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Toward a Quantitative Basis for Sufficiency of Friction Ridge Pattern Detail

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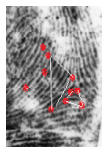
Motivation and Approach

- A scientific measure of confidence is needed to support an examiner's decision, particularly for latent prints
  (*Daubert v. Merrell Dow Pharmaceuticals*, 1993)
- Latent prints are often blurred or partial, so we need to …
  - investigate *causes* of distortion
  - utilize grayscale information, unlike many AFIS implementations
  - utilize information from Levels 1, 2, and 3

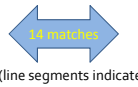
Quality Assessment based on Minutia Detection

- The NBIS "remove false minutiae" step utilizes 9 separate software filters ⇒ **512 different ON/OFF** combinations
- *Our idea:* Higher-quality minutiae should survive processing by more filter combinations
- *Experiment:* We investigated a case from NIST Special Database 27
  - A human examiner selected 16 minutiae from a latent print
  - The examiner then identified 14 matches in a ten-print image from the same subject
  - Our approach found **8 of those 14** minutiae to be of high quality

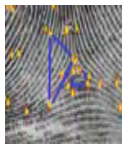
Latent image



Red points indicate some of the minutiae that were selected by the examiner



(line segments indicate high-quality points)



Ten-print image for same individual, with minutiae detected by NBIS

Minutia identifier	Frequency	Modified	Our score	NBIS score
589	511/511	No	HIGH	Low
571	255/511	Yes	Average	High

- Future work: Incorporate information related to 2-D point distributions, minutia orientations, ridge-based connectivity

Distortion from Motion Blur

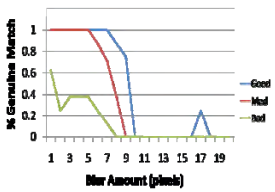
- In our simulations, minutia-based feature matching could tolerate blur up to about 8 pixels
- Motion blur filter (frequency domain):

$$H(u,v) = \frac{T}{\pi(ua+vb)} \sin[\pi(ua+vb)]e^{-j\pi}$$

T – amount of blur
a – blur in x direction
b – blur in y direction
(a, b) determines direction of blur

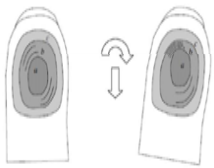
Increasing blur

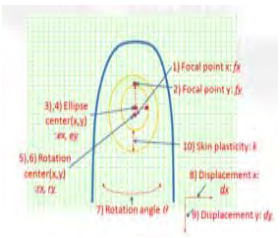
Sample smeared prints



Distortion from Skin Elasticity

- Small movements of the finger cause nonlinear changes in the imaged print
- These effects can be modeled using assumptions of skin elasticity
- We have developed a new software tool, *fpCreator*, which allows us to experiment with these concepts

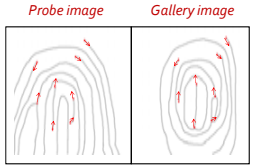




Elastic deformation model (after Maltoni and Cappelli, 2009)

Analysis of Friction Ridges

- Minutiae alone are not enough, especially when dealing with latent prints



Level 2 details (minutiae) match in this example,
but Level 1 details (ridges) do not match

- NBIS produces an *image quality map*, which we have extended to assign quality scores to individual ridges
- Ridge quality can be used to increase confidence in identifying correspondences between images

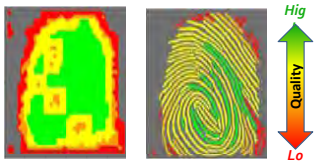


Image quality map

Ridge quality map

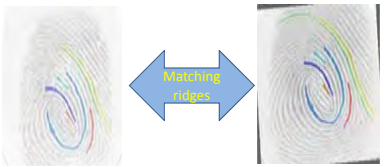
- We define **ridge component** as a connected portion of a friction ridge image that is terminated by two minutiae
- Let a **ridge connection** refer to a ridge component together with its two associated minutiae
- Ridge connections can be used to improve the confidence of matched minutiae

Probe image

Extracted ridge components

Ridge connections, indicated by line segments

- We expect our ridge component matching algorithm to perform better than minutia based matching in prints with low minutia counts

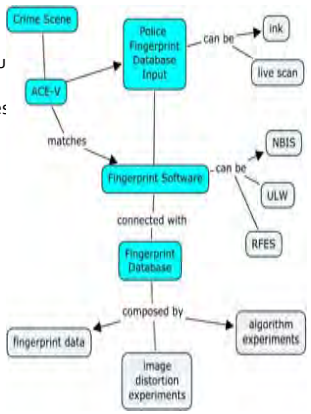


Probe image, with high-quality ridge components

Gallery image, showing matched ridge components

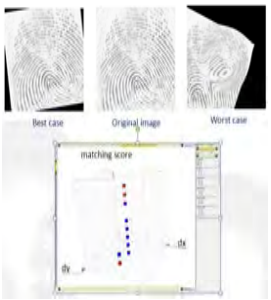
Database Design and Image Synthesis

- We have proposed a database schema to describe fingerprint information, distortions, and experimental data
- Motivated by NBIS:
  - information from individuals
  - description/parameters of the experiment with associated resu
  - time and evaluation of the experiment
  - information from original (latent) images and distorted images
  - parameters used to create the distorted images
  - computed distance between two compared images



Overview of approach to database development

Screenshot of *fpCreator*



Experimental results using distorted images generated by *fpCreator*

Acknowledgements

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