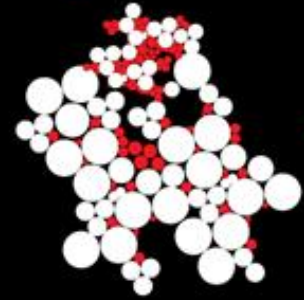


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NETHERLANDS



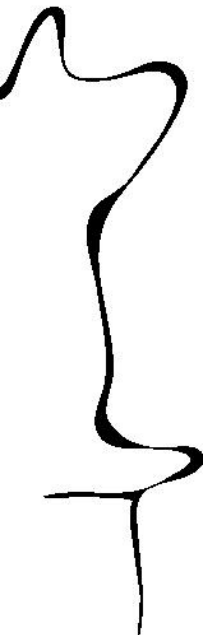

Spectral Minutiae Representations for Fingerprint Recognition

Raymond Veldhuis
Haiyun Xu



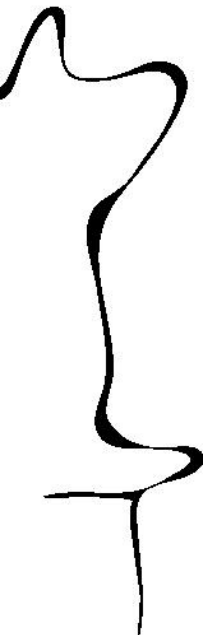


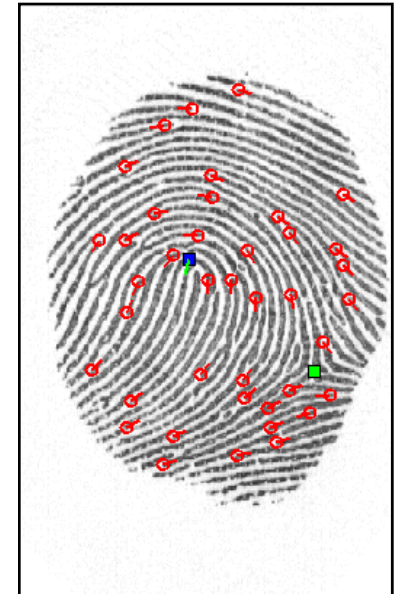
Content

- 
- 
- ❑ **Background: motivations & targets**
 - ❑ **Spectral Minutiae Representations**
 - ❑ **Enhancements**
 - ❑ **Conclusions**



Background

- 
- ❑ **Unprotected storage of biometrics:**
 1. Identity fraud
 2. Privacy violation
 - ❑ **Target:** Protecting the biometric data stored in database without additional keys.
 - ❑ **Combine fingerprint recognition system with template protection scheme.**



A decorative graphic on the left side of the slide, consisting of a vertical line with various colored elements: a yellow and black abstract shape at the top, green starburst shapes in the middle, and black circular shapes at the bottom.

Biometric template protection













- ❑ **Requirements in *ISO/IEC 24745 – Information technology – Security techniques – Biometric information protection***
 - Renewability: revocability or cancelable.
 - Unlinkability: against cross-matching between databases.
 - Irreversibility: privacy.

- ❑ **Current techniques**
 - Fuzzy Commitment
 - Fuzzy Vault
 - Cancelable Biometrics
 - ...

 - Our solution: **Helper Data Scheme** (equivalent to Fuzzy Commitment, presented later)
 - Requires:
 - High-performance biometric
 - Fixed-length feature set.

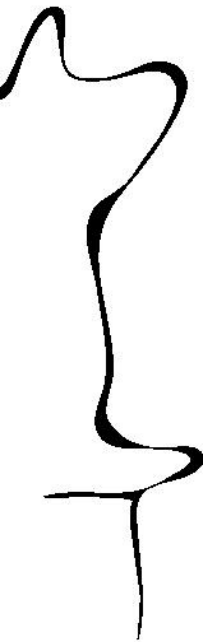

Targets

❑ Desired properties and current techniques

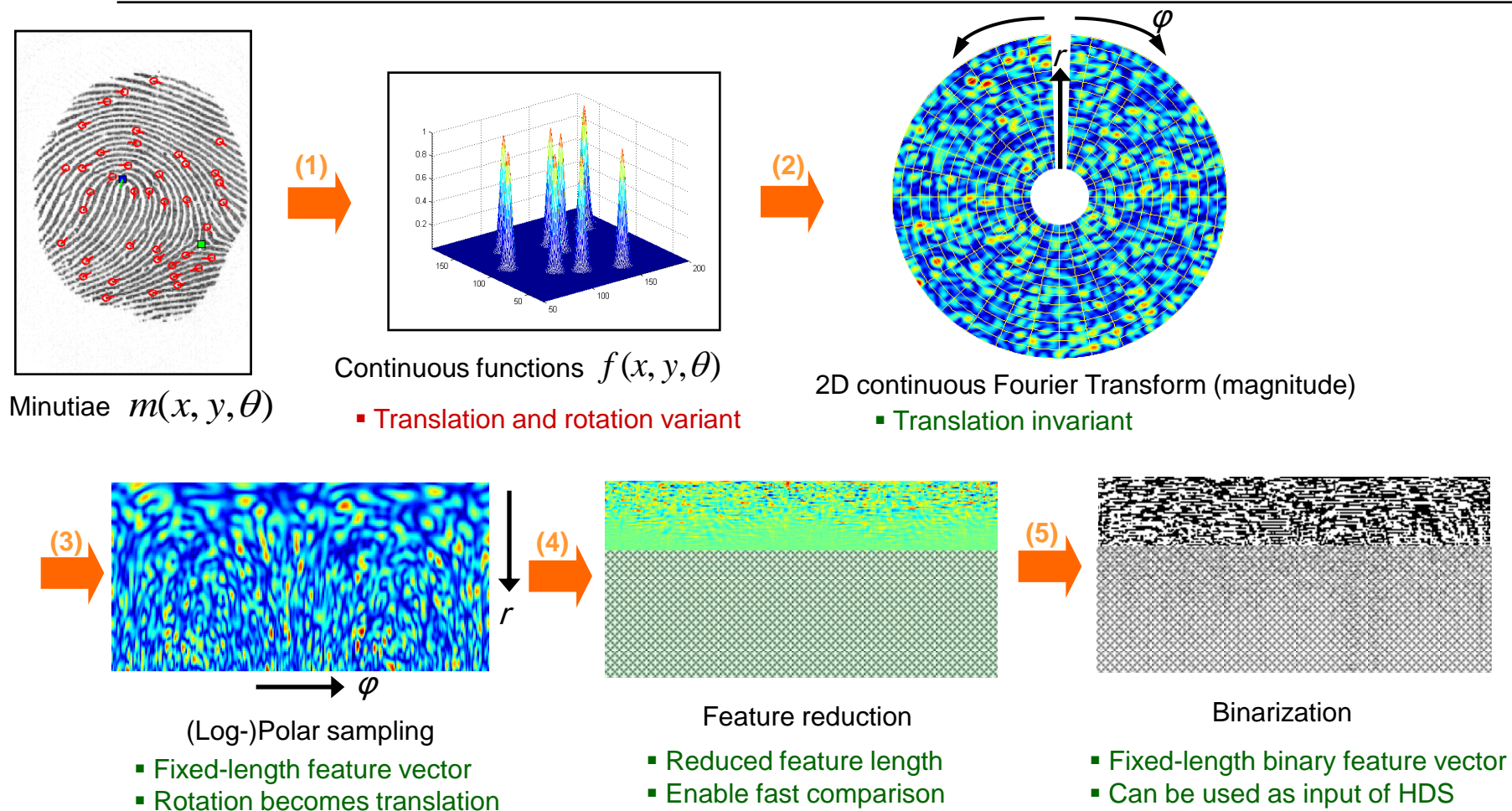
Methods \ Desired properties	Shape	Minutiae	Spectral minutiae
Fixed-length			
Translation rotation invariance			
Recognition Performance			
Speed			



