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Feature-Based Latent Processing

NIST Latent Testing Workshop
March 19 and 20, 2009

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Topic 2a

The CDEFFS Extended Feature Set Specification

2a. CDEFFS Features

2a.1 CDEFFS Definitions

1) Sufficient definitions to support all possible features including EFS

2) Further research (data collection and test) needed to prove usefulness of EFS

2a. CDEFFS Features

2a.2 Requirements of desirable features

1) Consistency of features

Consistency between latent and exemplar is the most important characteristics.

2) Stability of features

Robustness to noise (or damaged quality) is one of important characteristics especially for automatic matching (auto-latent, Positive ID).

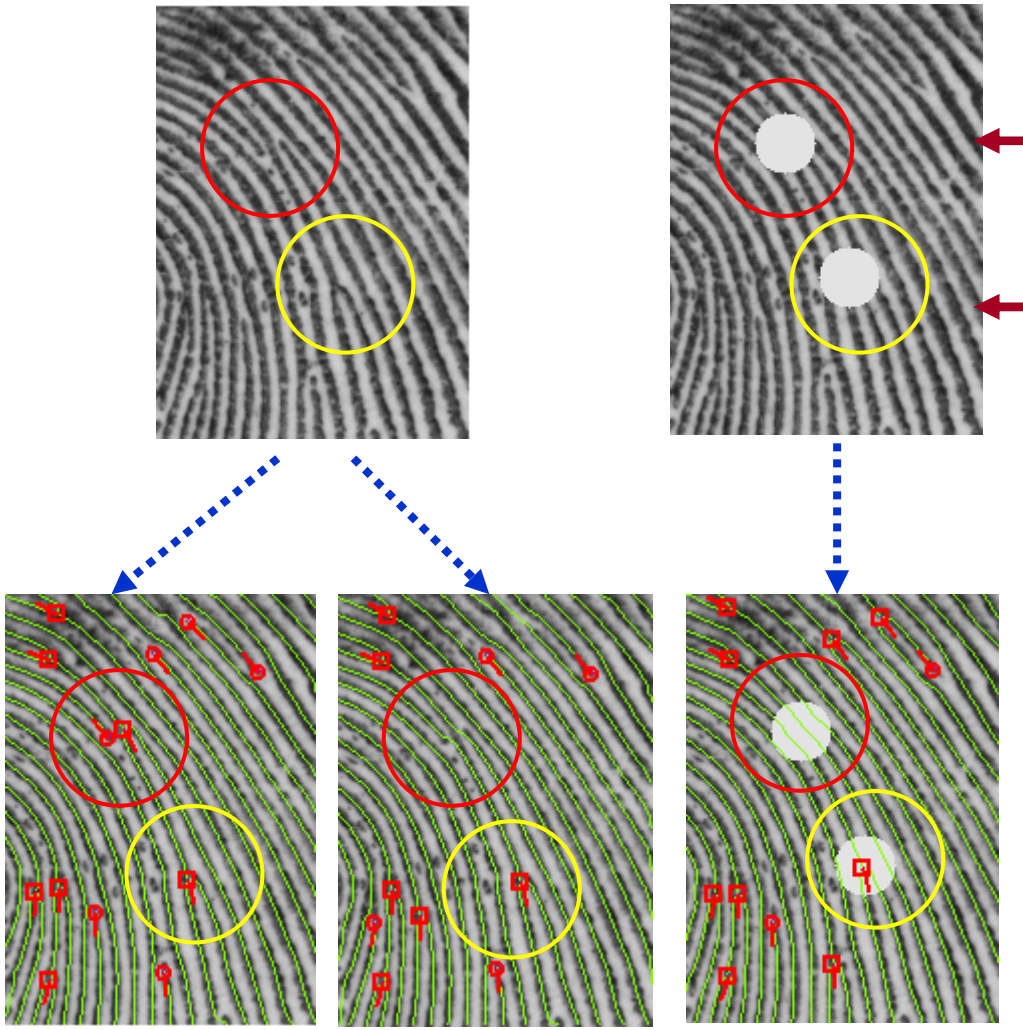
3) Less workload of manual coding for latent

4) Feasibility of full-auto coding for tenprint

5) Little change over life-time

2a. CDEFFS Features

2a.3 Stability of features



Unstable feature sample (e.g. crossover in red circle)

Stable feature sample (in yellow circle)

Stable features can be extracted even if image quality is damaged.

Most Level-2 features representing ridge structure are stable.

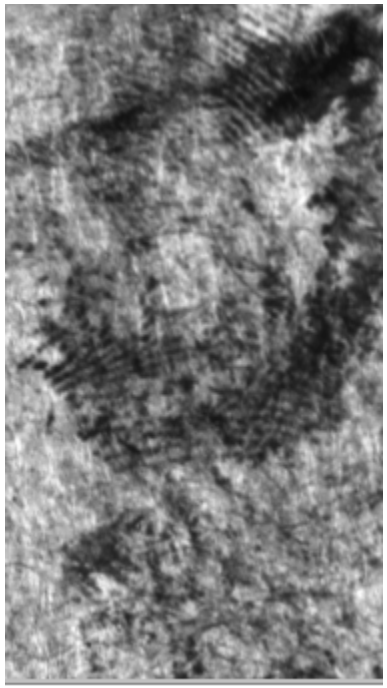
2a. CDEFFS Major Features

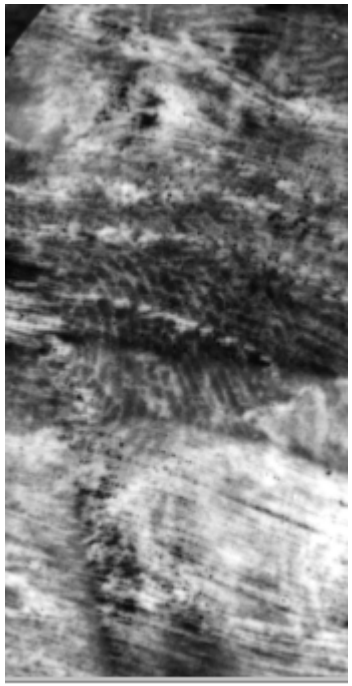
2a.4 Assessment of Features (Personal Opinion)

