A Feedback Paradigm for Latent Fingerprint Matching

Eryun Liu, Sunpreet S. Arora, Kai Cao, Anil. K. Jain Department of Computer Science and Engineering Michigan State University http://biometrics.cse.msu.edu/

Importance

- Latent fingerprints are an important source of forensic evidence for identifying suspects
- Improving latent fingerprint matching accuracy is one of the major goals of FBI's NGI program



Houston Cold case: Latent fingerprint found on the victim's car was used to identify the criminal using FBI's IAFIS.*

*http://www.fbi.gov/news/stories
/2011/october/print_101411

Motivation

- **NIST FpVTE**: Best matcher achieved rank-1 identification rate of ~99.4% on plain prints [1]
- **NIST ELFT EFS II:** Best rank-1 identification accuracy for latents is ~63.4% in "lights-out" mode [2]





NIST FpVTE

NIST ELFT-EFS

[1] C. Wilson *et. al,* Fingerprint vendor technology evaluation 2003: Summary of results and analysis report, NISTIR7123. http://fpvte.nist.gov/report/ir_7123_analysis.pdf, 2004

[2] M. Indovina *et. al,* ELFT-EFS Results, NIST Evaluation of Latent Fingerprint Technologies: Extended Feature Sets Evaluation#2, http://biometrics.nist.gov/cs_links/latent/elft-efs/IAI_2012/ELFT-EFS2_IAI_2012_Final.pdf

Challenges in Latent Matching



Poor Ridge Clarity

Small Friction Ridge Area

Complex Background Noise

Bottom-up Matching Paradigm

- Latent matchers [3] [4]: "bottom-up matching"
- Feature extraction for latents is not reliable due to poor ridge clarity and background noise



[3] A. Jain and J. Feng, "Latent Fingerprint Matching", IEEE TPAMI, 33(1):88–100, 2011.

[4] A. Paulino et al., "Latent Fingerprint Matching using Descriptor-based Hough Transform", IEEE TIFS, 2013. 5

Proposed Feedback Paradigm

 Incorporate "top-down information" or feedback from exemplars to improve latent feature extraction



Resorting Candidate List



Resorting Candidate List

1. Initial Matching and Alignment

2. Exemplar Feature Extraction

3. Latent Feature Extraction and Refinement

4. Match Score Computation

Initial Matching and Alignment

- Latent matcher matches the latent image to the exemplar (Bottom-up mode)
- Matched minutiae used to align the latent-exemplar pair



Exemplar Feature Extraction

• Exemplar features extracted using a COTS matcher



Exemplar orientation



Latent Feature Extraction

• Latent features extracted in Fourier Domain



 $\begin{bmatrix} 1 & 1 \\ 1 & 2 \\ 1$

Latent

Local Fourier Analysis in 16x16 blocks

Latent Feature Refinement

- **Refined latent orientation:** Latent ridge orientation closest to the exemplar orientation
- **Refined latent frequency:** Latent ridge frequency corresponding to the selected orientation



Refined latent feature

Feedback Similarity Computation

Feedback orientation similarity



• Feedback frequency similarity



Match Score Update

• Product fusion to obtain the updated match score:



Performance Evaluation: NIST SD27



Latent Matcher [4]

Latents: 258 operational latents

Background: ~32k exemplars

Rank-1 identification accuracy improves by ~8%

Performance Evaluation: WVU Database



Latent Matcher [4]

Database: 449 latents collected at WVU

Background: ~32k exemplars

Rank-1 identification accuracy improves by ~3%

[4] A. Paulino et al., "Latent Fingerprint Matching using Descriptor-based Hough Transform", IEEE TIFS, 2013.

Successful Case 1



Latent







Mated exemplar



Refined orientation field

Rank of the mated exemplar improved from 92 to 5 after feedback

Successful Case 2



Latent



Extracted orientation field



Mated exemplar



Refined orientation field

Rank of the mated exemplar improved from 42 to 2 after feedback

Failure Case

- Ridge structure of the impostor is very similar to the mated exemplar
- Mated exemplar is of poor quality



Rank of the mated exemplar degrades from 6 to 27 after feedback

Conclusions and Future Work

- Feature extraction from latents is challenging due to poor ridge clarity and complex background noise
- We incorporate feedback from exemplars to refine latent features
- Experimental results show significant performance improvement using the feedback paradigm
- Proposed paradigm can be wrapped around any latent matcher to improve its matching accuracy
- Future work:
 - Include additional features in the feedback paradigm
 - Improve feedback similarity computation