Content

- 
- ❑ Background: motivations & targets
 - ❑ **Spectral Minutiae Representations**
 - ❑ Enhancements
 - ❑ Conclusions
- 

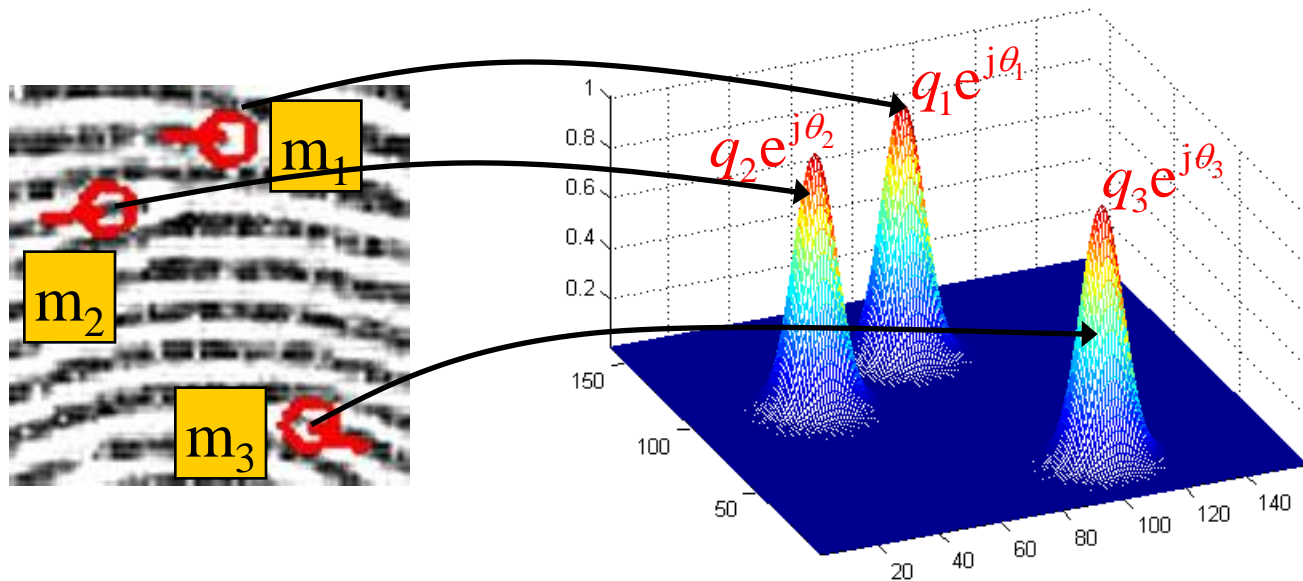
Spectral Minutiae Representation: procedure



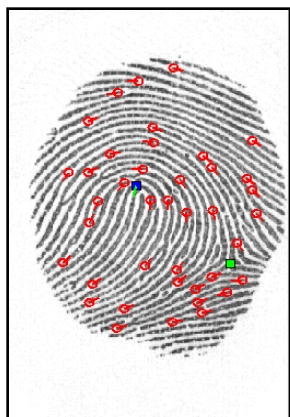
Complex Spectral Minutiae Representation: SMC

Minutiae: $m(x, y, \theta)$

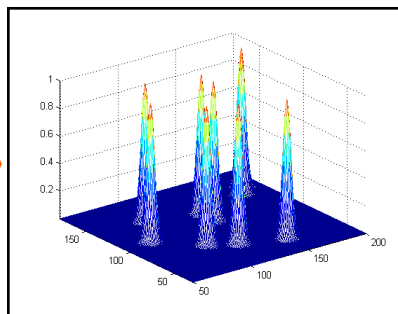
x, y : location, θ : orientation



Spectral Minutiae Representation: General Procedure

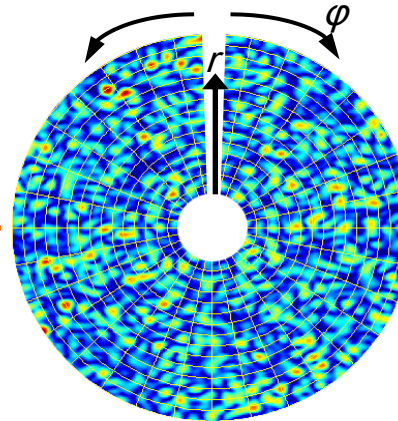


minutia : x, y, θ



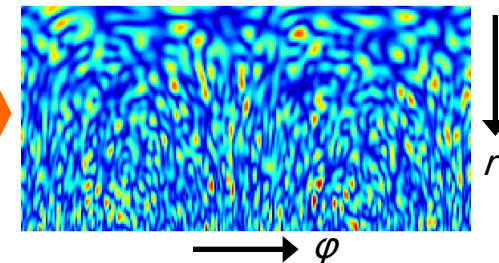
Continuous functions $f(x, y, \theta)$

- Translation and rotation variant



2D continuous Fourier Transform (magnitude)