Major Features	Level 1,2,3	Coding Workload	Consistency and Stability	Value in Matching	Current Usage in Matching (NEC)
Region of Interest (ROI)	1	1 (Lowest)	Good	Low	Yes
Orientation (ORT)	1	1	Good	Low	Yes
Finger/palm Position(s) (FPP)	1	1	Good	Low	Yes
Pattern Classification (PAT)	1	1	Good	Low	Yes
Ridge Quality Map (RQM)	**1**	**2**	**Good**	**Medium**	**Yes**
Ridge Flow Map (RFM)	**1**	**3**	**Good**	**Low**	**Yes (optional)**
Ridge Wavelength Map (RWM)	**1.5**	**5 (Highest)**	**?**	**?**	**No**
Cores (COR) and Delta (DEL)	1	1	Good	Low	No
Core-delta Ridge Counts (CDR)	1.5	2	Good	Low	No
Center Point of Reference (CPR)	**1**	**1**	**Good**	**Medium**	**Yes**
Minutiae (MIN) - X, Y, D	**2**	**2**	**Good**	**High**	**Yes**
Minutiae Ridge Counts (MRC)	**2**	**3**	**Good**	**Medium**	**Yes**
Dots (DOT)	**2.9**	**2**	**?**	**?**	**No**
Incipient Ridges (INR)	**2.7**	**3**	**?**	**?**	**No**
Creases and Linear Discontinuities (CLD)	**3**	**2**	**?**	**?**	**No**
Ridge Edge Features (REF)	**3**	**4**	**?**	**?**	**No**
Pores (POR)	**3**	**3**	**?**	**?**	**No**
Skeletonized image data (SIM)	**2**	**4**	**Good**	**Low**	**Yes (optional)**

2a. CDEFFS Features

2a.5 Tough latent-print samples (SD#27)


B211U.gry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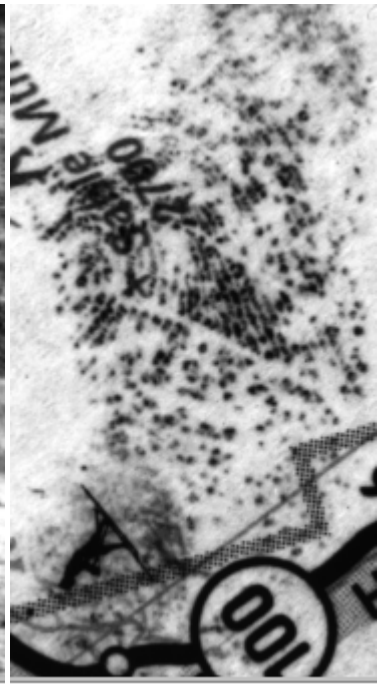
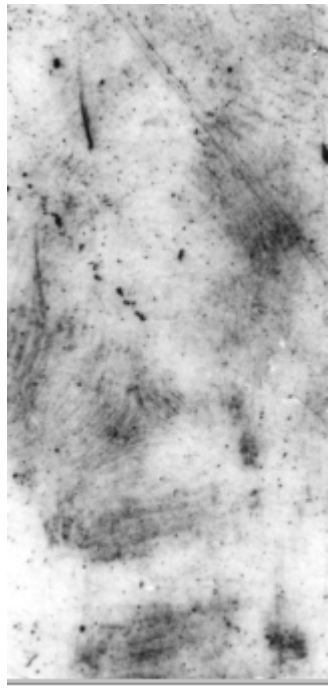

B215U.gry


C266U.gry


K276U.gry

Level-3 features not visible on tough latent-prints

→ Little accuracy improvement from Level-3 features expected on SD#27

2a. CDEFFS Features

2a.6 Necessity of 1000dpi Images

1) 1000dpi images are necessary to reliably detect Level-3 features.

2) 1000dpi images are better for examiners to conduct identification (visual verification).

3) 500dpi images are more than sufficient to reliably detect ”ridge structure”.

4) 1000dpi images are not important for most AFISs which rely on “consistent and stable Level-1/2 features” produced from ridge structure.

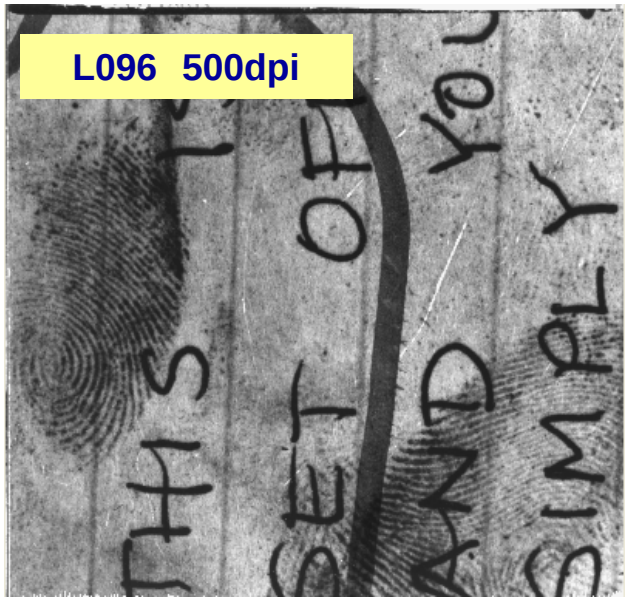
2a. CDEFFS Features

NIST SD#27 500dpi/1000dpi Comparison Table

	500dpi Better	1000dpi Better		
Because of proper Crop	L096G	L102B	L165B	L193B
		L116B	L181B	L288U
		L148B	L185B	L293U
Because of proper Orientation	L223U			
Because of better Dynamic Range		L052G	L206U	L280U
		L074G	L259U	
		L124B	L261U	
Because of Density Saturation	None	None		
Because of sufficient Gray Medium Scale	None	None		
Because of Higher Resolution	-	None		

