# Extended Fingerprint and Palmprint Features

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# Data Format

- "Data Format for the Interchange of Extended Fingerprint and Palmprint Features"
  - Addendum to ANSI/NIST-ITL 1-2007
  - Defines a new Type-18 record
- Current status:
  - Proposed draft
  - Will be made public after comments from CDEFFS members are incorporated
  - Will remain "proposed draft" for period of test & evaluation
  - Amended draft will be put out for ANSI canvassing

# Purpose

- To define a quantifiable, repeatable, and clear method of characterizing the information content of a fingerprint or other friction ridge image.

# Uses

- Uses may include, but are not limited to

  - automated searches of fingerprint or palmprint systems

  - information exchange between human examiners

  - definitions of information content of fingerprints or palmprints

Note that the requirements differ between uses!

# Potential Benefits

- **Improved accuracy for AFIS searches**

- **Common interchange format**
  - between human examiners
  - Between AFISs

- **More complete basis for quantifying the similarity of a given comparison**

*All require evaluation to be known benefits rather than just potential*

# Committee

Includes 45 people from 23 organizations

Behnam Bavarian (Motorola), Vincent Bouatou (Sagem Morpho), John Burt (NEC), Christophe Champod (University of Lausanne, Switzerland), Yi Chen (Michigan State), Vladimir Dvornychenko (NIST), Jeri Eaton , Brian Finegold (BAE), Jean-Christophe Fondeur (Sagem Morpho), Mike Garris (NIST), Ed German , Mike Gilchrist (FBI-CJIS), Paul Griffin (Identix), Masanori Hara (NEC), Austin Hicklin (Noblis), Tom Hopper (FBI-CJIS), Anil Jain (Michigan State), Creed Jones (Sagem Morpho), Artour Karaguiozian (Motorola), Peter Komarinski (IAI), Debbie Leben (US Secret Service), Bill Long (TBS), Davide Maltoni (University of Bologna), Dana Marohn (IBG), Brian Martin (Identix), Mike McCabe (NIST), Glen McNeil (Sagem Morpho), Steve Meagher (FBI-Lab), John Mayer-Splain (Noblis), Dmitry Mikhailov (Jobin Yvon (SPEX)), Elaine Newton (NIST), Afzel Noore (WVU), Geppy Parziale , Wade Petroka (King County WA Sheriff's Office), Ann Punter (Cogent), Richa Singh (WVU), Greg Soltis (DEA), Scott Swann (FBI-CJIS), Elham Tabassi (NIST), Cedric Thuillier (Sagem Morpho), Anne Wang (Cogent), Phillip Wasserman (NIST), Kasey Wertheim, Brian Wong (IBG), Stephen Wood (NIST)

*Thank you!*

# Please Note:

- Different uses will require different subsets of the features defined in this addendum. This is a data format, NOT a definition of different types of transactions.

- Automated algorithms can use the extended features defined for a latent search without explicitly computing them for the exemplar image, and thus it must be emphasized that automated extraction of the extended features on the exemplar is not necessarily the only nor the best way to use this information.

# Next steps

1. Proposed Draft Addendum
    1. Review by CDEFFS (current)
    2. Publicly available
2. Evaluation data
    1. First set: BDM (NIST SD27)
    2. Second set: from FBI lab
3. Evaluation
4. ANSI Canvass

# Not all features are appropriate in all cases

- Both latent examiners and AFIS vendors have costs associated with additional features:
    - encoding time for the examiners
    - R&D costs and processing complexity for the AFIS vendors.

- Which features may be associated with relatively greater improvements in accuracy cannot be known without testing.

- We should assume that different implementations of CDEFFS would require some of the features, allow others as optional, and (possibly) ignore others.

- I suspect that the full set of CDEFFS features would be encoded by hand in both the search and exemplar fingers in ***A FEW*** situations such as challenged identifications or courtroom presentations.

- I suspect that AFIS searches will only use some of the features we have defined – which features should be used in these cases requires testing.