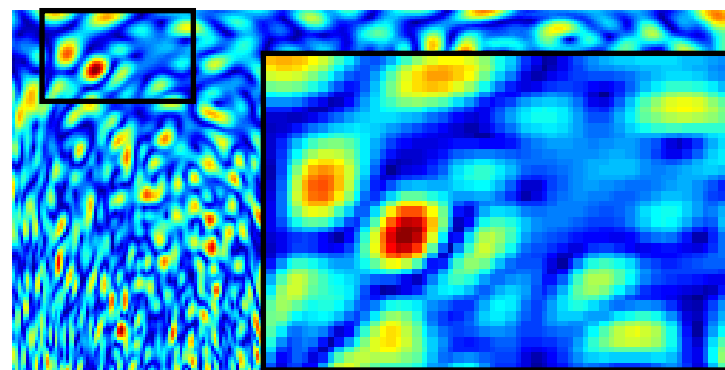
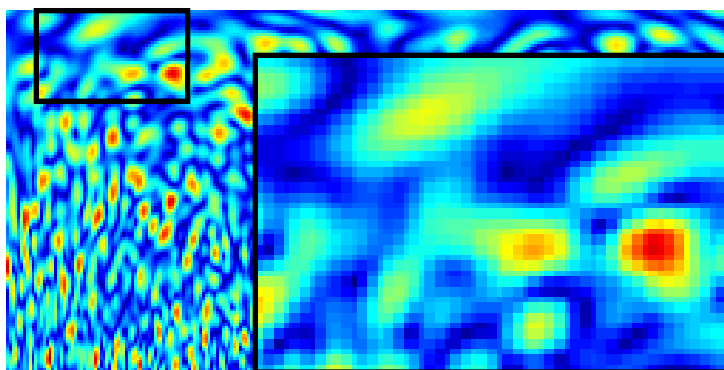
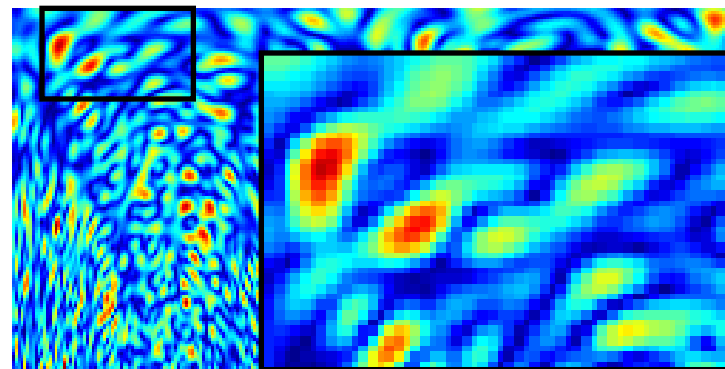
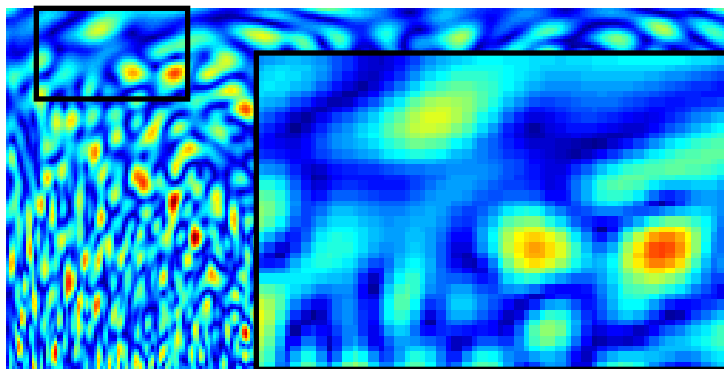
- Translation invariant



(Log-) Polar sampling

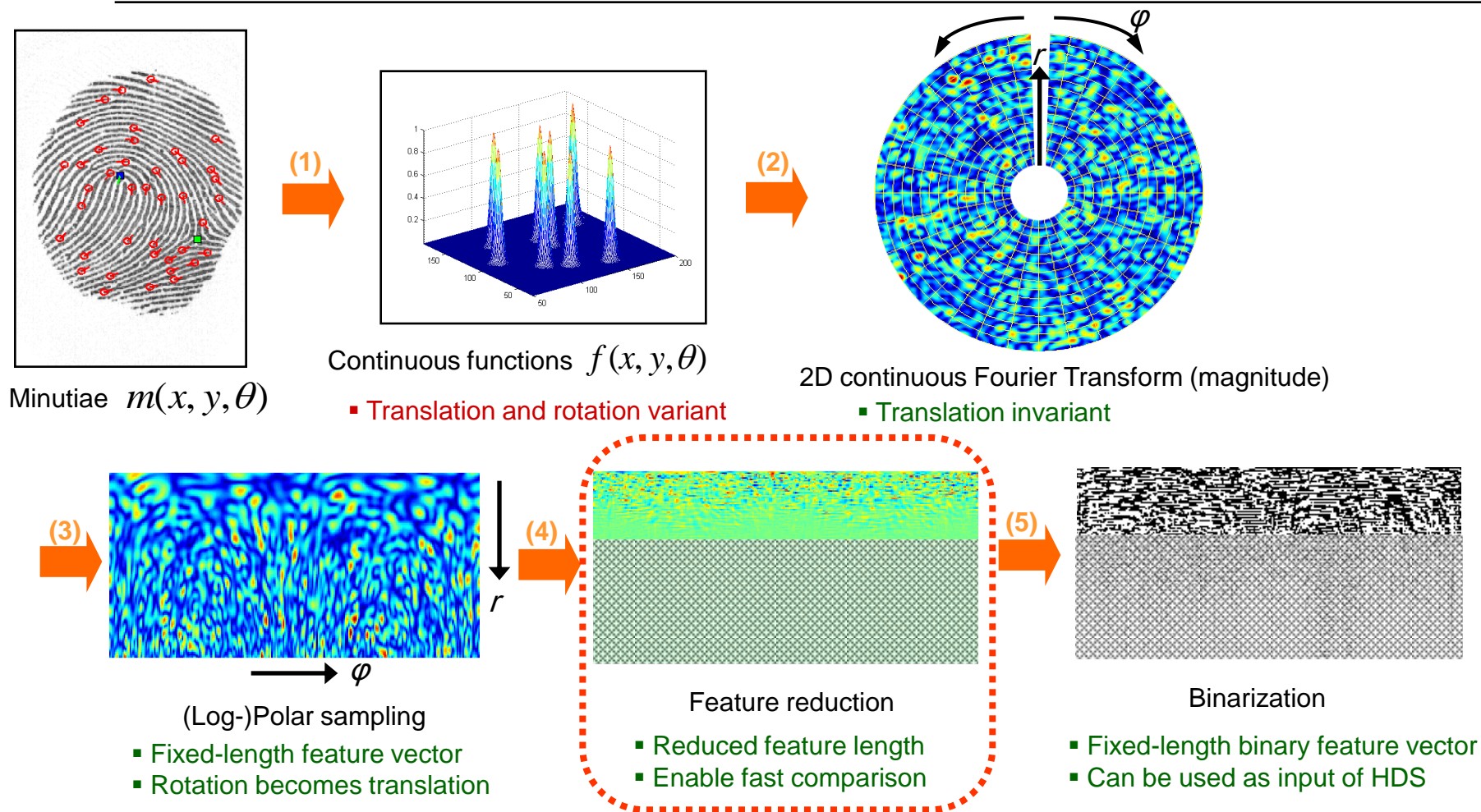
- Fixed-length feature vector
- Rotation becomes translation
- Comparison based on correlation
- Trying various rotations.

Examples of SMC features



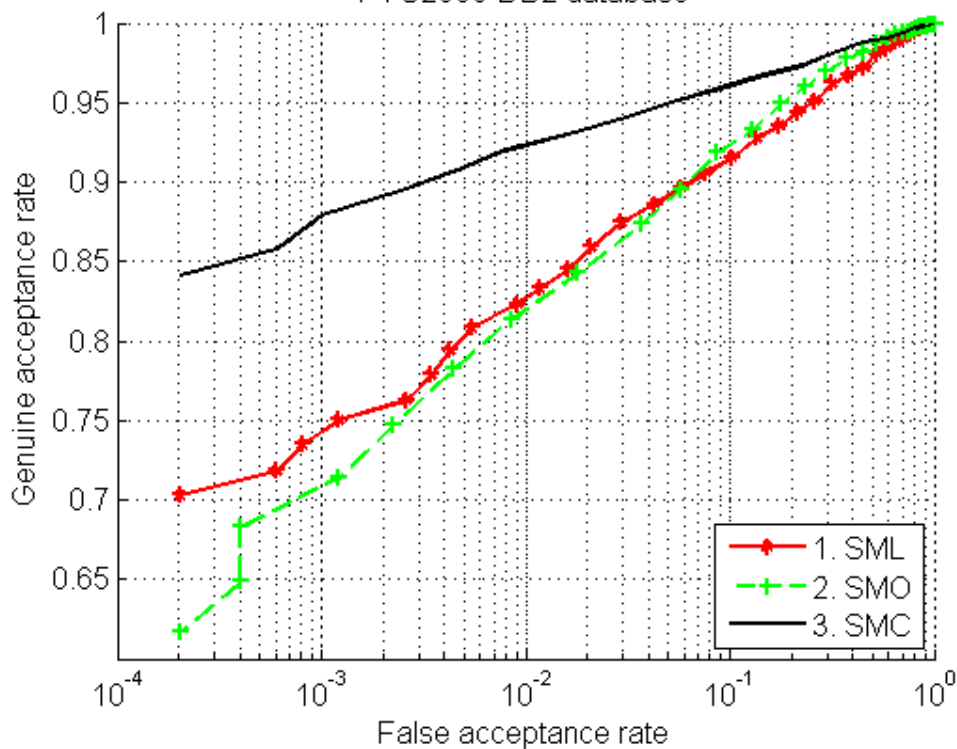
Answer: the left two are from the same finger; the right two are from another finger.