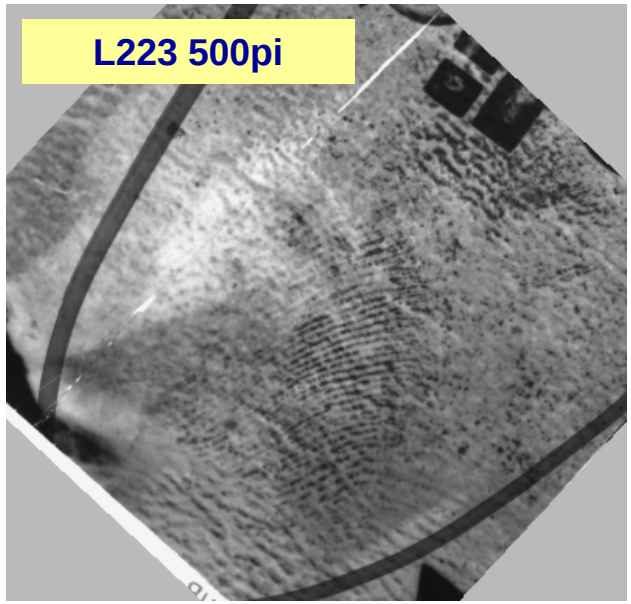
New NIST SD#27 rescanned by 1000dpi shows better matching results than old SD#27 (500dpi). However, major contributions are not from higher resolution but from "proper crop" and from "better dynamic range".

2a. CDEFFS Features



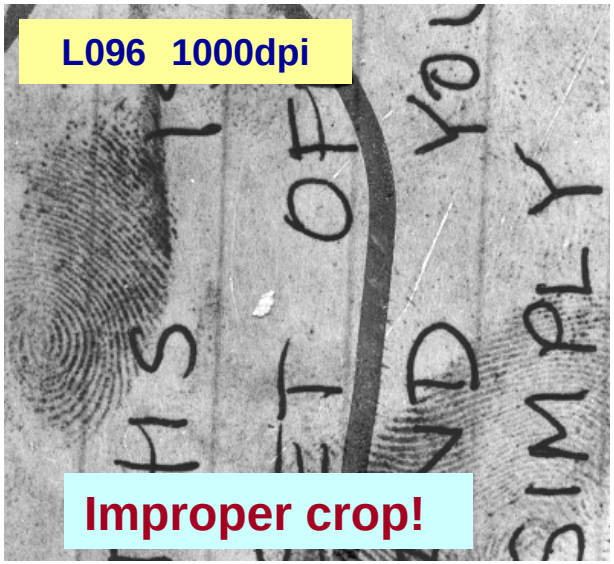
500dpi better

1.60x1.54 inch
800x768
@ 500dpi



500dpi better

1.60x1.54 inch
800x768
@ 500dpi

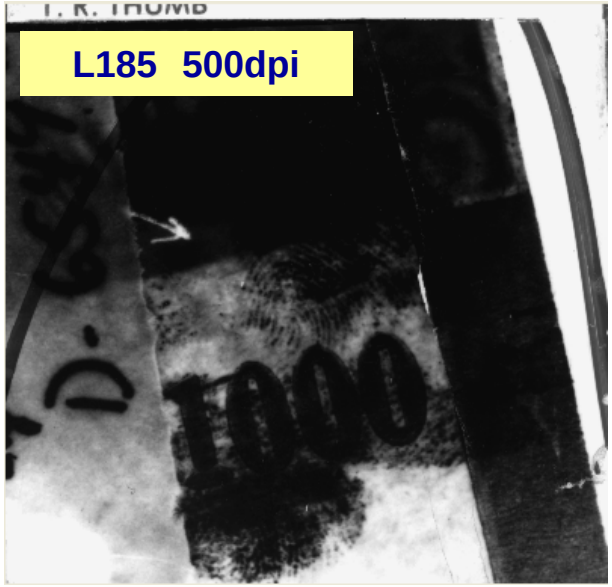


1.59x1.46 inch
1588x1459
@ 1000dpi

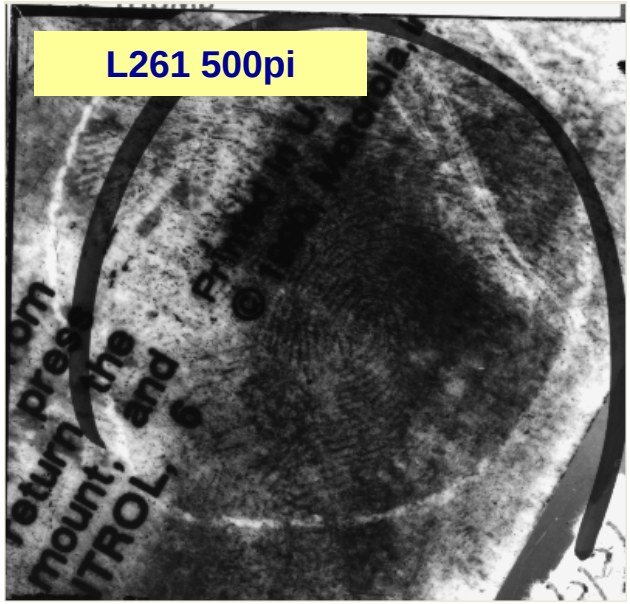
L223 1000dpi

1.42x1.08 inch
1418x1083
@ 1000dpi

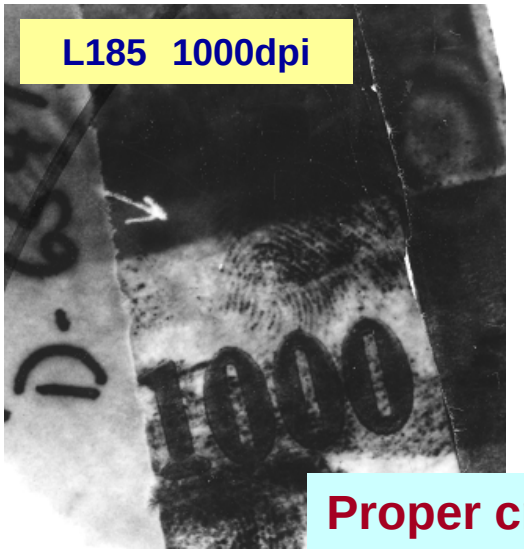
2a. CDEFFS Features



1.60x1.54 inch
800x768
@ 500dpi



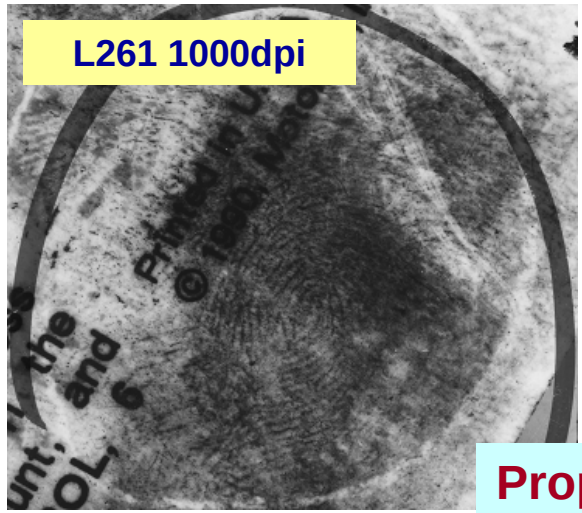
1.60x1.54 inch
800x768
@ 500dpi



1000dpi better

1.14x1.24 inch
1138x1241
@ 100dpi

Proper crop!



