Extended Fingerprint Feature Set

ANSI/NIST ITL 1-2000 Standard Workshop

6 December 2005

Overview

- Present SWGFAST Proposal, which defines additional types of fingerprint features, beyond those in the ANSI/NIST or IAFIS type-9 minutiae definitions
- Present Extended Feature Set Committee's ideas
- Plan for an addendum to the new ANSI/NIST standard, and a committee to formulate it

SWGFAST Proposal

Steve Meagher, FBI

SWGFAST Concern

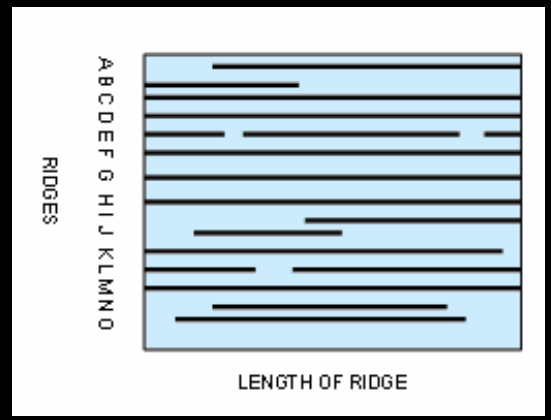
- “AFIS technology, since its onset, has utilized a very limited amount of fingerprint detail. Latent print experts must rely on far more information in effecting individualizations/exclusions than just ending ridges and bifurcations, i.e., the Type 9 minutiae record. SWGFAST is attempting to educate and provide to the vendor community the additional features and how they are utilized by these experts.”

SWGFAST goals

1. Increase fingerprint image quality.
2. Increase extraction of more fingerprint features.
3. Improve the reliability of extracted features
4. Improved latent print operations, both manually and in an automated system, by increasing identification rates and reducing risk of errors.

Key Concepts: Ridges in sequence

- Shift the AFIS approach away from the traditional “minutiae in sequence” to a new approach of “ridges in sequence.”



Key Concepts: Exclusions

- Current AFIS technology focuses on determining degrees of similarity, but does not collect the breadth of information needed for use in excluding non-matches

Extended Features

Level 1 Features

a. Ridge flow
b. Cores and deltas
c. Finer level of classification

Level 3 Features

a. Pores
b. Edge Shapes
c. Ridge/Furrow Width

Level 2 Features

a. Ridge path elements:
   - Continuous or Open Ridge
   - Minutiae/Ridge Relationship
   - Ridge Curvature
   - Feature Relationship
b. Open Field of Ridges
c. Greater definition of minutiae
   - Shape and size
d. Scars
e. Creases
f. Incipient ridges
g. Dots

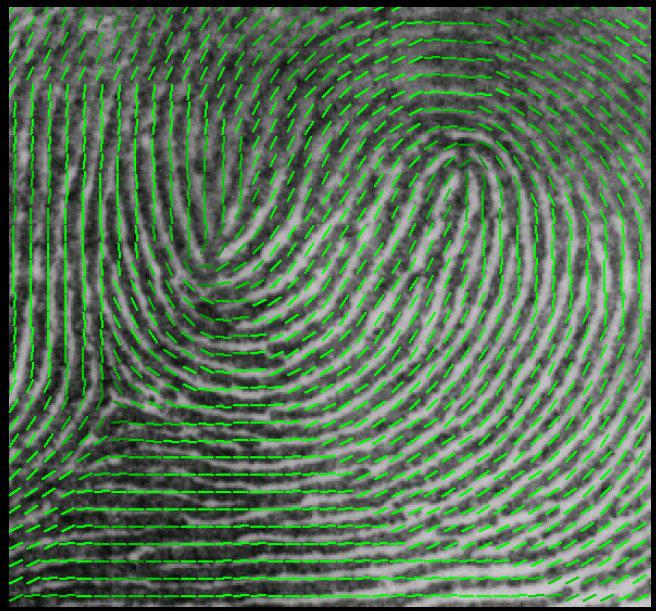
Discussion of Extended Features

Austin Hicklin, Mitretek

Overview

- For each feature, discuss briefly
  - What is meant
  - Practicality of definition
  - Practicality of automatic detection
- Some of these lend themselves better to definition and detection much better than others
- From a latent perspective (and for very poor quality non-latents), current AFIS is only a filter, not really a matcher
  - If matchers are going to take the next step into more effective latent matching, matchers should take advantage of a broader set of features than currently used

