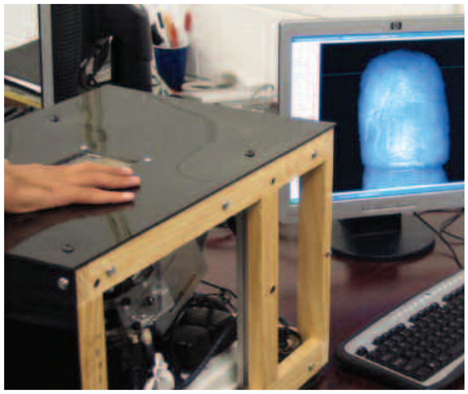

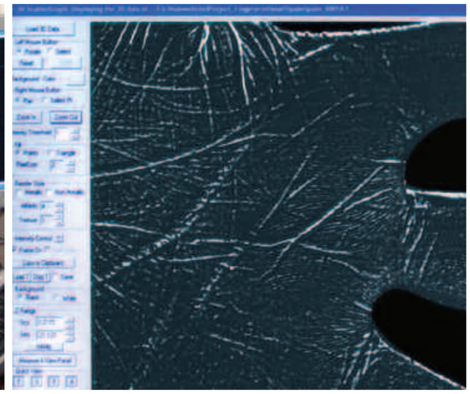

Lights and stripes

and the future of fingerprinting

Most of us have seen fingerprinting in the movies or on TV. We're familiar with the ink-stained fingers, and a gloved technician rolling the subject's fingertips onto a card. Take a look at forensic training materials and you'll learn that taking fingerprints is a delicate process. Indeed, the FBI's fingerprinting training materials include detailed instructions on how to fingerprint an individual, guidelines for the appropriate tools, proper technique, and several examples of unacceptable fingerprints.

Modern live scan technologies complement the traditional ink method. Live scan methods use the same technique as the ink method: a technician or operator rolls a subject's finger from the edge of the nail to the other across a glass plate instead of an inkpad. But whether the prints are taken on paper or glass, the process is very cumbersome and time consuming. "These live scan technologies require 5-10 minutes on average to enroll a single person," explains Dr. Laurence Hassebrook, Associate Professor of Electrical and Computer Engineering at the University of Kentucky (UK). But users of live scan machines have a more serious issue. "We've heard anecdotal evidence that the glass distorts the image," says Hassebrook's colleague Dr. Daniel Lau, also Associate Professor of Electrical and Computer Engineering at UK.

As far as the authorities are concerned, a solution is needed. Considering that the Department of Homeland Security (DHS) has instructed the FBI to expand its fingerprint database, reducing the scanning time is extremely important. So in 2004, the National Institute of Justice (NIJ) solicited applications to the Fast Fingerprint Capture program, an initiative to develop more efficient methods for collecting fingerprints.

"The FBI wants to include not only criminals and those who undergo an FBI background check, but pretty much any person who applies for a state driver's license or passport, or any foreign national entering the United States," notes Lau. "That's an expansion of 5 million to 30 million unique human subjects."

Hassebrook and Lau explain that the NIJ has two basic requirements for Fast Fingerprint Capture systems. First, the system must scan all digits of one hand in less than 10 seconds' acquisition time, and second, it must generate an image of a rolled-equivalent scan (finger nail to finger nail) at 500 ppi (pixels per inch) or better – without the help of a human operator.

The answer is behind bars

"The [traditional fingerprinting] process is a 3-dimensional process because the recorded print is dependent on the fingerprint ridge depth," says Hassebrook. "Our method is the digital analogy to this traditional process."

The method relies on structured light illumination (SLI), a scanning process of projecting and capturing a series of striped patterns over an object. Its shape can then be deduced by analyzing the way the stripes warp over the object's surface when viewed at an angle by a camera. Given Hassebrook's twenty-five years' experience with SLI and his recent work with Lau on real-time SLI video, their answer to the FBI's dilemma was obvious: develop a system that scans a hand to generate a 3D image in real time and convert that image to simulate a 2D rolled fingerprint. So in combination with a third faculty member, Hank Dietz, and a commercial partner, FlashScan 3D (Austin, TX), they developed a 'non-contact' system – a system that generates the subject's prints without the need to touch a surface.

Their initial prototypes scanned a single finger. When in operation, the subject places a finger over an opening in the system's enclosure (images left and center). An off-the-shelf DLP (digital light processing) projector projects a series of striped patterns onto the finger ridges. An array of three Basler Camera Link® cameras acquires a series of images that "wrap" around the finger. These images are subsequently transferred into the host Dell Precision workstation with two Matrox Solios XCL video capture cards.

A second prototype uses a single 4-megapixel Camera Link® camera (with a single Matrox Helios XCL capture card) to acquire a scan region large enough to capture a human subject's palm (image right). This system can also acquire the prints of all four fingers simultaneously, but it does not achieve wrap-around scanning of any finger. To achieve instantaneous acquisition, future prototypes will feature a single, continuously projected, custom-designed composite pattern instead of the projected striped patterns, as well as larger camera arrays for simultaneous acquisition of the entire hand, with wrap-around finger scanning. Finally, Hassebrook and Lau also have a plan to replace the cameras with mirrors as a means of reducing costs and making the system more commercially viable.

By projecting an array of multiple stripes that completely cover the target surface in a single projection, the stripes can be spatially encoded in such a way as to be uniquely identifiable in the captured image. Hassebrook developed the algorithms that accomplish these tasks, rendering a 3D composite image of the subject's finger. Lau's software then post-processes the 3D composite image with custom warping functions into a two-dimensional equivalent, a 2-D image that emulates the result of a rolled inked finger. Results of the single-finger prototype are encouraging: multiple cameras positioned around a finger generate multiple 3-D scans that are merged to form a single, wrap-around scan of the finger which is "flattened" to acquire the rolled-equivalent image. "In fact, we can go as far as to tell you the height of each ridge versus its neighboring valleys as well as detect pores in the skin," adds Lau.

"Non-contact based systems will be the future in this area," explains Lau. "First with these camera array systems like ours, you can scan a hand's entire surface to achieve wrap-around scanning. Second, the cost of ultra-high resolution camera sensors is quite affordable." Taking advantage of consumer cameras that can be controlled remotely through a USB connection (such as a Canon Powershot camera) keeps the overall system cost down. Finally, the full-hand systems can be fully automated and may function without the intervention of an outside operator. The hand's pose can be determined through software that can even correct the subject's position.

This project is being funded directly by the Department for Homeland Security, and when Hassebrook and Lau are satisfied, they will give it to members of the Kentucky State Police who will perform live testing and evaluation of the system. Upon completion of that testing, a prototype system will be delivered to the NIJ for their evaluation. Indeed, only four independent projects for live-scan replacement systems are included under the NIJ's Fast Fingerprint Capture program. In the meantime, the initial single finger and palm print prototypes are being further developed in collaboration with FlashScan 3D for FBI certification and commercial release. FlashScan3D will focus on increasing the speed of the system while at the same time reducing the size and cost.

The future of fingerprinting

One issue that remains unanswered is what the NIJ intends to do with the acquired scans. Indeed, Lau estimates the space required for storing scans of 30 million individuals could be around 300 million megabytes. Furthermore, if the scans will be used to match prints acquired at crime scenes, the NIJ would require a method for comparing the scans. At the time of printing, the NIJ had yet to announce plans for a database to keep this information. We'll have to wait to see what happens, but with the improvements to live scan fingerprinting technologies, we can keep our fingers clean. M

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All images courtesy of the University of Kentucky.