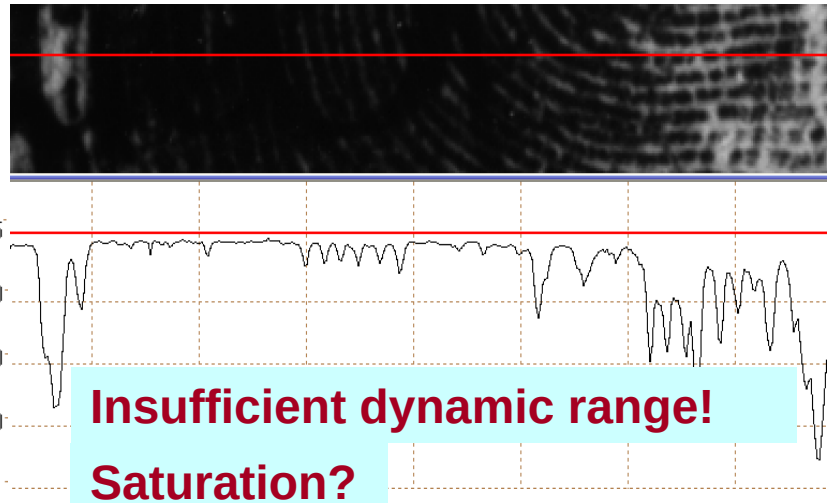
1000dpi better

1.47x1.30 inch
1471x1301
@ 1000dpi

Proper crop!

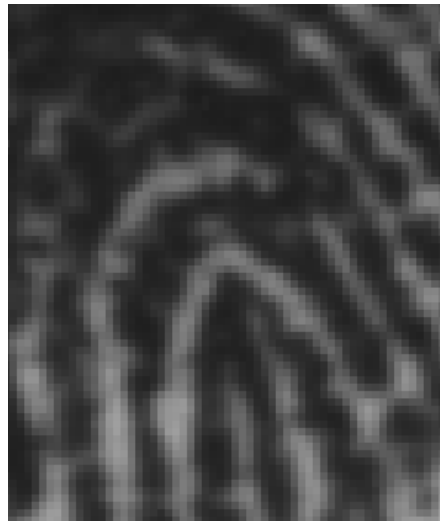
2a. CDEFFS Features

L052 500dpi

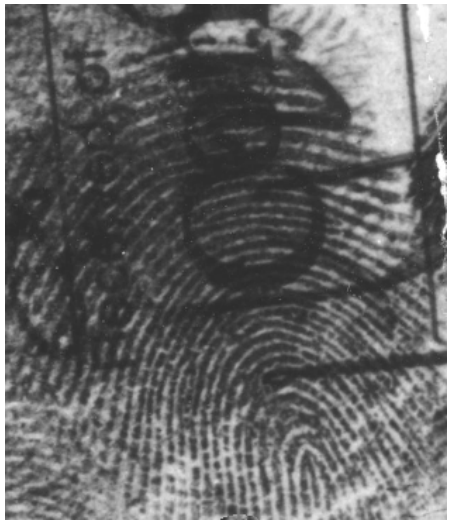


Insufficient dynamic range!

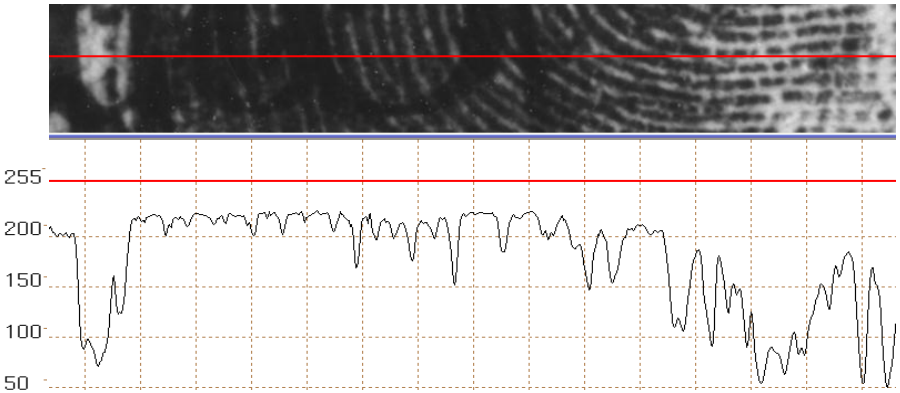
Saturation?

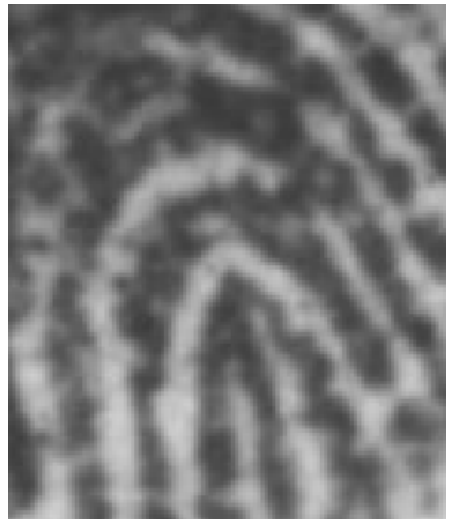


1000dpi better



L052 1000dpi





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Topic 2b

Interoperable Latent Feature Sets in light of the NAS Recommendation #12

2b. Interoperable Latent Feature Sets

2b.1 Technical obstacles to AFIS interoperability

a) Tenprint: Already established (Type4/14 image base)