1a: Ridge flow



- Adjacent friction ridges in a directional arrangement
- Used to a limited extent for pattern classification in AFIS
  - Role of pattern classification is diminishing as AFIS moves from rolls to flats
  - Some AFIS use ridge flow for screening
- Used by some matchers (e.g. BioScrypt) but not generally in AFIS

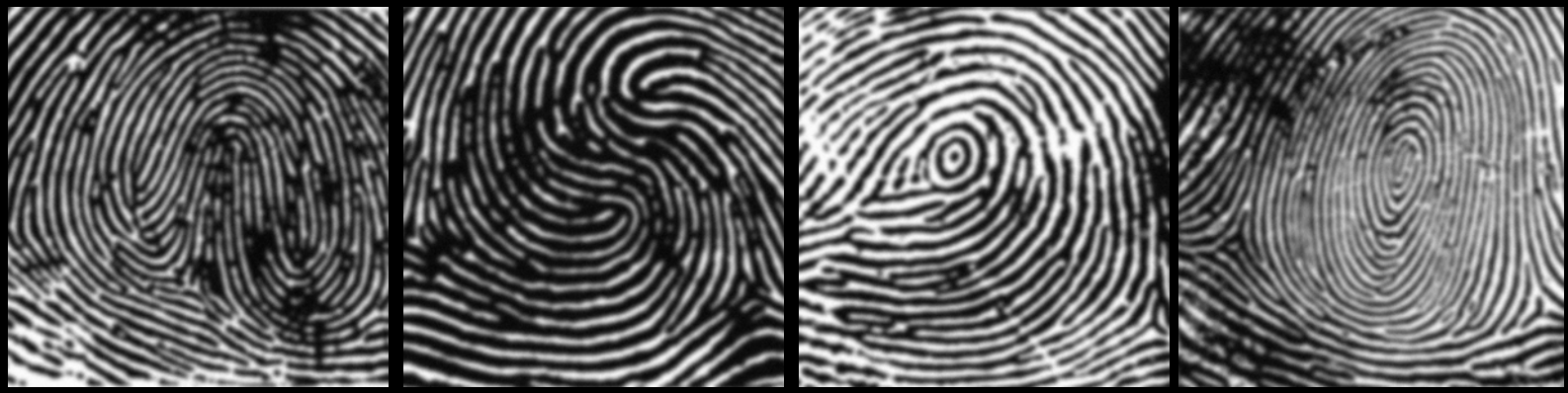
- ***Most encoders use a similar process***
- ***The M1 Finger Pattern proposed standard could be used as a model for definition***

1b: Cores and Deltas

- Cores and deltas are underutilized in AFIS technology
- Core and delta position, shape, and relationships are all of use
- Using minutiae in areas of high curvature would address some of the issue