Spectral Minutiae Representation: procedure



Performance: SML, SMO, SMC

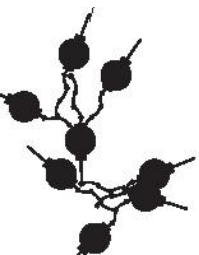
FVC2000-DB2 database



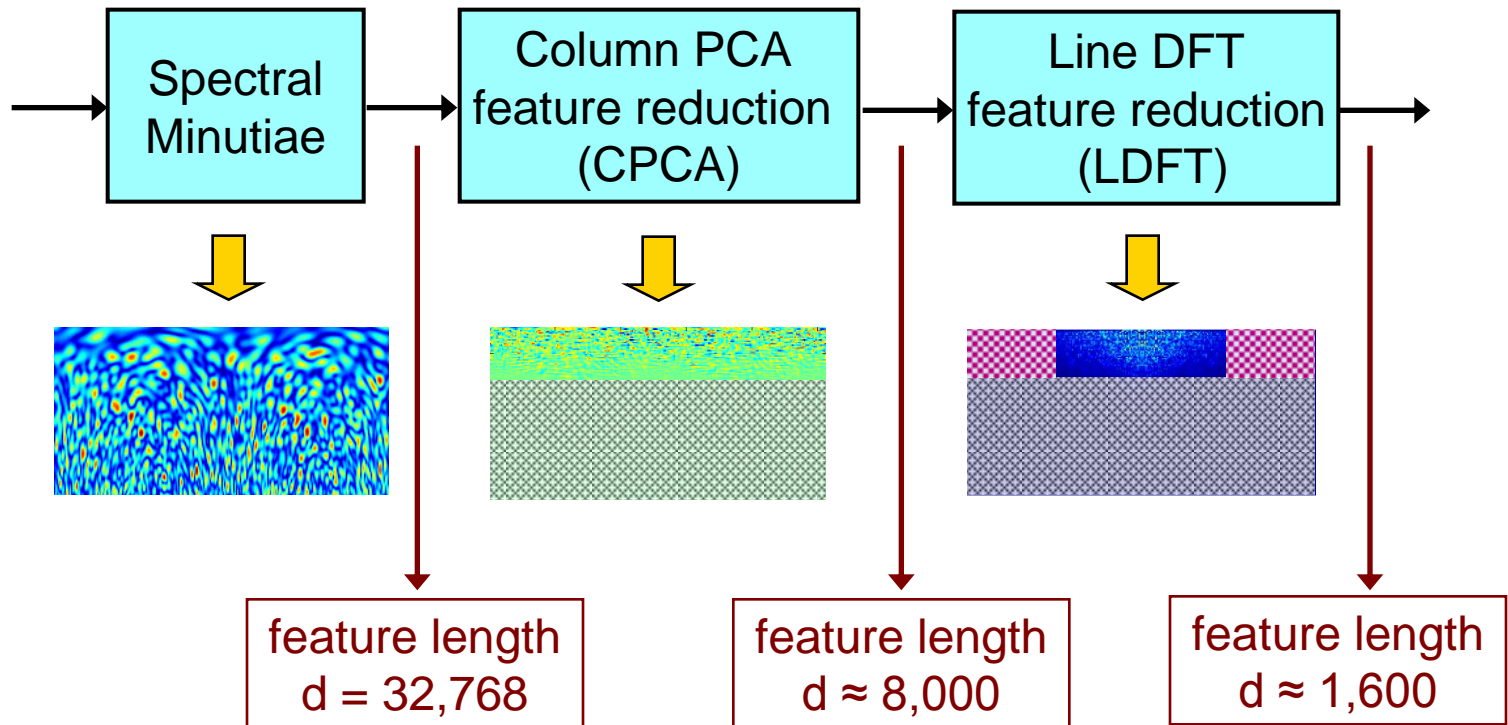
Database: FVC2000-DB2
(100x8 fingerprints)

Comparison: correlation-based matching.

Methods	EER	GAR @ FAR= 10^{-3}
SML	0.088	0.743
SMO	0.083	0.710
SMC	0.050	0.882

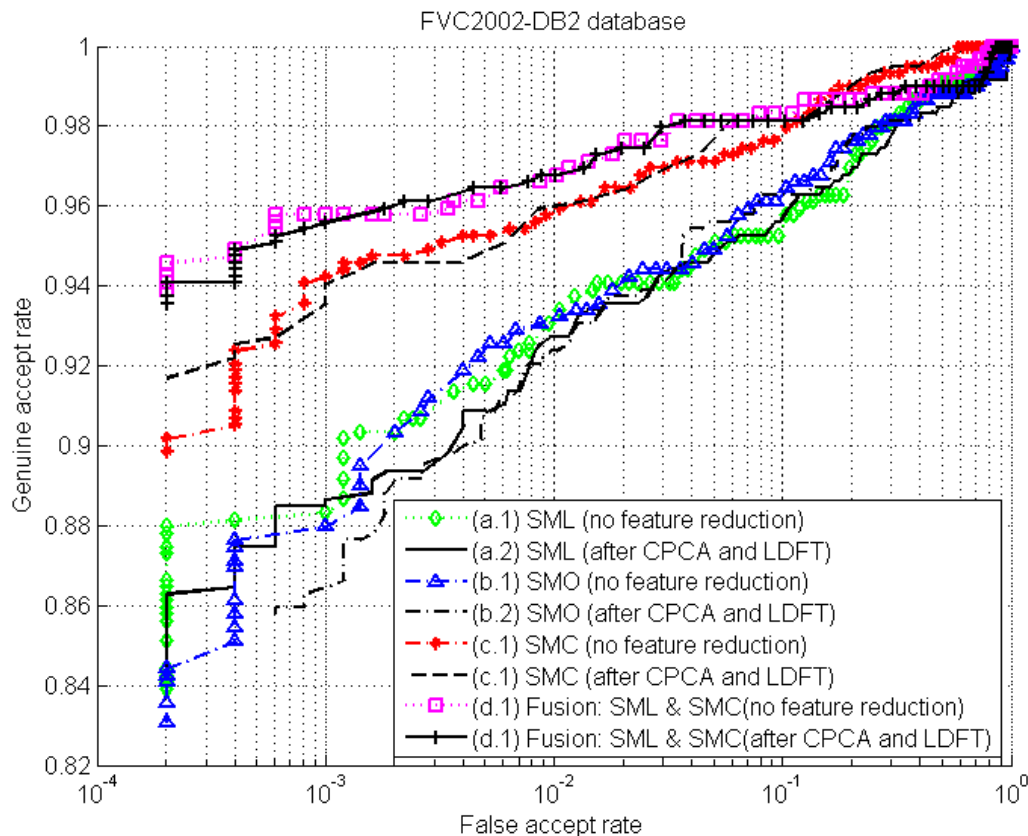


Feature Reduction: Line DFT (LDFT)