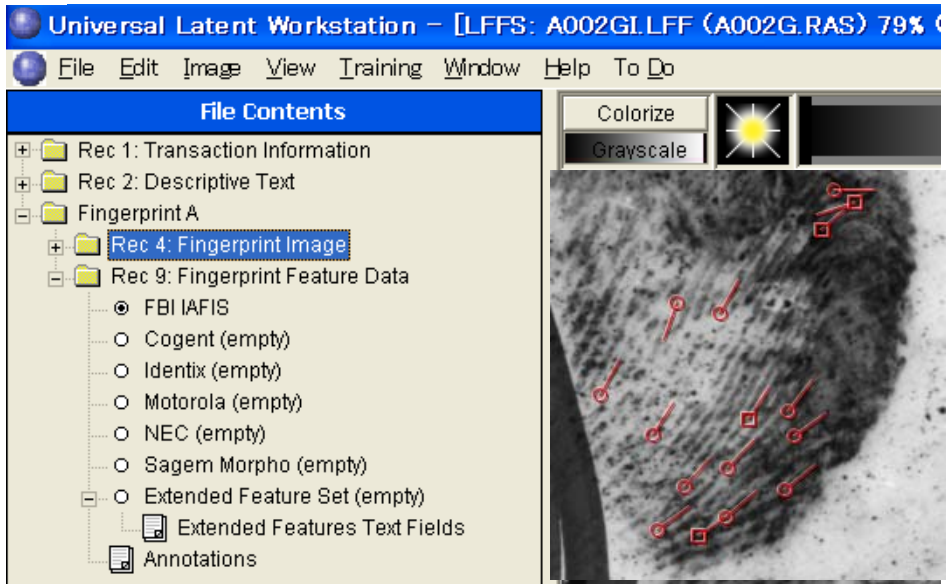
(*) Recipient AFIS accuracy not sacrificed

b) Latent: Already established using ULW

Examiner's options on ULW

- Add/modify features to maximize recipient AFIS accuracy

- No further edit to eliminate additional workload



2b. Interoperable Latent Feature Sets

2b.2 Operational and administrative obstacles to AFIS interoperability

1) Cost for “additional” matching workload

Need to limit incoming search requests, but how?

2) Data security protection

Need to send candidate images and demographics to “outside” examiners. How to protect data security?

3) System security protection

Need to restrict system access from “outside” examiners, but is it feasible?

4) Cost for “additional” system administration

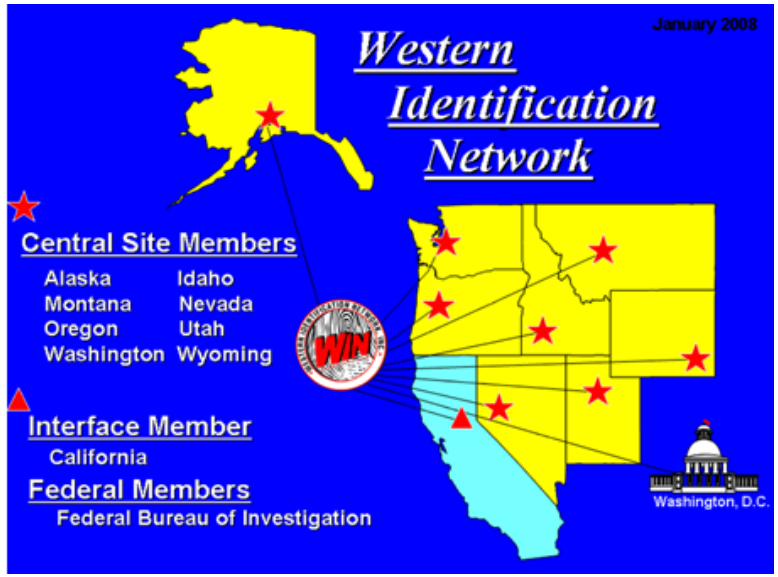
2b. Interoperable Latent Feature Sets

2b.3 Regional AFIS

1) Regional AFIS (e.g. WIN) with fingerprints from nearby law enforcement agencies is one of solutions to overcome operational and administrative obstacles.

2) Several regional AFIS sites over the US may be less expensive than "huge" federal AFIS solution.

3) Most crimes can be solved by searching adjacent states or nearby LE agencies.



WIN is a consortium that have a shared network and AFIS processing service bureau.
http://www.winid.org/winid/who/

2b. Interoperable Latent Feature Sets

2b.4 Availability of test data base

NAS Recommendation #12 says: **"Additionally, greater scientific benefits can be realized through the availability of fingerprint data or databases for research purposes".**

1) Need to renew fingerprint data base which represent characteristics of up-to-date data.

2) NIST SDs are VERY useful. However, they are old and may not represent new problems (e.g. live scanner specific noises).

3) Vendors/researchers cannot propose solutions if they do not understand problems.

Topic 2c

How to Test Extended Feature Sets for Latent Matching

2c. How to Test EFS

2c.1 Recommended procedure

1) Collection of proper test data

2) Public release of test data base

3) Periodic contest

4) Opportunity for miss analysis

2c.2 Collection of proper test data

Data collection is the first step of this process and proper data collection is the most important thing.