# Sample Data

- "Ground truth" widely distributed datasets for testing and evaluation

- For CDEFFS fingerprint data to exist, proof-of-concept CDEFFS client software needs to allow CDEFFS feature markup. At first,
  - we are just looking for manual, not automated CDEFFS markup (we have to walk before we run)
  - may require/request input from CDEFFS members/vendors for some features (e.g. ridge flow, skeletonized images, local quality map)

- First set: the venerable BDM/SD27 latent set, re-encoded using CDEFFS

- Second set(s): 1000ppi sets, preferably with two latents per exemplar

- Such markup requires examiners: "Ground-truth" markup should have at least two examiners.  Note that both latents and exemplars need to be marked up.

# Evaluations of effectiveness

- The development of the test datasets may be a good sanity check to weed out features (if any) that are not worth further pursuing, or need further definition

- Further testing seems to be a chicken-and-egg problem: effective testing requires development of algorithms, and justifying development of algorithms presumably requires some level of expected benefit.
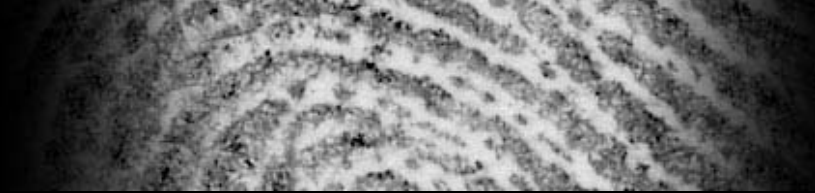
# Supporting Material

# List of Features (1 of 5)

ANSI/NIST File Format Fields

    18.001        Logical Record Length

    18.002        Image Designation Character

Impression Type

    18.003        Impression Type

Orientation Fields

    18.004        Region of Interest

    18.005        Orientation

# List of Features (2 of 5)

- Overall Image Characteristics
- 18.006 Physical Location(s)
- 18.007 Pattern Classification
- 18.008 Ridge Quality Map
- 18.009 Ridge Quality Map Format
- 18.01   Ridge Flow Map
- 18.011 Ridge Flow Map Format
- 18.012 Ridge Wavelength Map
- 18.013 Ridge Wavelength Map Format
- 18.014 Inverted Image
- 18.015 Degree of Distortion

# List of Features (3 of 5)

- Reference Points
- 18.02   Cores
- 18.021 Deltas
- 18.022 Core-Delta Ridge Counts
- 18.023 Center Point of Reference
- 18.024 Distinctive Features
- Minutiae
- 18.03   Number of Minutiae
- 18.031 Minutiae
- 18.032 Minutiae Ridge Count Algorithm
- 18.033 Minutiae Ridge Counts

# List of Features (4 of 5)

- Minor Features
- 18.04   Dots
- 18.041 Incipient Ridges
- 18.042 Creases and Linear Discontinuities
- 18.043 Ridge Edge Features
- 18.044 Area of Pore Characterization
- 18.045 Pores
- Annotations
- 18.05   Method of Feature Detection
- 18.051 Comments

# List of Features (5 of 5)

- Skeletonized Image
  - 18.996 Skeletonized Image Scale
  - 18.997 Skeletonized Image Scale Units
  - 18.998 Skeletonized Image Compression Algorithm
  - 18.999 Skeletonized Image