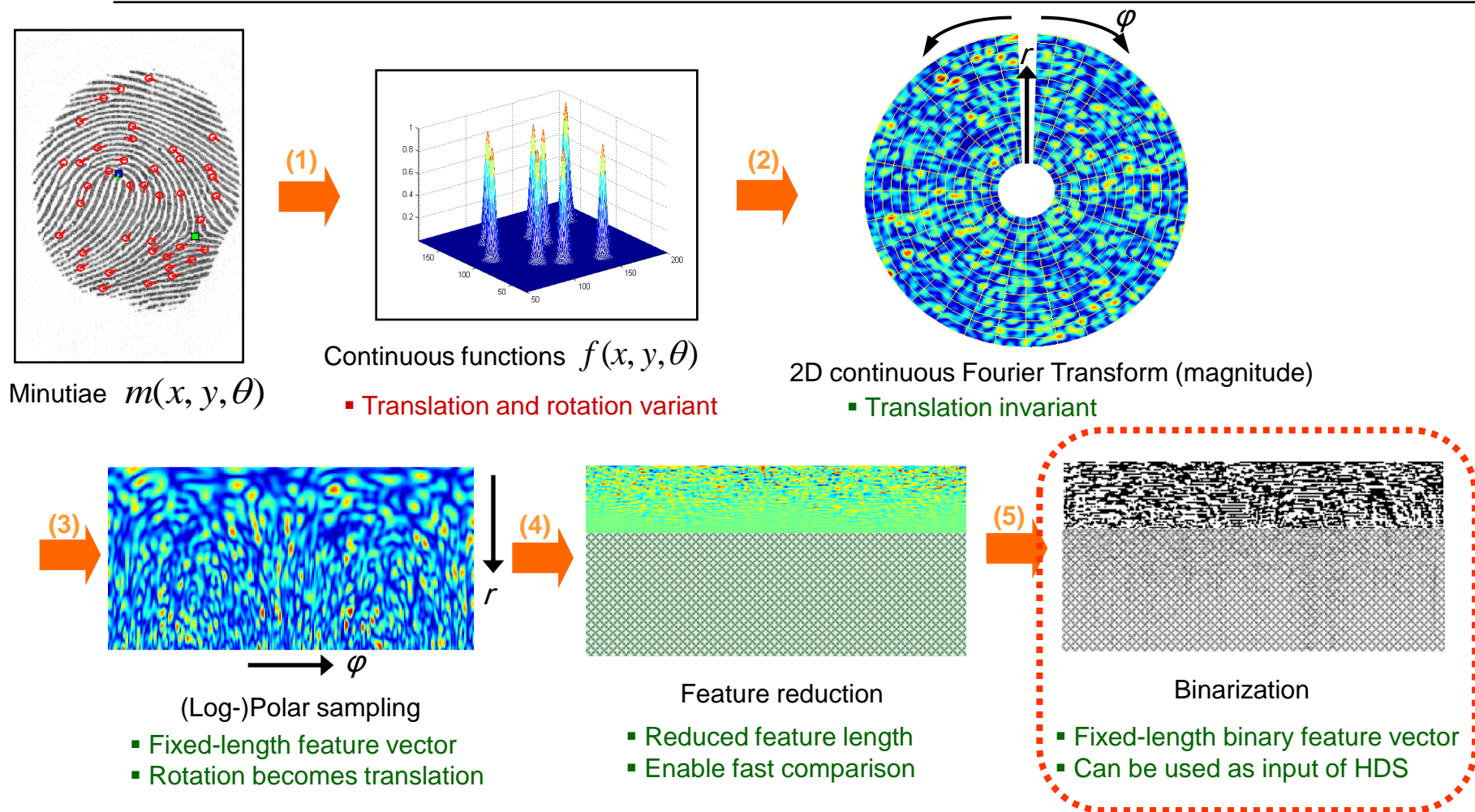
The feature becomes **20** times smaller!

Performance: CPCA and LDFT

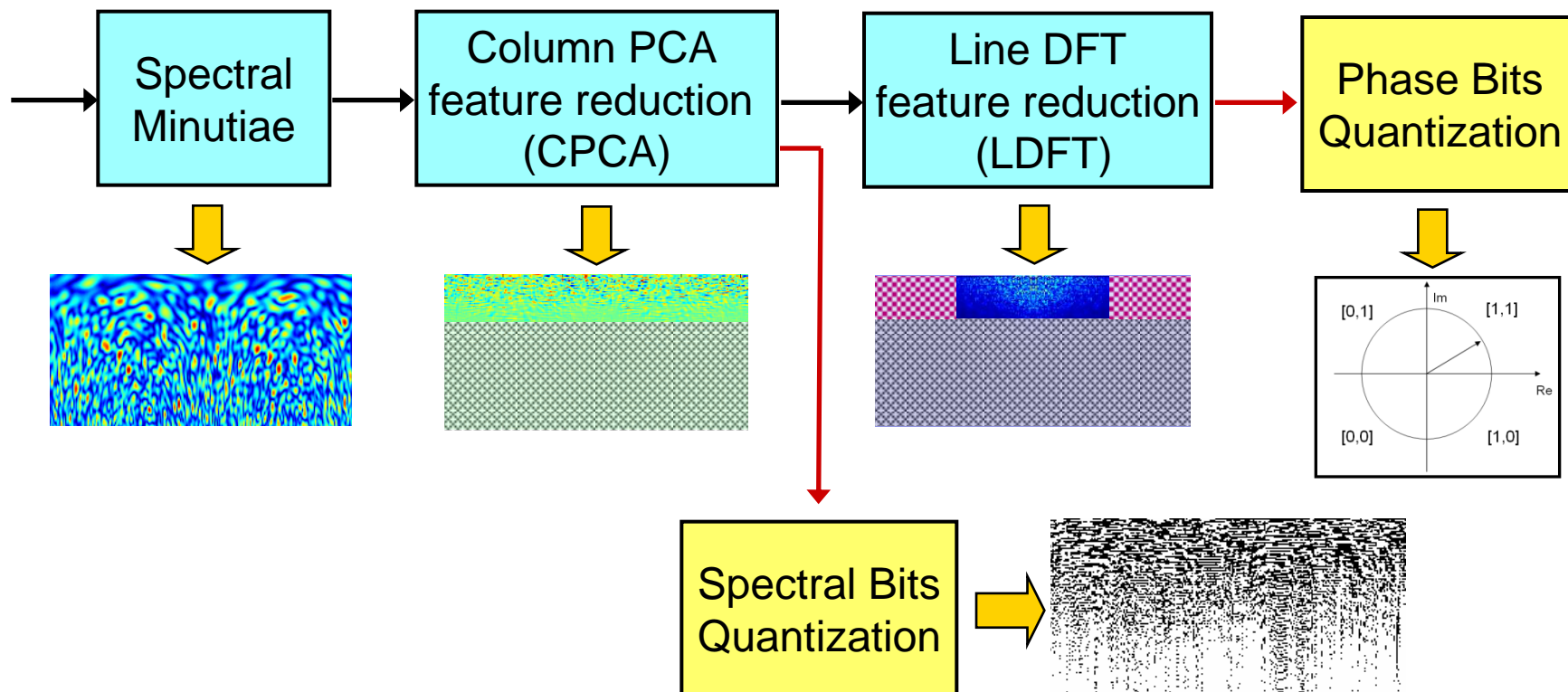


* ROC figure from publication in CVPR 2010.