1) Identifiable by expert examiner

2) Tough data - not current AFIS hit level

3) Manually coded features associated

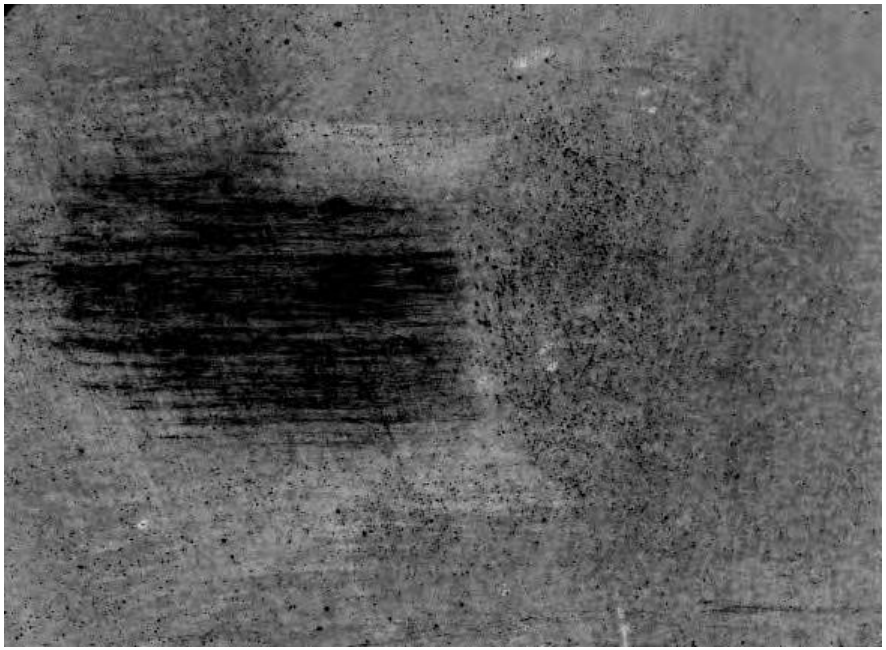
4) IQS quality preferable

5) Higher resolution (1000 dpi) preferable

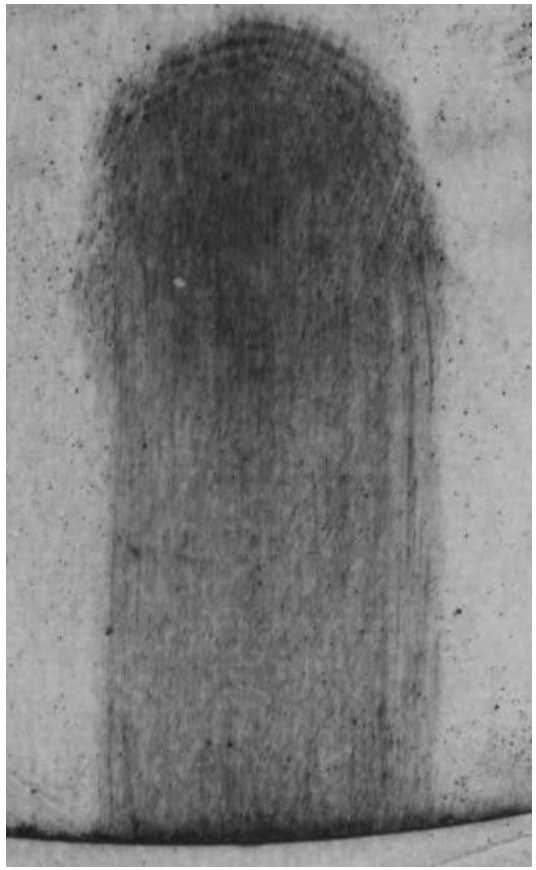
2c. How to Test FES

Samples for proper data collection

CDEFFS A04_L01XD2P



CDEFFS B03_L05XD2P



Too poor quality - Not identifiable (even by examiners?)

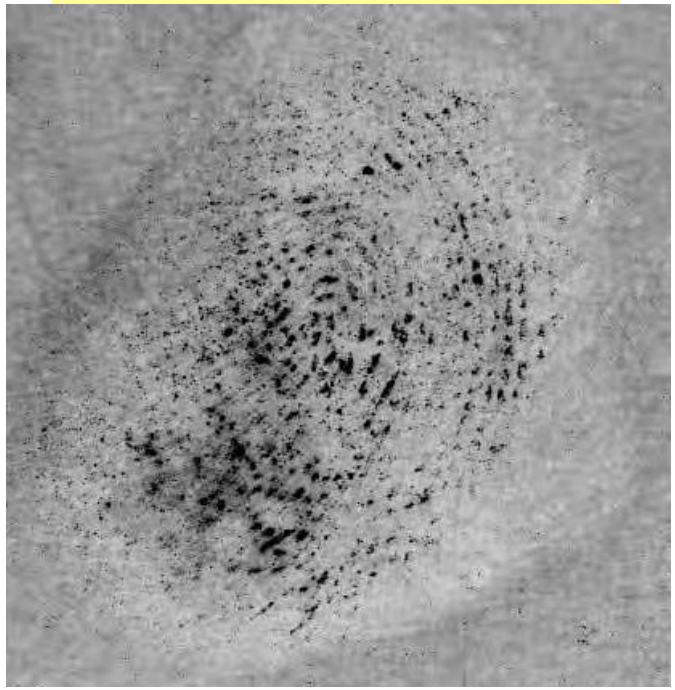
2a. How to Test FES

Samples for proper data collection

CDEFFS A10_L01XD2P

Too good quality - Current AFIS hit level

CDEFFS A02_L02XD2P



Proper quality for test data

2c.3 Public release of test data base

1) NIST SDs are VERY useful. However, they are old and may not represent new problems (such as new live scanner specific problem).

2) Vendors/researchers need to freely access test data in order to efficiently find solutions to problems of these data.

3) Need to find a way to resolve “privacy issues” which restricts producing new DBs

2c.4 Periodic contest

1) **Reliable and fair contests such as ELFT, PFT Study, SlapSeg, FpVTE are very useful to stimulate research activities.**

   - Large volume fingerprint data randomly selected from versatile sources
   - Test procedures and evaluation protocols are well defined in advance.
   - Black-box test without any human influence

2) **Current accuracy level is not achieved w/o these contests. Periodic contests are needed to keep encouraging researchers.**

2c.5 Opportunity for miss analysis

1) Miss analysis is imperative to solve current problems and to further improve accuracy.

2) It is important for researchers at least to visually see problematic data (images).

3) Opportunity for miss analysis is requested for all contests.

4) We would also like to apply special analytic SDK to output “text” info (not sensitive data) to be sent back to us.