# 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."

# 1a: Ridge flow
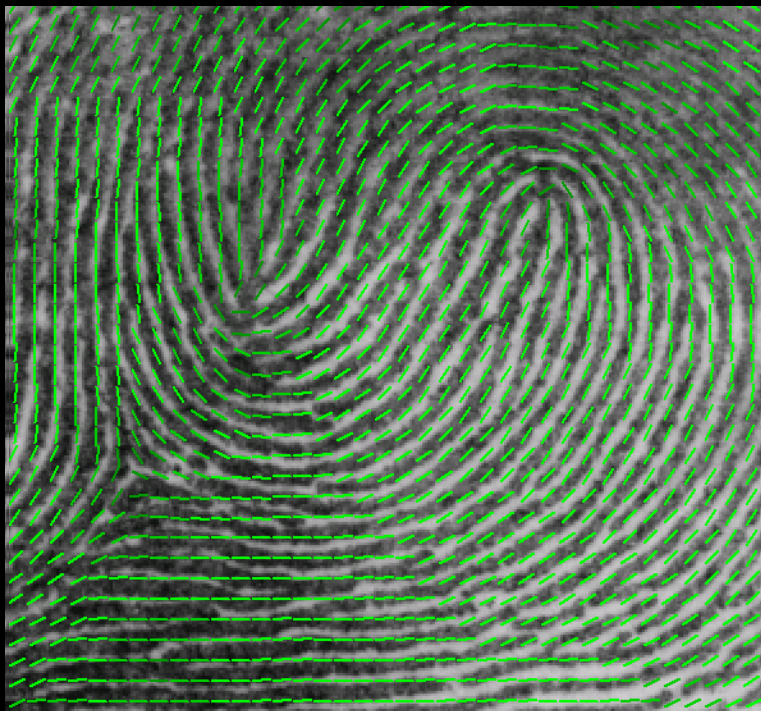


- Adjacent friction ridges in a directional arrangement

- 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

- Already used by some verification matchers (e.g. BioScrypt); used in some AFIS for screening

# 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

# 1c: Finer level of classification
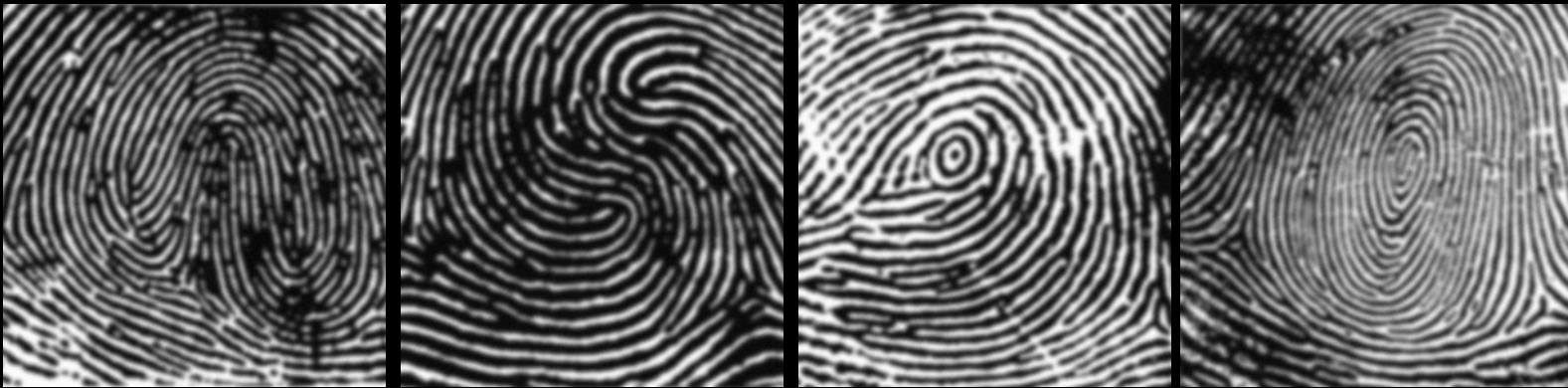


- The old Henry Classification was extremely beneficial to latent print searching