➢ ***Definition and detection will both need research***

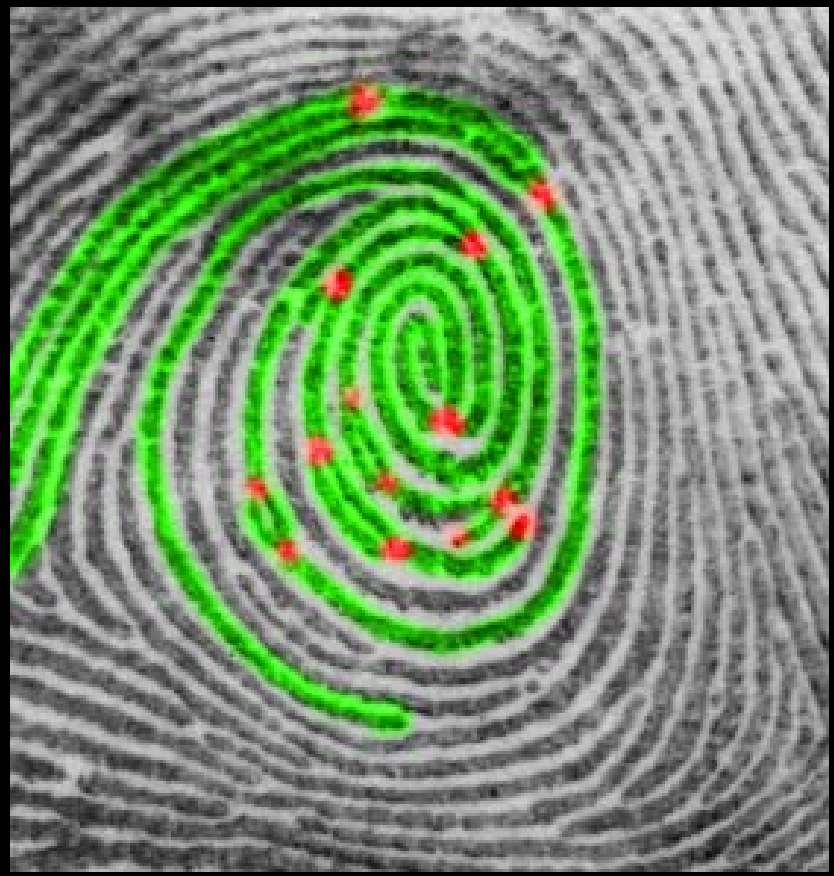
1c: Finer level of classification



- The old Henry Classification was extremely beneficial to latent print searching
- AFIS processing uses a simplified model, due to
  - the limited benefit a finer level of classification provided
  - The difficulty of accurate automatic pattern classification to this level

- ***The definition of these (via Henry or NCIC) is well defined***
- ***Automatic detection at this level is an unsolved problem, and generally requires rolls***