Topic 2d

Latent Matching of Palms and Lower Joints Differences with Latent AFIS

2c.1 Difference with latent matching for finger

1) Larger ridge interval (ridge to ridge distance) than finger → Need to tune ridge enhance “filters” in feature extraction (FE) for palm

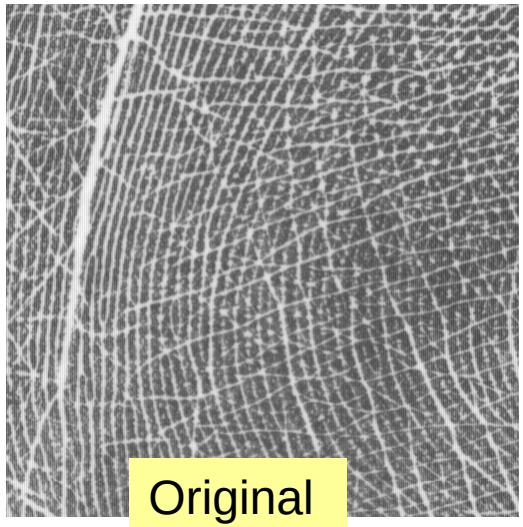
2) Effects of significant wrinkles → Need to enhance FE function to distinguish “ridges” and “wrinkles”

3) Larger area to be searched → Need to enhance “initial/rough” search function for coordinate adjustment in matching

4) Common latent coding method applied among finger, palm and lower joints

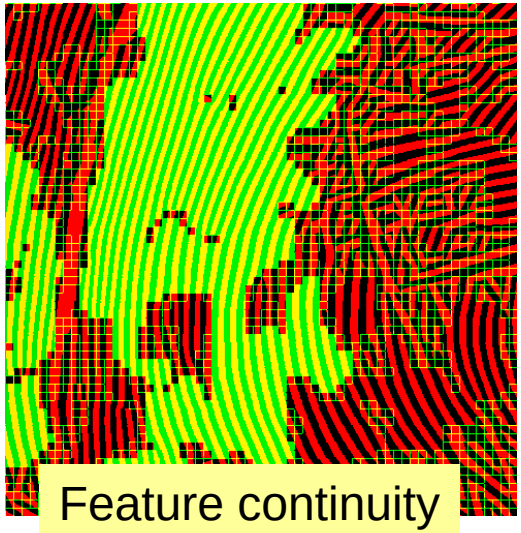
2c.2 FE Enhancement for Exemplar Palm

Smart ridge selection base on “continuity” of features (of ridges)