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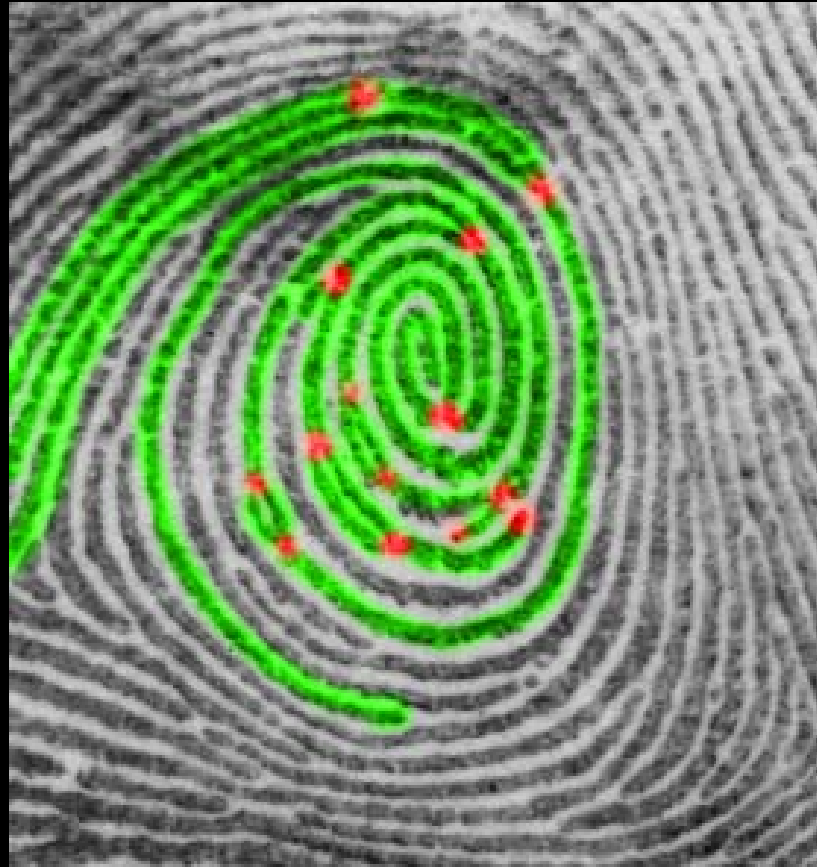
# 2a: Ridge Path *(2 of 2)*



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

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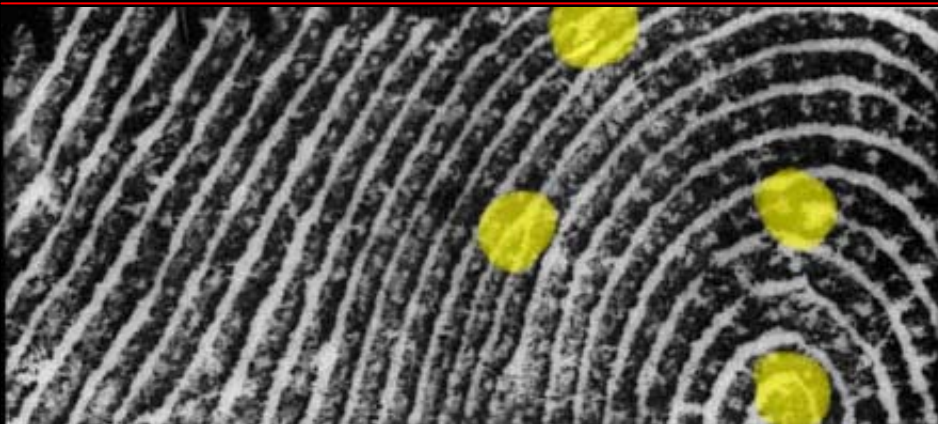


- A matcher has to know if the absence of marked minutiae is definitive: does a space without marked minutiae mean:

