Comparative Fingerprint Quality and Performance: Rolls, Slaps, and Flats

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Can we use 1 or 2 flat index fingers to do criminal history checks?

How can we speed civil background checks?

How do we screen Visa applicants?

We can predict performance through (imperfect) projections based on fingerprint quality.
Case Study: IDENT / IAFIS Image Quality Study

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Purpose:
How would the existing FBI IAFIS perform when searched with representative INS IDENT data?
IDENT and IAFIS Requirements

IDENT
- Flat fingerprints
- 2 index fingers
- 2 minute response
- Automated verification

IAFIS Ten-print System
- Rolled fingerprints
- 10 fingers
- 2 hour response
- Human verification
  - Now automated for very high scores

or

IAFIS Latent System
- Latent fingerprints
- 1+ fingers
- 24 hour response
- List of top 20 candidates returned
Types of fingerprints

- Rolled
- Flat
- Slap (four-finger simultaneous)
- Latent
Rolled Fingerprints

- 1 to 2.5 square inches
- Average 80 minutiae
- Sufficient ridge detail to allow classification in almost all cases
- Slow capture process requires trained staff
Flat Fingerprints

- About 0.5 square inches
- Average 40 minutiae
- Can be fully classified less than half of the time
- Rapid capture process requires little training
- Often associated with inexpensive capture devices, which have additional quality implications
Slap Fingerprints

- 6+ square inches
- Average 40 minutiae / finger
- Each finger can be fully classified less than half of the time
- Rapid capture process requires little training
- Require more expensive capture devices, with improved quality
- Segmenting images can introduce errors
- Multiple fingers dramatically improve AFIS reliability
Latent Fingerprints

- Latent searching and identification require great expertise
- Latent processing is very computer-intensive
  - Searching 700 latents on IAFIS takes the same resources as 40,000 ten-print subjects
- Latent algorithms could be used to search flat fingerprints, but:
  - The manual latent process would have to be reengineered for automatic ID
  - The cost would probably be unacceptable
IDENT Flats vs. IAFIS Rolls

Poor quality

Average quality

High quality
What Determines the "Matchability" of Fingerprints?

- Number of Fingers
- Correspondence between Search and File images
  - Overlapping areas
  - Lack of mutual distortion
- Quality of *both* Search and File images:
  - Quality of Ridge Detail
  - Number of Features
  - Size of Image
The Effect of Correspondence

Mates (Matched)  Mates (Did not match)
Fingerprint Quality Metrics

- AFIS matching is based on
  - Classification,
  - Topology, and
  - Minutiae
- Therefore, fingerprint quality needs to measure
  - "Classifiability"
  - Ridge definition and clarity
  - Minutiae definition and clarity
Factors Limiting Fingerprint Quality

- Subject characteristics
  - Age, sex, occupation, scars, skin disease
- Fingerprint size
  - Roll vs. flat
- Acquisition device
  - Paper, expensive livescan, cheap livescan
- Processing
  - Recompression
Quality vs. Performance

Flat Good (Eq) Minutiae vs Matcher Score

Flat Good (Eq) Minutiae vs TP Reliability
Measuring Performance

- False Accept Rates are hard to predict in testing
  - Due to relatively small databases, necessary FARs of $10^{-11}$ can only be predicted, not measured

- Reliability is hard to measure during operations
  - There is no way of knowing if the mate is in the database
Testing Data Set Problems

- A Conundrum:
  - Data sets must be representative of a population,
  - but
  - Data sets must be mated to allow for testing
Data Sets and Survivor Bias

- Survivor bias is the incorrect assumption that the subjects remaining at the end of a study are representative of the subjects that started the study.

- Mated data sets are necessarily suspect: the process by which mates are determined *almost always* biases the results.
  - AFIS-mated data sets are only representative of fingerprints that can be matched by an AFIS, and should not be expected to provide meaningful performance results.
  - Name-matched data sets are much more...
Importance of Predicting Performance from Quality

Summary of IQS Results:

• Searching 2 flat IDENT-quality fingerprints against the current IAFIS ten-print system will result in unacceptable performance.

• Searching 2 flat IDENT-quality fingerprints against a modified IAFIS latent system would result in acceptable performance if the computer resources were increased by a factor of 8 to 10 times.

• Searching 4 or more (preferably 6 or more) flat IDENT-quality fingerprints against the current IAFIS ten-print system will result in acceptable performance.
Why is This Relevant?

- Because this same process will have to be repeated for ...
  - Travel document checks (PATRIOT Act)
  - Rapid civil background checks
  - Border control (IDENT/ IAFIS)
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