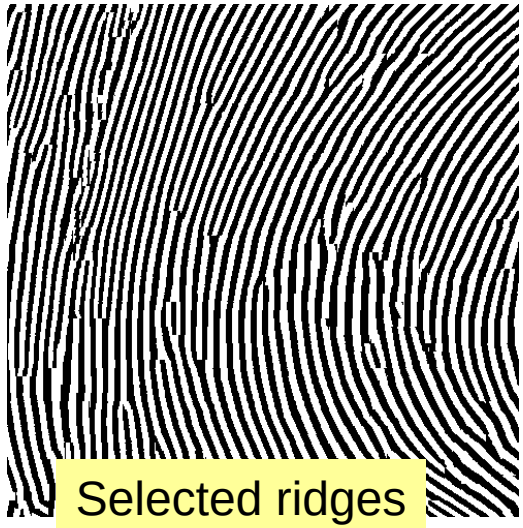


Original

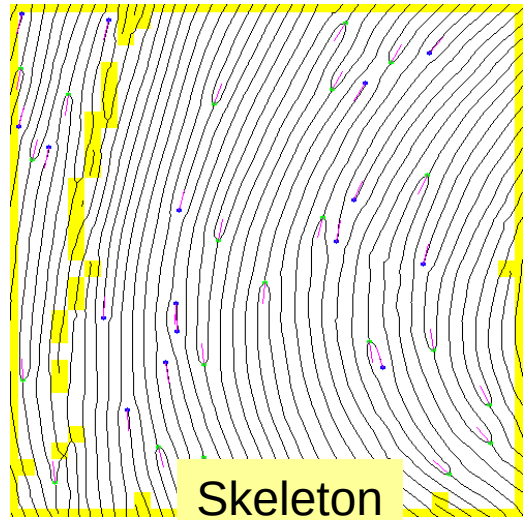
Ridges from 1st FFT peak



Feature continuity



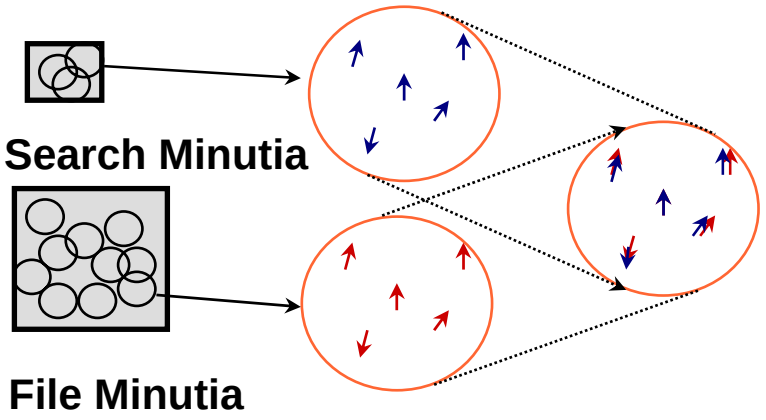
Selected ridges



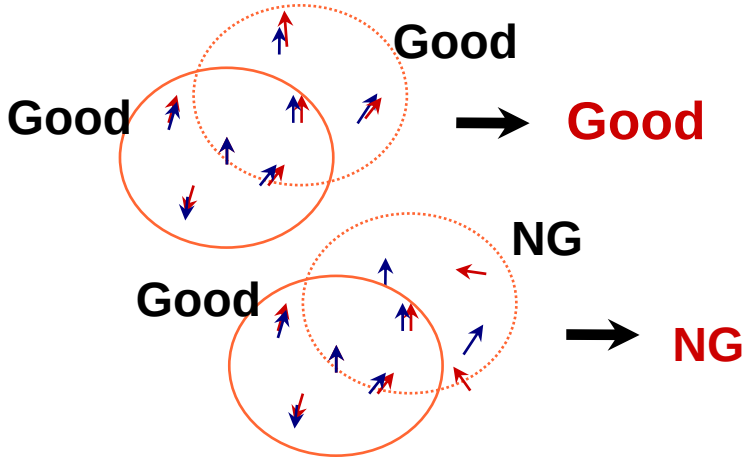
Skeleton

2c.3 Enhanced coordinate adjustment for palm

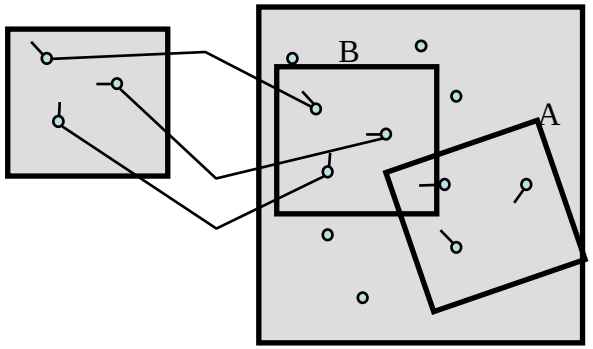
1) Regional minutia clustering

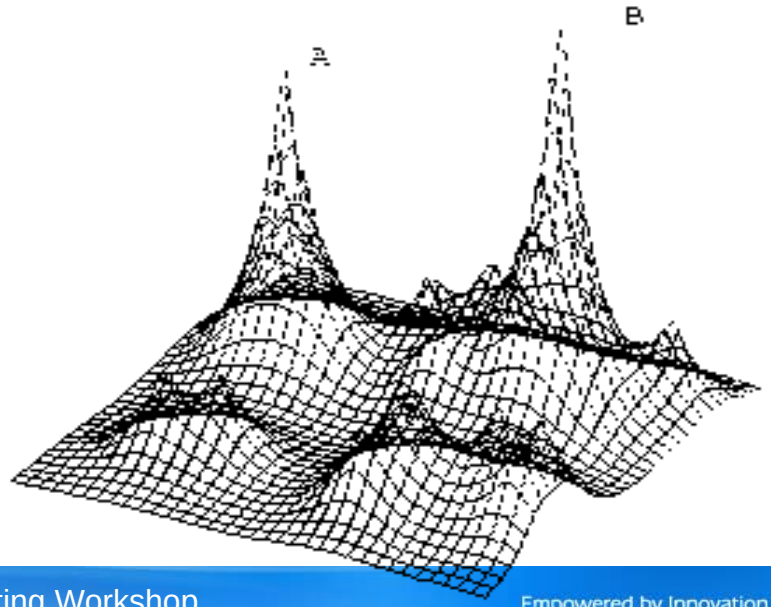


2) Elimination of wrong pairing



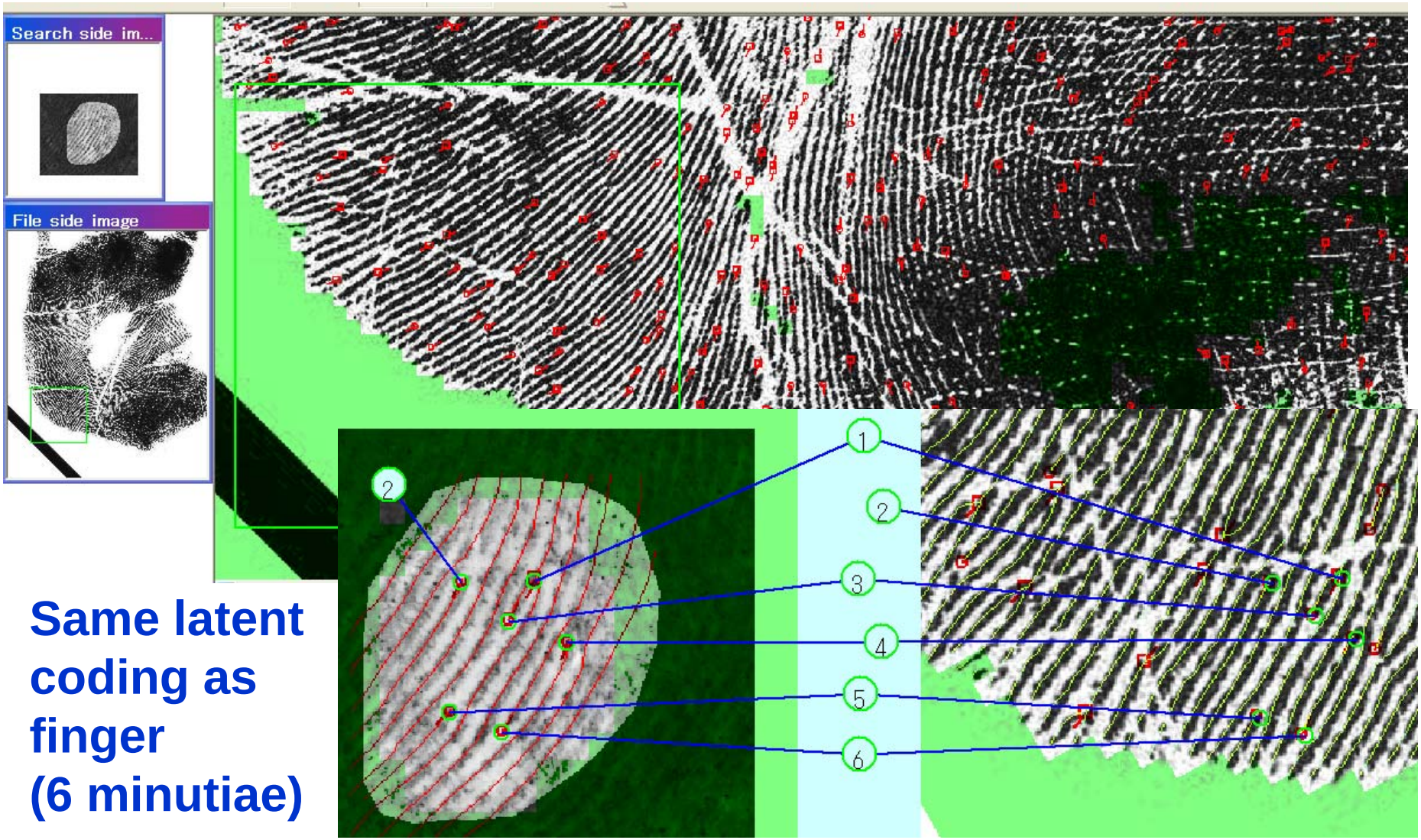
3) Coordinate adjustment





2c. Latent Matching for “Palm and Joint”

2c.4 Latent coding sample



Same latent coding as finger (6 minutiae)

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