  - There are definitely no minutiae there OR

  - There may be minutiae there
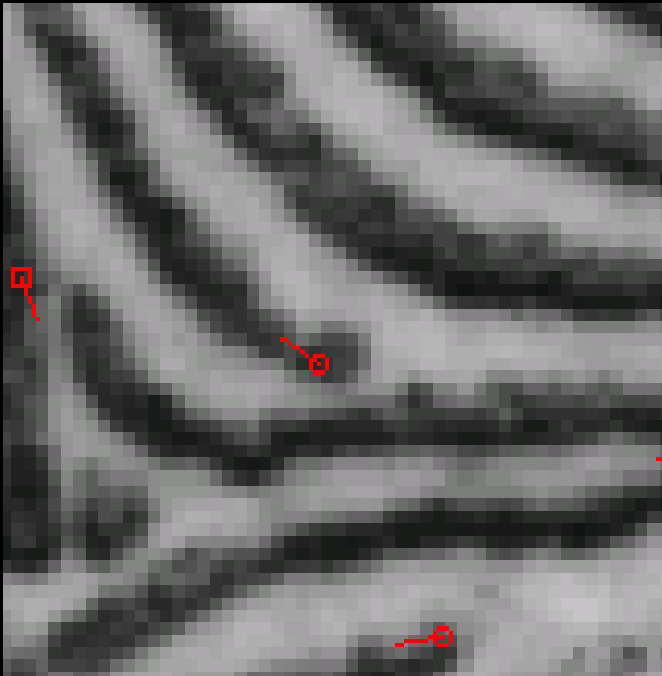
# 2c: Greater definition of minutiae
*(1 of 3)*
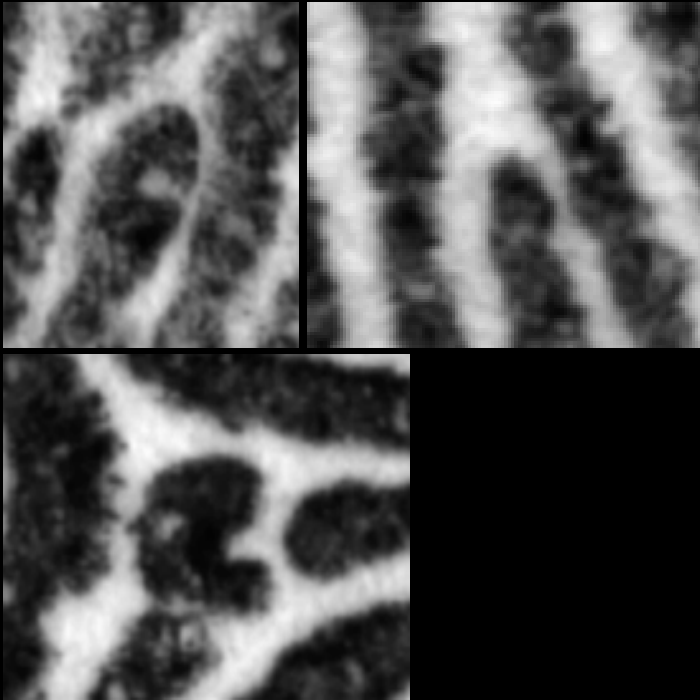


- Shape, size, and configuration of minutiae are distinctive

- 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)*

- 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.
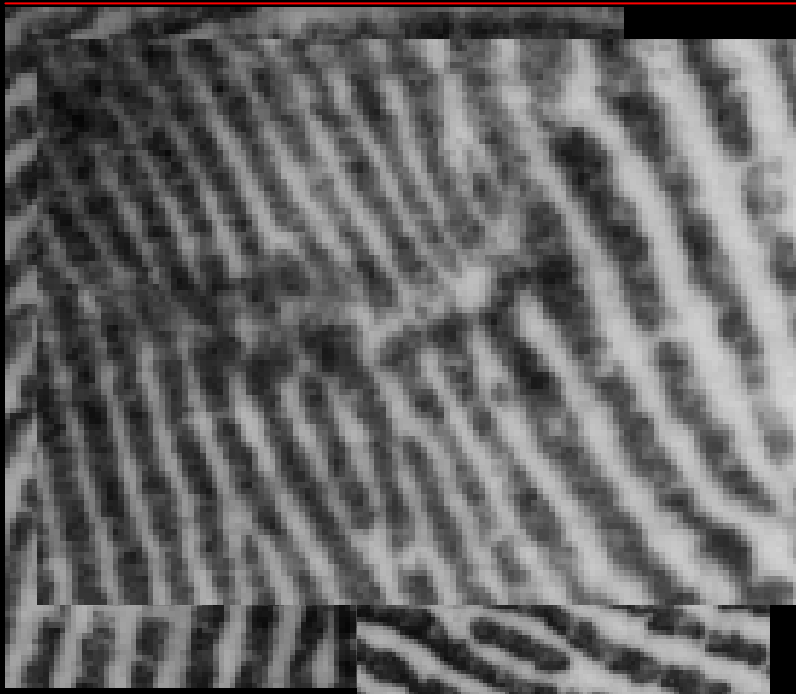- Theta can be described in terms of different distances from the minutia location(s).