2a: Ridge Path *(1 of 2)*

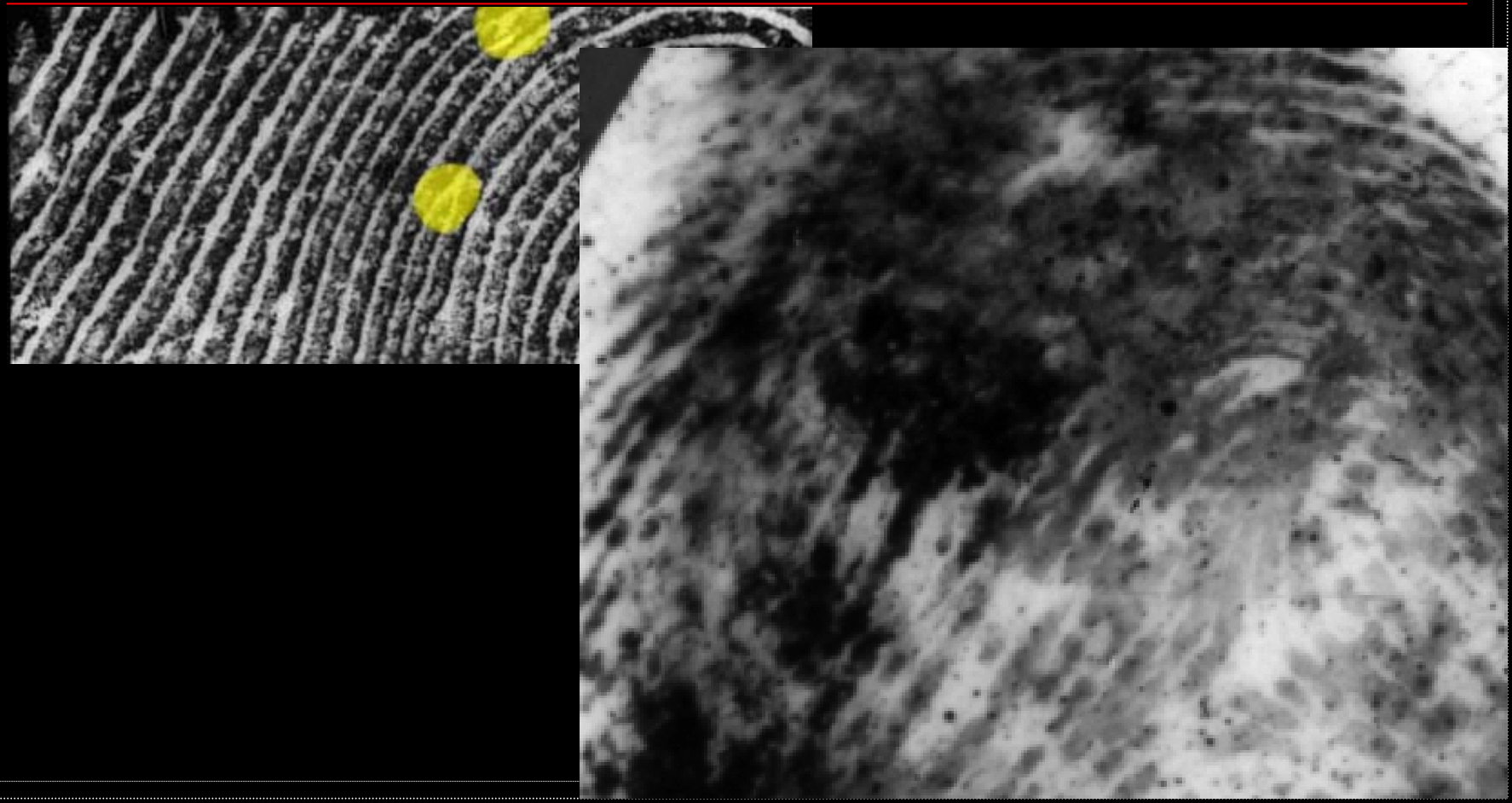


2a: Ridge Path *(2 of 2)*

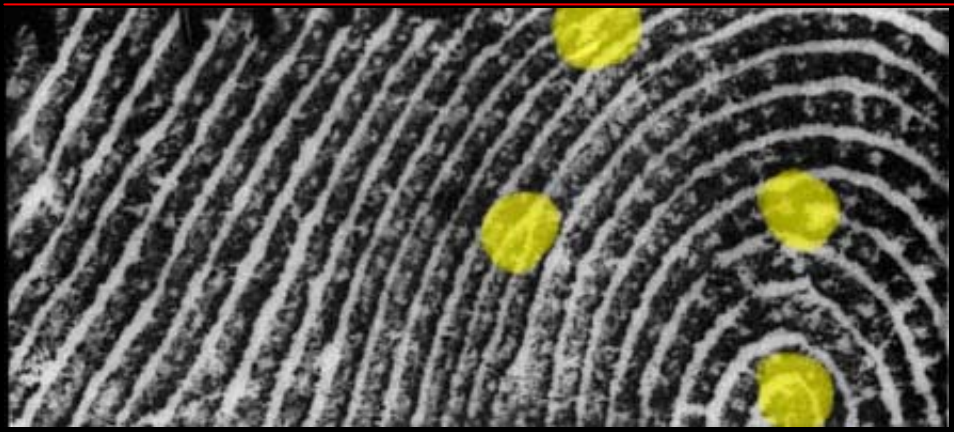
- A single ridge can be distinctive if all these factors are accounted for:
  - Continuity
  - Minutiae relationships
  - Curvature
  - Relationships of non-minutiae features