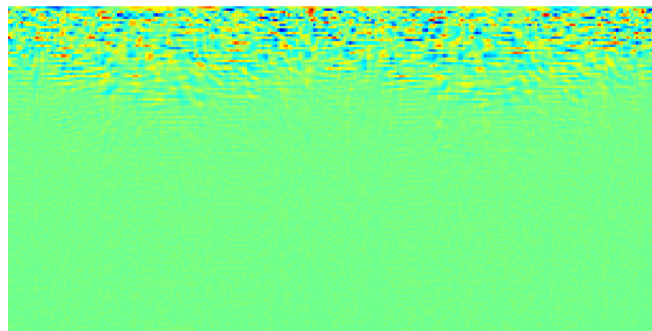
Spectral Minutiae Representation: procedure



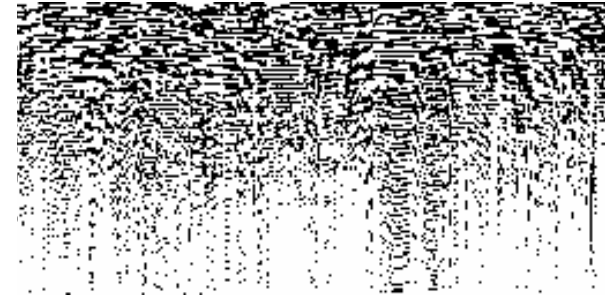
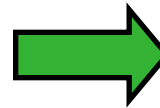
Binarization Overview



Binarization: Spectral Bits



SMC spectra (after CPCA)



Sign bits

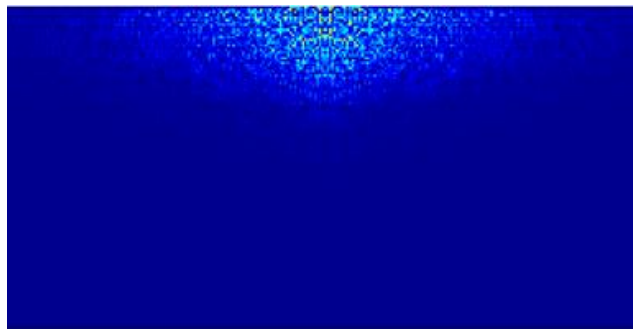


mask

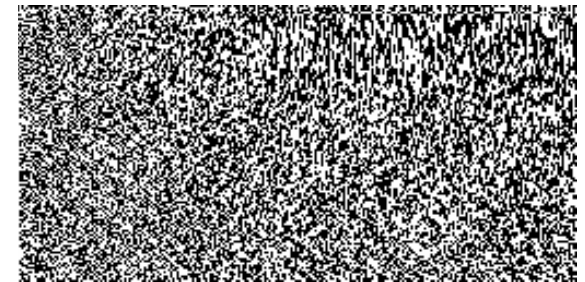
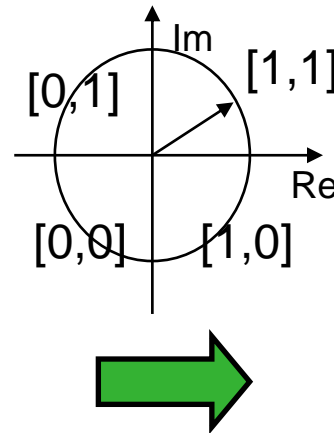
$$FHD = \frac{\|(\text{codeA} \otimes \text{codeB}) \cap \text{maskA} \cap \text{maskB}\|}{\|\text{maskA} \cap \text{maskB}\|}$$

Binarization: Phase Bits

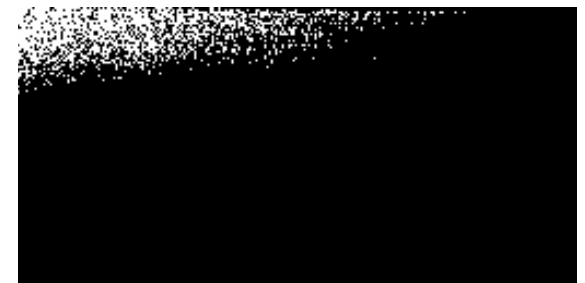
- ❑ After LDFT features become complex.



SMC spectra (after LDFT)



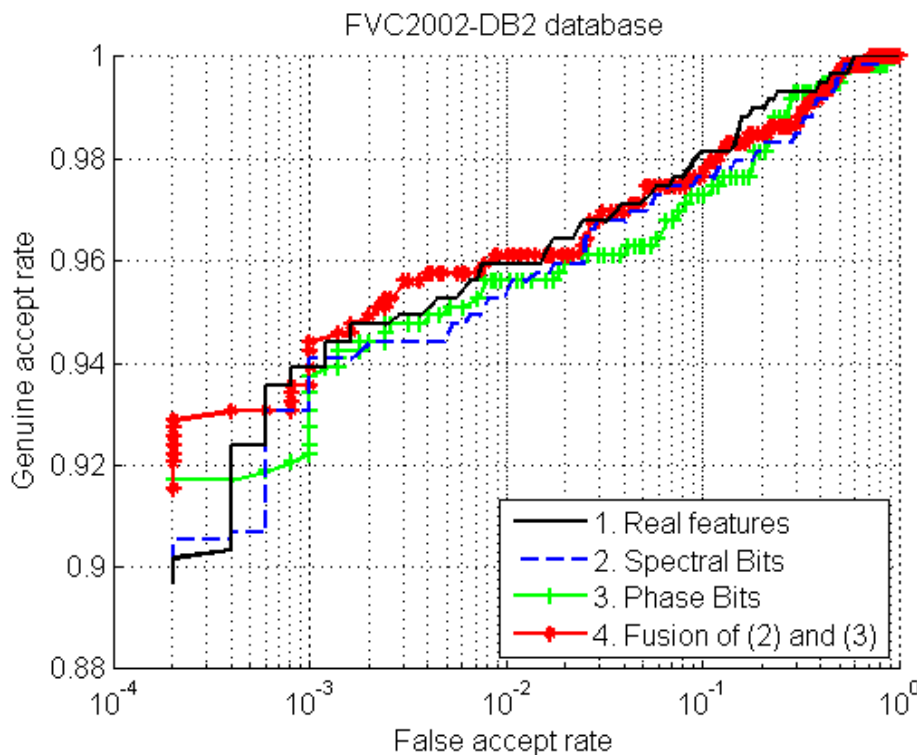
Sign bits



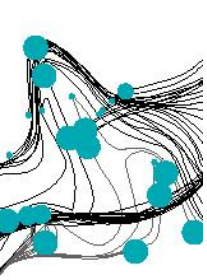
mask

$$FHD = \frac{\|(\text{codeA} \otimes \text{codeB}) \cap \text{maskA} \cap \text{maskB}\|}{\|\text{maskA} \cap \text{maskB}\|}$$

Performance: Spectral Bits and Phase Bits

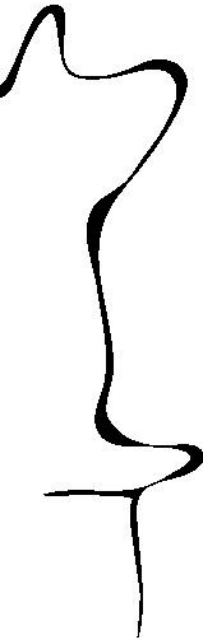


* ROC figure from publication in ICPR 2010.