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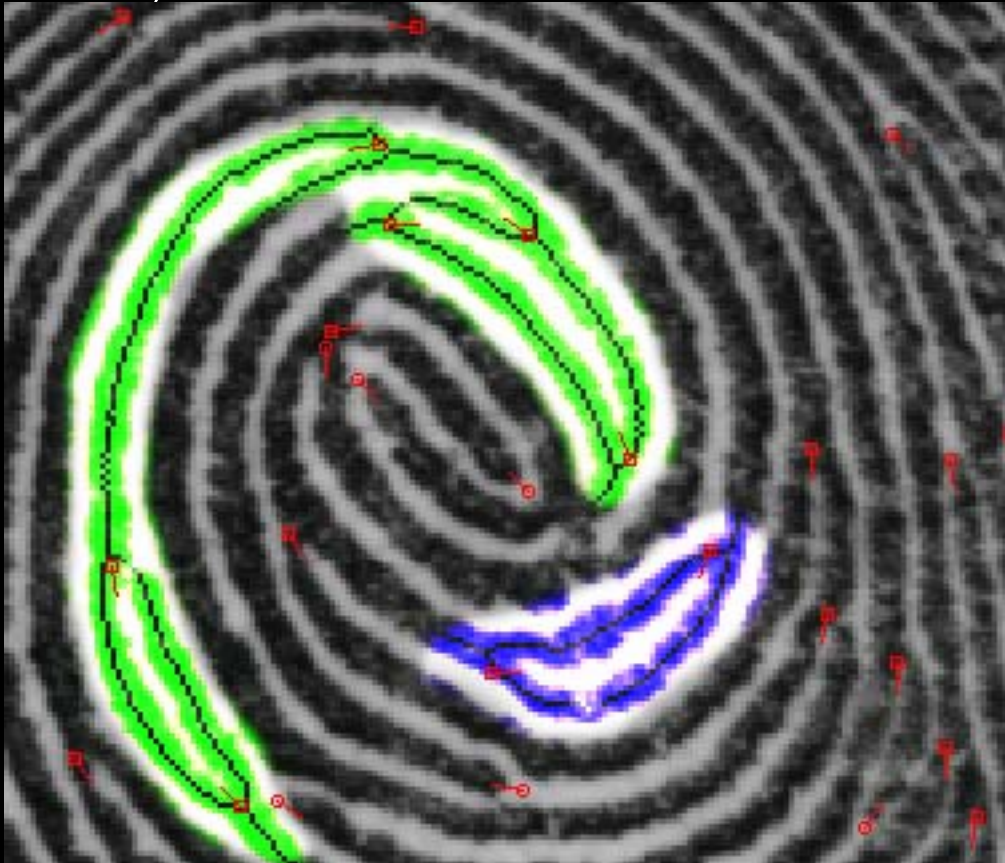


- Minutiae on same ridge need to be flagged

- Much richer interrelationships than simply ridge counts between neighbors

- Binarization and tracing already provide detection basis

# 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

# 2e: Creases
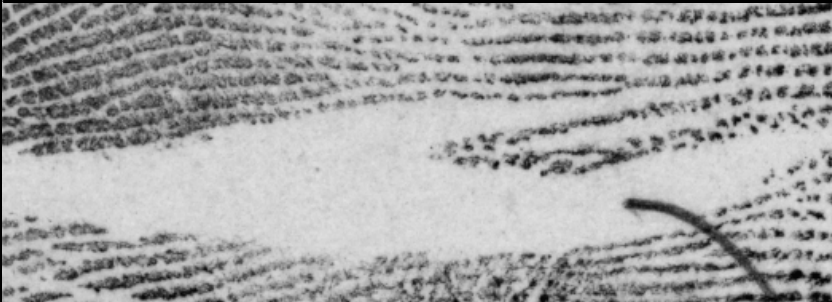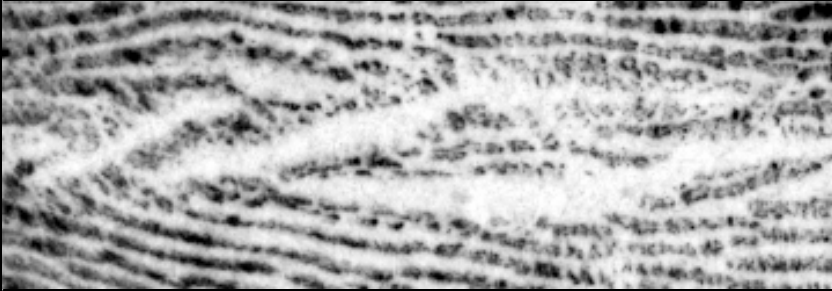




- Creases
    - between major fields of friction ridge skin (Flexure creases) are permanent and provide distinctive configurations of features (but vary between captures)
    - within friction ridged area creases can be permanent or non-permanent.