- ***Definition and detection both need research***

2b: Open Field of Ridges *(1 of 2)*



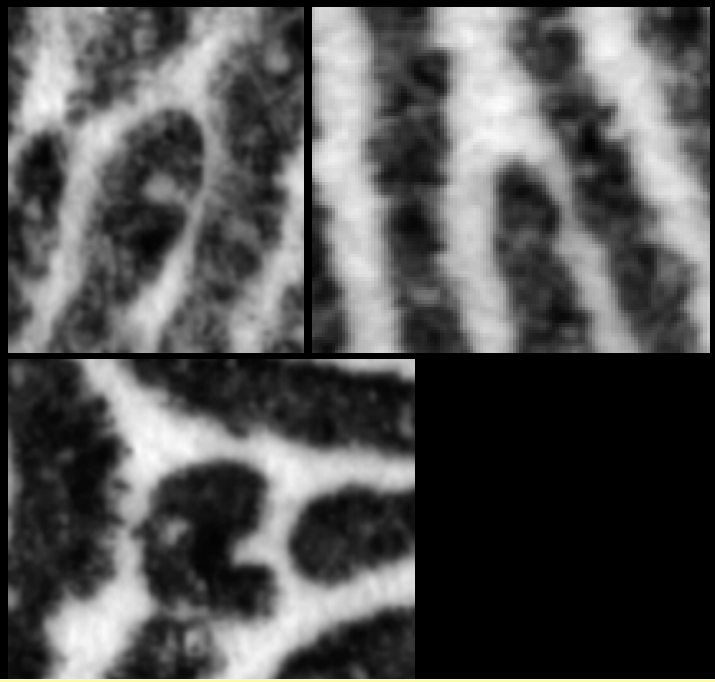
2b: Open Field of Ridges *(2 of 2)*



- A matcher has to know if the absence of marked minutiae is definitive: does a space without marked minutiae mean:
  - There are definitely no minutiae there OR
  - There may be minutiae there

- ***The absence of such information in IAFIS makes the system sensitive to prints with concavities or holes***
- ***Readily definable and automatically detectable***

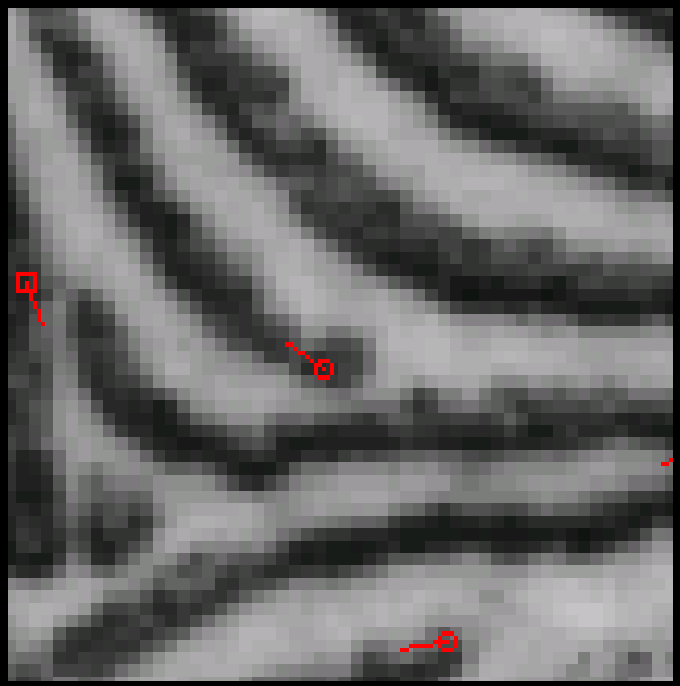
2c: Greater definition of minutiae
(1 of 3)



- Shape, size, and configuration of minutiae are distinctive
- Could use a finer level of description of the ridge ending shape and configuration of the actual bifurcation
- Use minutiae in addition to endings and bifurcations:
  - Crossovers
  - Trifurcations
  - *(etc)*

- ***Definition:***
  - ***Additional types of features reasonable***
  - ***Shape of minutiae needs research***
- ***Detection needs research***