Content

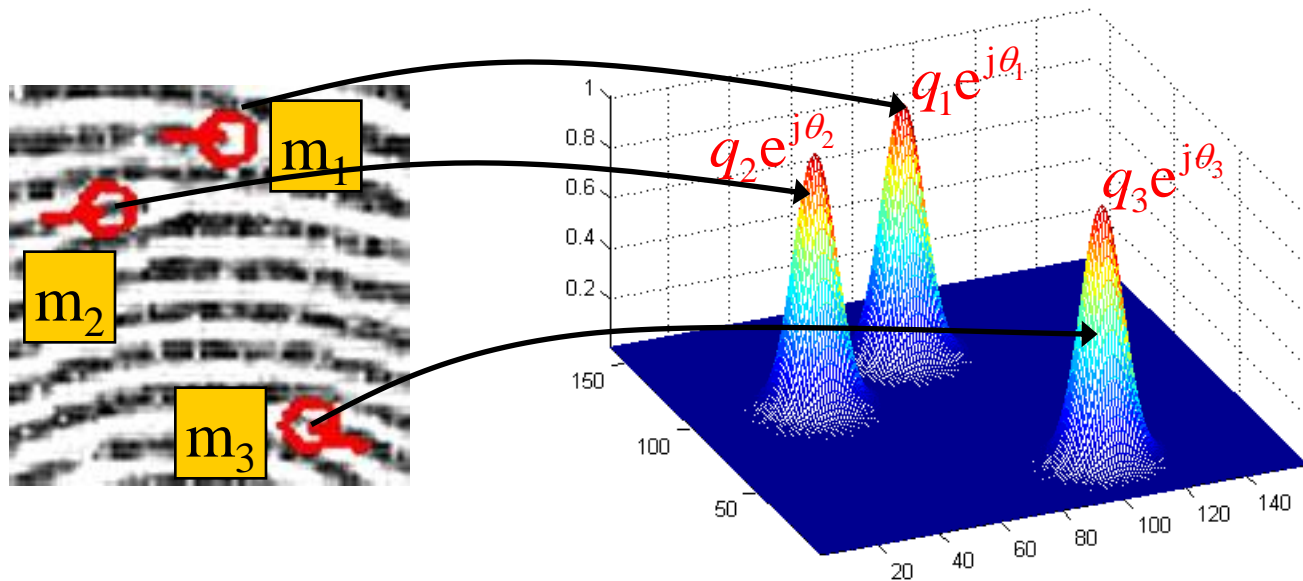
- ❑ Background: motivations & targets
- ❑ Spectral Minutiae Representations
- ❑ **Enhancements**
- ❑ Conclusions



Enhancement: incorporating minutiae quality

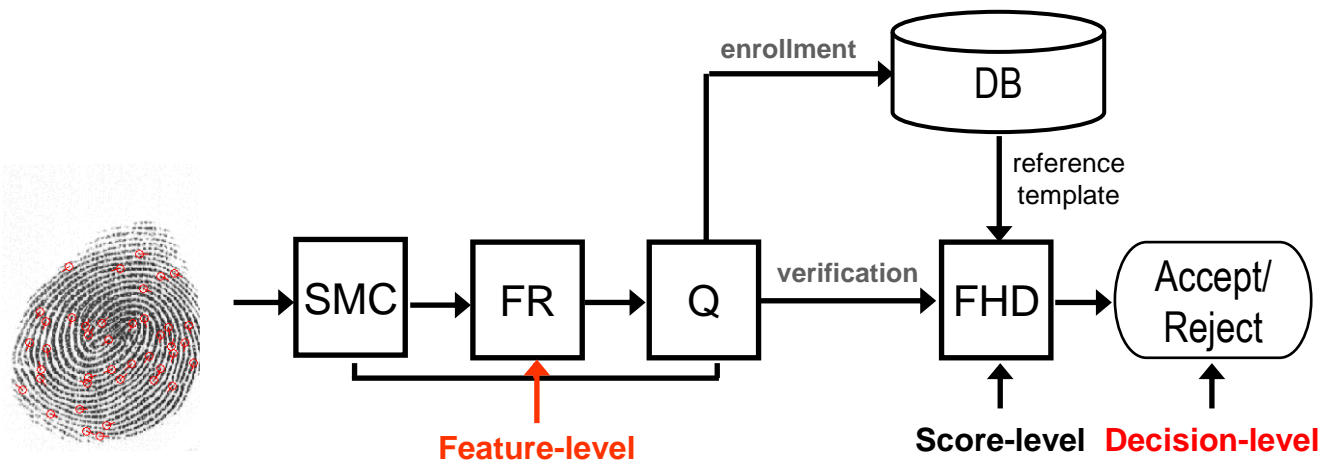
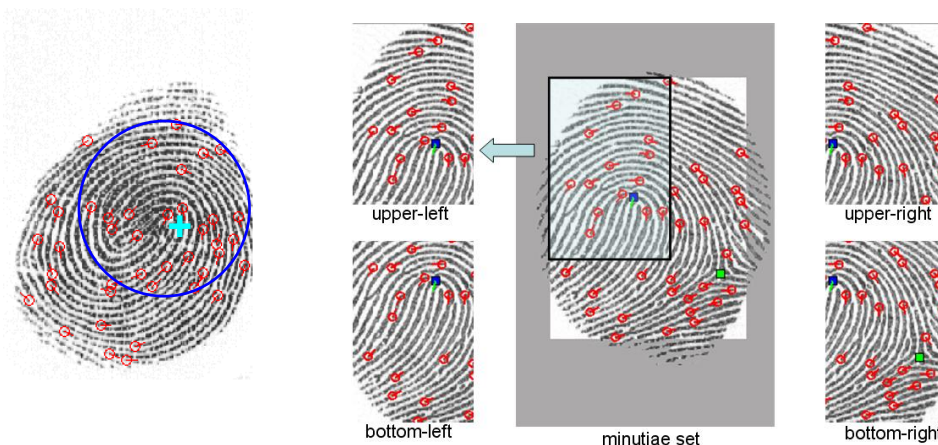
Minutiae: $m(x, y, \theta, q)$