- Flexure creases provide "feathering" which provides both location and direction to each aspect of the crease.

# 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
    - Shallower than ordinary ridges
- Often distinctive in propensity, presence, and location – to human examiners
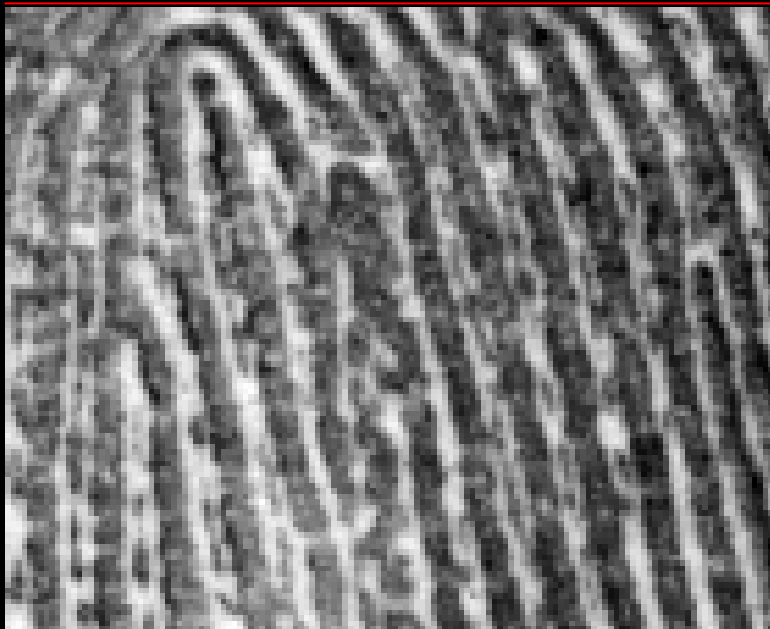
# 2g: Dots



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

- These are particularly distinctive

# 3a: Pores
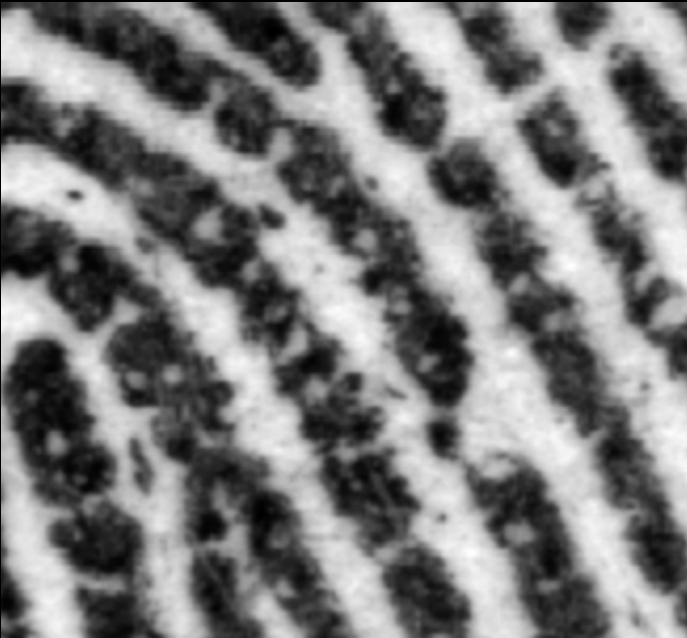


- Pores are distinctive in several ways:
  - Size
  - Shape/form
  - Position on the ridge
  - Number or frequency

- Pores are not generally reliable unless both fingerprints are at a resolution of 1000ppi or more

# 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

# 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