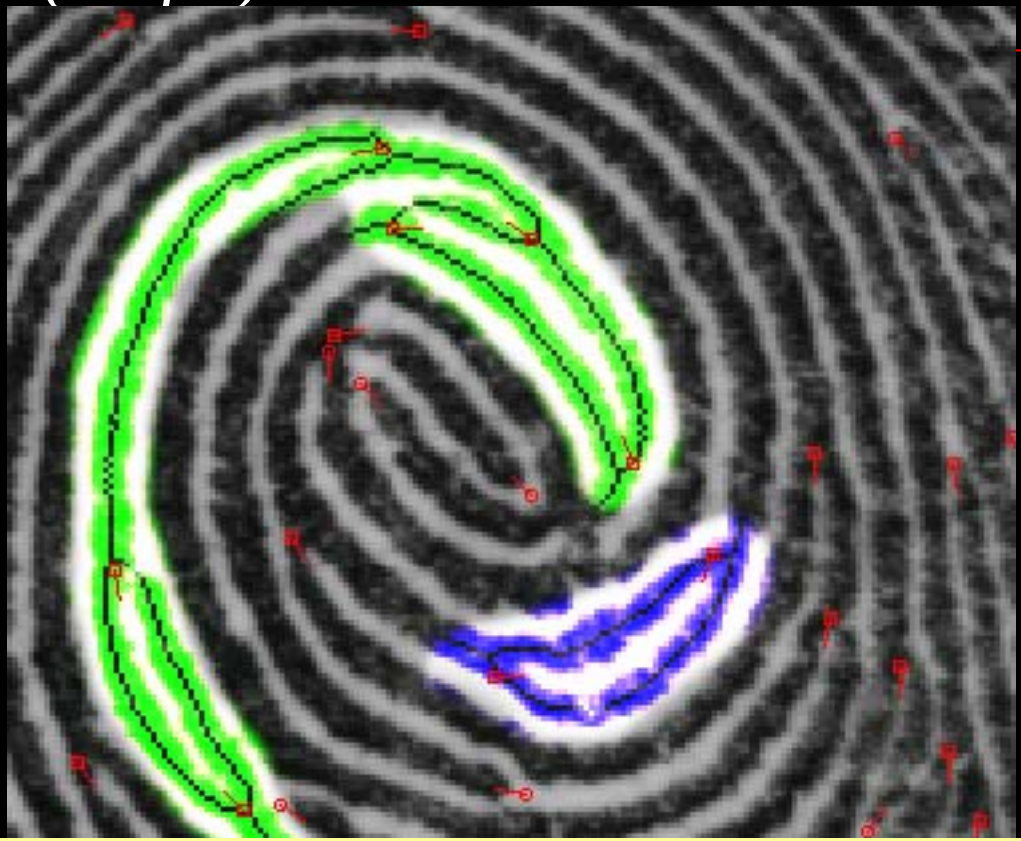
2c: Greater definition of minutiae
(2 of 3)



- Ridge endings can be defined in terms of
  - the fork of the tracing of the valley,
  - the end of the tracing of the ridge, and/or
  - the end of the ridge (e.g. the end of the binarized image) –
- Bifurcations can be regarded as the same definition with black-white reversal.
- Theta can be described in terms of different distances from the minutia location(s).

➢ ***Definition and Detection both reasonable***

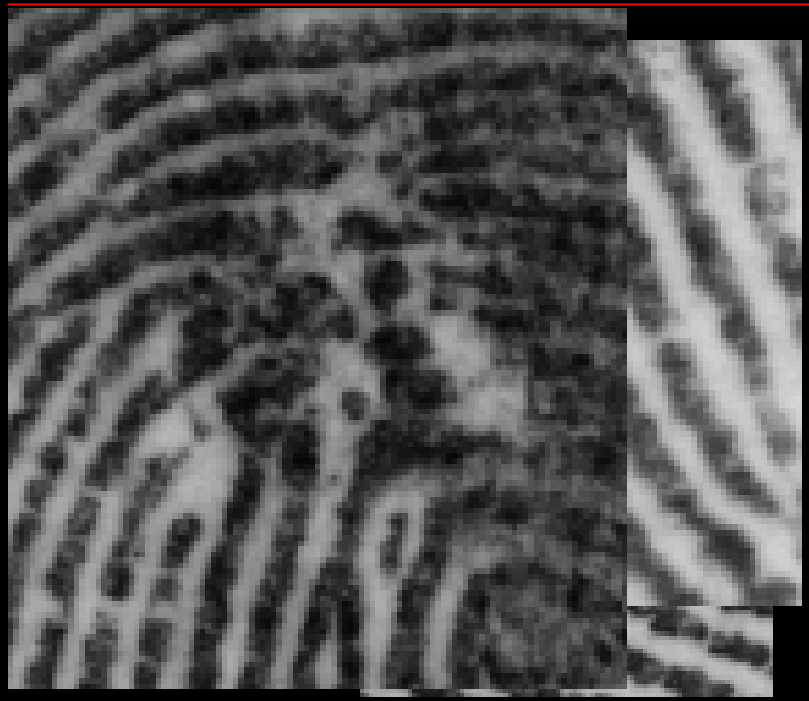
2c: Greater definition of minutiae
(3 of 3)



- Minutiae on same ridge need to be flagged
- Much richer interrelationships than simply ridge counts between neighbors
- Binarization and tracing already provide detection basis