x, y : location, θ : orientation, q : quality

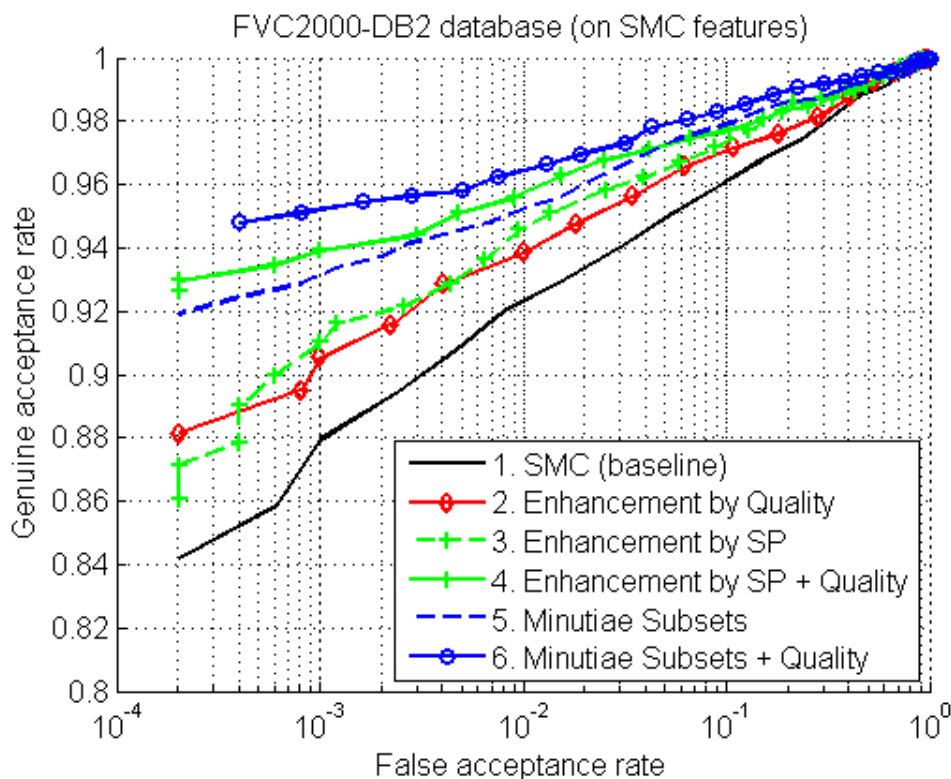


Further enhancements

- Incorporating singular points
- Minutiae subsets
- Multi sample fusion



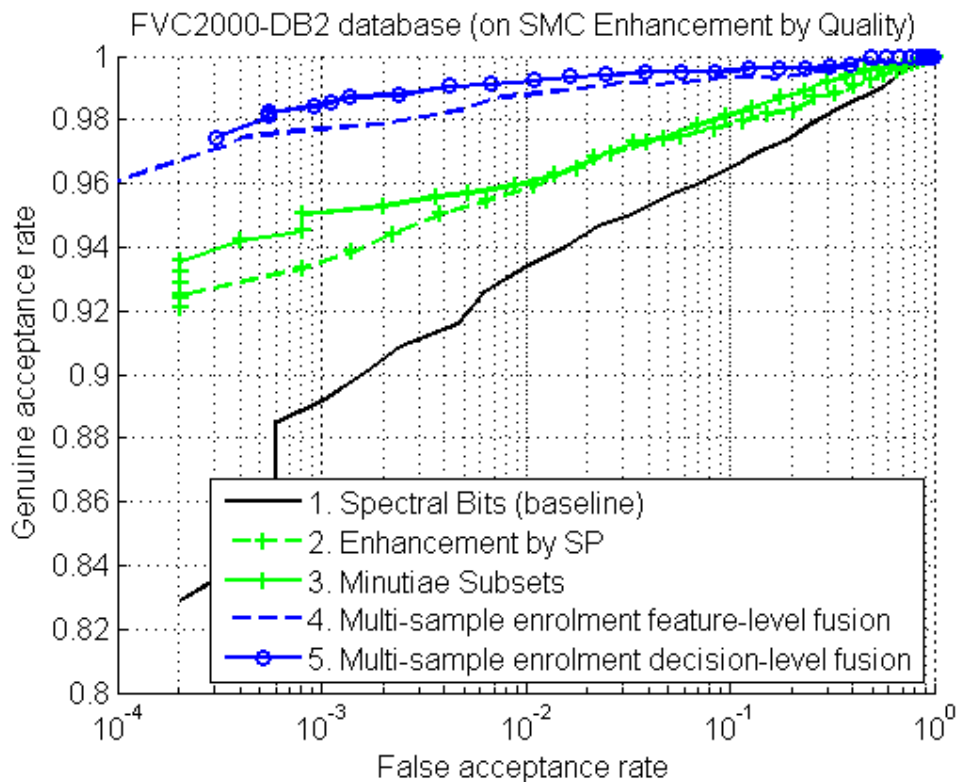
Enhancement results on real-valued features



Methods	EER	GAR @ FAR=10 ⁻³
SMC(baseline)	0.050	0.882
Quality	0.040	0.906
SP	0.038	0.913
SP+Quality	0.031	0.939
Subsets	0.033	0.932
Subsets+Quality	0.028	0.952

* Results of real-valued features.

Enhancement results on binary features

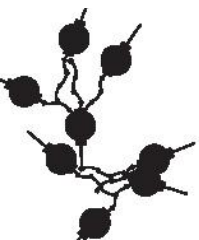


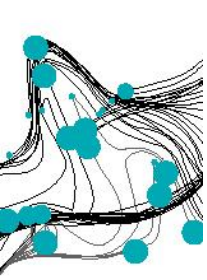
(1) Multi-sample fusion: recognition performances improved about 4 times in terms of equal error rates.

(2) Decision and score-level fusion received a better result since they are more robust to outliers.

(3) Feature-level fusion has the storage and speed advantages.

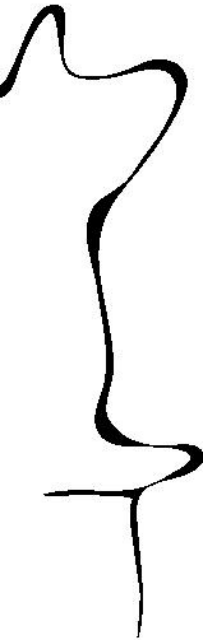
Methods	EER	GAR @ FAR=10 ⁻³
Spectral Bits (baseline)	0.044	0.893
SP	0.029	0.937
Subsets	0.028	0.950
Feature-level fusion	0.011	0.978
Decision-level fusion	0.008	0.985



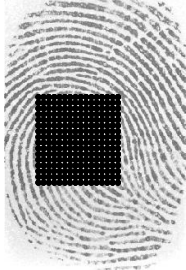
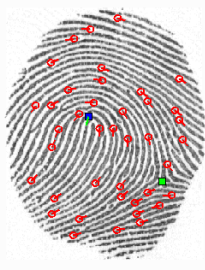
















Content

- ❑ Background: motivations & targets
- ❑ Spectral Minutiae Representations
- ❑ Enhancements
- ❑ **Conclusions**



Conclusions and future work

Methods \ Desired properties	Shape 	Minutiae 	Spectral minutiae 
Fixed-length			 ++
Translation rotation invariance			 +
Recognition performance		 	 +
Speed			 ++

- Completely rotation invariant representations.
- Error correcting code design (for helper data scheme).



Questions

Thank you!