Developments in Latent Fingerprint Technologies

Evaluation of Latent Fingerprint Technologies (ELFT) Project

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Rolled Fingerprint
(ink capture)

Plain Fingerprint
(ink capture)

Latent Fingerprint
(powder lift)
ELFT Project Timeline

- **2006**
  - NIST Latent Fingerprint Testing Workshop

- **2007**
  - ELFT Phase I Evaluation

- **2008**
  - ELFT Phase II Evaluation

- **2009**
  - NIST Latent Fingerprint Testing Workshop
  - ELFT Phase II Miss Analysis Sessions
  - ELFT-EFS Public Challenge

- **2010**
  - ELFT-EFS Evaluation #1
  - ELFT-EFS Miss Analysis Sessions

- **2011**
  - ELFT-EFS Evaluation #2
NIST Evaluation of Latent Fingerprint Technologies (ELFT)

1. Acquire Latent Matchers (SDKs)
2. Compile Latent Test Sets
3. Configure Hardware

Evaluation Protocol
- Execute 1-to-Many searches
  - Image-only searches
  - Examiner-assisted searches (image + feature markup)
  - Operational images
  - Extended Feature Sets
- Measure & Analyze Results
  - Accuracy
  - Selectivity
  - Resource requirements
  - Gap analysis

Iterate process

1. Evaluation Reports
2. Feedback to Standardization
3. Technological Gap Analysis
4. Reference Data
Latent Examiner

Latent image (+ features) “Search”

AFIS

Potential matches

<table>
<thead>
<tr>
<th>Rank</th>
<th>Candidate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>2</td>
<td>![Fingerprint]</td>
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<tr>
<td>20</td>
<td>![Fingerprint]</td>
</tr>
</tbody>
</table>
Latent AFIS Technology Gaps: Relatively Low Accuracy

Fewer identifications

- Conventional AFIS
- Latent AFIS
Latent AFIS Technology Gaps

- Relatively low accuracy
  - 65-70% identification rate considered “high performance”

- High manual workload
  - features selection & markup
  - candidate list evaluation

**Solution:** Measurement and evaluation of searches using image only (“lights out”) vs. manually assisted search performance, and evaluation of candidate list reduction methods.
ELFT Results:
“Lights out” vs Manual Feature Selection

Number of Minutiae

Accuracy

1-5 6-10 11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-

image only image + features
ELFT Results: Accuracy vs. Examiner Workload

![Graph showing accuracy vs. examiner workload](image)
Latent AFIS Technology Gaps

- Limited interoperability
  - best accuracy requires manual feature selection/markup
  - commercial AFIS use non-standard features
  - even the same features vary between AFIS
  - no universal standard for feature selection/markup
  - features re-selected/marked for each new AFIS searched

**Solution:** Develop a comprehensive set of features which can be used to build a universal set of latent fingerprint search transactions. Latent Interoperability Transmission Specification (LITS) based on ANSI/NIST-ITL 2011 which includes Extended Feature Sets (EFS) and FBI EBTS.
AFIS Interoperability: Now
AFIS Interoperability: Future
## Extended Feature Set (EFS)

- **Improved Feature Quality**
  - *region quality map*

- **Improved Feature Set:**
  - *endings/bifurcations*
  - *pores*
  - *protrusions*
  - *incipient ridges*
  - *dots*
  - *creases*
  - *scars*
  - *skeleton*

- **Ridge ending**
- **Incipient**
- **Protrusion**
- **Pore**
- **Indeterminate**
- **Dot**
- **Core**
- **Bifurcation**
EFS Evaluation & Testing

- **ELFT-EFS Evaluation #1**
  - 1\textsuperscript{st} Multi-vendor AFIS matcher evaluation using a common feature set (EFS)
  - Features defined by upcoming ANSI/NIST-ITL 2011 standard
  - Feature marked by experienced latent examiners using a common guidelines
  - Assesses the performance of latent AFIS search technology with:
    - minutiae only
    - image only
    - image + various subsets of EFS
  - Final Report: **NISTIR 7775**, March 2011

- **ELFT-EFS Evaluation #2**
  - Re-iteration of Evaluation #1 with updated algorithms
  - Follows miss analysis sessions conducted with developers
  - Measures improvements/regressions in matcher performance
  - Provides better estimate of state of the art
  - Final Report TBD October 2011
ELFT-EFS Results: Accuracy vs. EFS Feature Subset

![Accuracy vs. EFS Feature Subset](chart.png)
ELFT-EFS Results:
Accuracy Improvement (Eval 1 vs. 2)
Future Work

- **ELFT-LITS** *(start date to be announced Fall 2011)*
  - LITS = Latent Interoperability Transmission Specification (LITS)
  - evaluation of LITS based search transaction performance

- **ELFT-PALM** *(start date to be announced Fall 2011)*
  - evaluation of AFIS performance for latent palm vs. enrolled palm

Future ELFT evaluations will also evaluate:
- high-, medium-, and low-resource algorithm performance tradeoffs
- “reverse latent” (rolled-/plain-print to enrolled latent) matching performance
- fusion approaches to enhancing performance
For More Information…

Web ➔ http://fingerprint.nist.gov/latent

Email ➔ latent-efs@nist.gov
Presentation Overview

1. Introduction to automated latent print ID
2. Automated latent ID technology (AFIS)
3. Latent AFIS technology gaps
4. NIST latent testing & evaluation (ELFT)
Automated Latent Fingerprint Identification Systems (AFIS)
Latent workstation

Latent matching unit & database (AKA “AFIS”)

Image of a man using a computer with a large server in the background.
Collective Matcher Performance
(1,114 latents)

Evaluation #1
- Missed by all: 78%
- Hit at > r1: 13%
- Hit at r1: 9%

Evaluation #2
- Missed by all: 81%
- Hit at > r1: 12%
- Hit at r1: 7%
Latent Examiner

Ridge ending

Indeterminate

Core

Core

Bifurcation

Latent Workstation Screenshot
Roadblocks to Interoperability

➢ Lack of cross-jurisdictional interconnectivity
  • technological differences
  • lack of exchange processes/agreements
  • funding issues, usage policies, legal issues, …

➢ Variation in feature selection, markup, and exchange
  • best accuracy requires hand-marked features
  • lack of universal standard for data exchange
  • additional AFIS searches = additional examiner workload
Solutions

- Improve AFIS accuracy
  - testing & evaluation to analyze performance/gaps
  - standard reference data for developers

- Reduce the need for manual processing
  - determine where “lights out” processing is viable
  - improved selectivity (fewer/better candidates)

- Develop interoperable latent search features
  - based on ANSI/NIST-ITL EFS and FBI EBTS (LITS)
  - assess accuracy and utility of interoperable features
ELFT-EFS Results: Accuracy vs. Minutiae Count