- ***Definition and detection both reasonable***

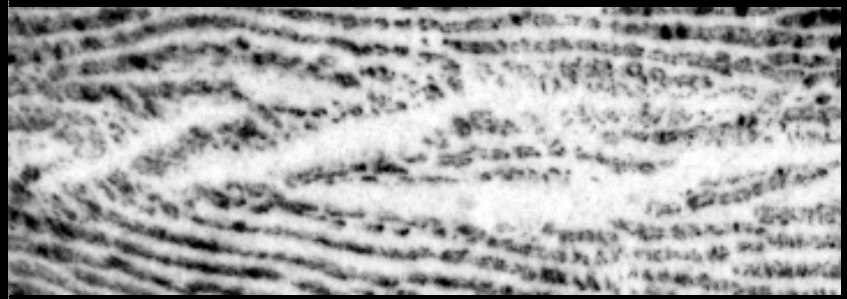
2d: Scars

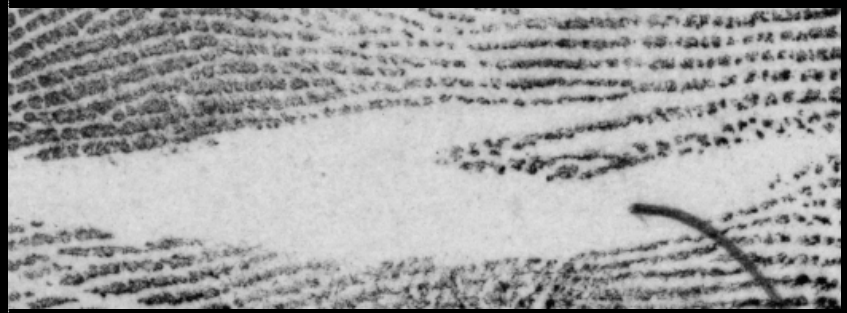


- Presence, location, size, and configuration of scars can be very discriminating IF present in both images
- Linear ridge discontinuities could readily be defined and detected

- ***Definition and detection both need research***
- ***Matching using scars needs to be fault-tolerant to account for the potential absence of the scar***

2e: Creases





- Creases
  - between major fields of friction ridge skin (Flexure creases) are permanent and provide distinctive configurations of features (but vary between captures)
  - within friction ridged area creases can be permanent or non-permanent.
- Flexure creases provide “feathering” which provides both location and direction to each aspect of the crease.

- ***Definition and detection need research***

2f: Incipient ridges

- Friction ridges not fully developed which may appear shorter, thinner in appearance, or more intermittent than fully developed friction ridges.
  - Rarely bifurcates
  - Rarely/never has pores
  - May appear at times as a series of dots
- Distinctive in propensity, presence, and location

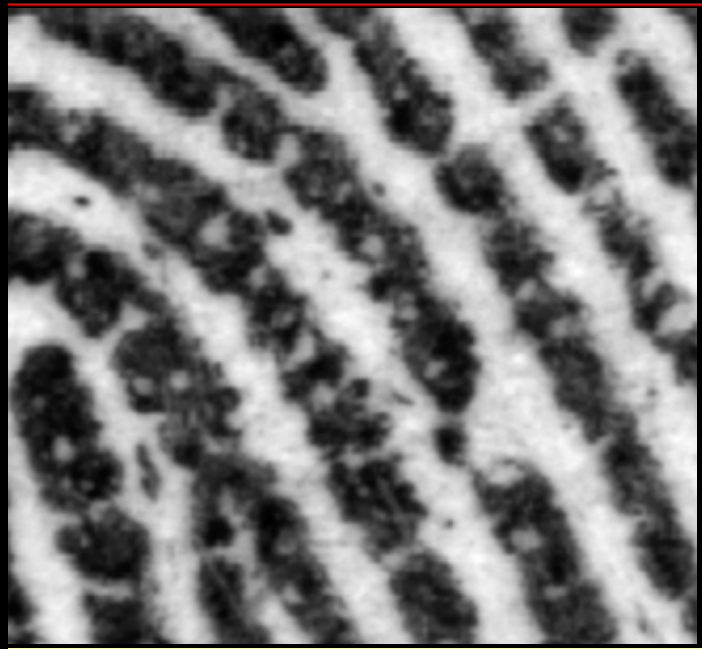
➢ ***Definition and detection need research in determining how/whether to differentiate from standard ridges***

2g: Dots

- Dots, short ridges, and short enclosures are not generally used in IAFIS
- These are particularly distinctive

➢ ***Readily definable and detectable***

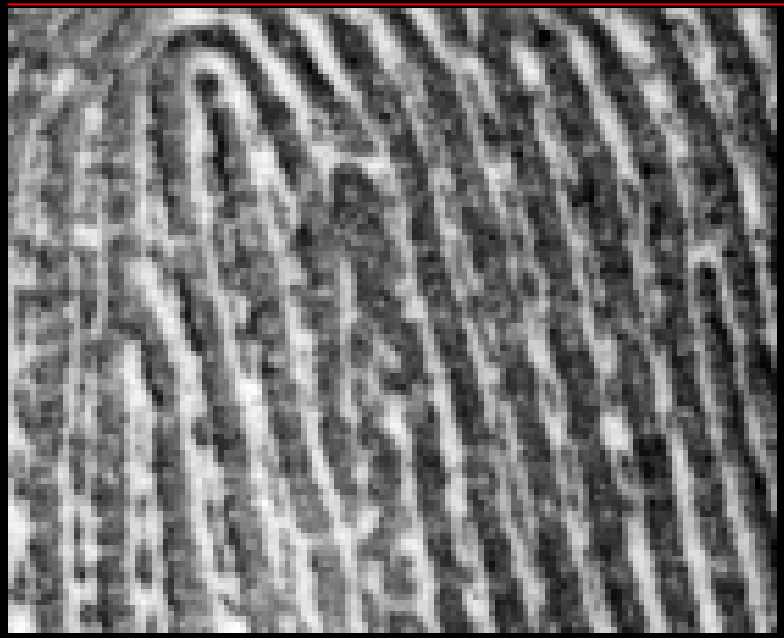
3a: Pores



- Pores are distinctive in several ways:
  - Size
  - Shape/form
  - Position on the ridge
  - Number or frequency
- Pores are not generally reliable unless both fingerprints are at a resolution of 1000ppi or more.

- ***Definition and detection are practical given enough resolution***
- ***See Roddy & Stosz 1999 IEEE paper "Fingerprint features statistical analysis" for discussion***

3b: Edge shapes



- Morphological features (width, major deviation, etc.) defining the contour or shape of the ridge edge
- Major deviations and discontinuities are usable at 500 ppi (though obviously better at 1000+ppi)
- Edge features can be defined using Chatterjee's edge feature classification

- ***Major deviations and discontinuities:***
  - ***Definition and detection are probably both practical***
- ***Other features:***
  - ***Definitions can be based on Chatterjee***
  - ***Detection would require more research***

3c: Ridge/Valley width

- Measurements from
  - Edge-to-edge of a ridge
  - Edge-to-edge of a valley
  - Center-to-center of adjacent ridges
- Special case of edge shapes (3b)
- Possible to define and detect:
  - Actual width of ridges and valleys at regular intervals
  - Major deviations in width
  - Discontinuities

➢ ***May be practical to define and detect, even at 500ppi***

Additional Feature Types

- This does not preclude other types of features, such as
  - 3d features

Possible Uses

- Areas of improvement for feature extraction and matching algorithms, both for latent and non-latent systems
- Quantification of the features actually used in latent comparison
  - Without a richer feature set, automated matchers will be limited in advancements in latent searches
  - Basis for special-purpose latent end-stage matcher (matcher would require human markup of both fingerprints being compared, but would quantify similarity)
  - Human examiners would be able to detail more precisely the non-minutiae features used for comparison (for courtroom, Daubert use, etc.)
  - Improved feature set for use in modeling uniqueness of fingerprints

Next Steps

- Reserve block of fields in the Type-9 record for use for Extended Feature Definitions
  - e.g. 9.300 through 9.399
- Convene committee for Extended Fingerprint Feature Set definition
- Plan for Addendum to ANSI/NIST ITL-2006
  - Target of 3Q 2006 for proposed Addendum
- FBI will be providing data sets with marked up examples (similar to NIST SD27)