CDEFFS

ANSI/NIST Committee to Define an Extended Fingerprint Feature Set

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Charter

In the ANSI/NIST ITL 1-2000 Standard Workshop II (Dec. 2005), the committee was chartered to:

- Identify, define and provide guidance on additional fingerprint features beyond minutiae (not limited to level-3 detail)

- Develop draft Addendum to ANSI/NIST ITL-2006

- Cooperate with SWGFAST and AFIS vendors

- Report back by December 2006
Committee

Includes 28 people from 14 organizations — Open to new members

- Behnam Bavarian (Motorola)
- John Burt (NEC)
- Jeri Eaton (King County WA)
- 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 (Mitretek)
- Tom Hopper (FBI-CJIS)
- Anil Jain (Michigan State)
- Artour Karaguiozian (Motorola)
- Peter Komarinski (IAI)
- Debbie Leben (US Secret Service)
- Bill Long (TBS)
- Brian Martin (Identix)
- Mike McCabe (NIST)
- Glen McNeil (Sagem Morpho)
- Steve Meagher (FBI-Lab)
- Geppy Parziale (TBS)
- Scott Swann (FBI-CJIS)
- Anne Wang (Cogent)
- Phillip Wasserman (NIST)
- Kasey Wertheim (Lockheed Martin (DOD))
- Brian Wong (IBG)
- Stephen Wood (NIST)
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.”

- (from Nov. 2005 memo to NIST)
Extended Features
Under Consideration

Overview
Extended Features Under Consideration

Level 1 Features
a. Ridge flow
b. Cores and deltas
c. Finer level of classification

Level 2 Features
a. Ridge path elements
b. Open field of ridges
c. Greater definition of minutiae
d. Scars
e. Creases
f. Incipient ridges
g. Dots

Level 3 Features
a. Pores
b. Ridge edge shapes/width

c. 3d Features
a. Ridge height / valley depth
For each type of feature, the issues are

- Concurrence on
  - precisely what is meant
  - definition in ANSI/NIST fields
- Repeatability / reliability / stability
- Practicality of
  - automatic detection
  - human detection
- Use/value
  1. Human comparisons
  2. Human-encoded AFIS searches
  3. Fully automated encoding and matching?
Possible Uses

- Areas of improvement for feature extraction and matching algorithms (both for latent and non-latent fingerprints)
- Interoperability of fingerprint feature definitions
- Quantification of the features actually used in latent comparison
  - 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
- Basis for special-purpose latent end-stage matcher
  - A matcher that might require human markup of both fingerprints being compared, but would quantify similarity
1a: Ridge flow

- Adjacent friction ridges in a directional arrangement
- Basically pattern classification of a limited area
  - Role of traditional pattern classification is diminishing as AFIS moves from rolls to flats
- Used in some AFISs for screening
  - to exclude candidates, but not for identification
- Used by some matchers by itself

- 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 and ridge flow direction in areas of high curvature would address some of the issue
- Location of cores is useful / necessary in determining the centering of a fingerprint

- Minutiae within these areas should be more extensively used
- Otherwise, definition will need concurrence, and detection will 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, but for human classification
- Automatic detection at this level is an unsolved problem, and generally requires rolls
2a: Ridge Path (1 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)
The absence of such information in IAFIS makes the system sensitive to prints with concavities or holes.

- Readily definable and automatically detectable
- This can be bundled with the pattern definition (1a) – should it?

- 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)

- Definition:
  - Additional types of features reasonable
  - Shape of minutiae needs research
  - An interoperable definition would be worthwhile
- 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).

- **Concurrence in definition is the hard part**
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

- Overlaps with ridge path (2a)
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.

- **Hard**: Definition and detection both need research.
- **Concerns about consistency**
- **Matching using scars needs to be fault-tolerant to account for the potential absence of the scar**
2e: Creases and Cracks

- 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.

- Hard. Definition and detection need research

- Concerns about consistency
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

- Definition and detection need research in determining how/whether to differentiate from standard ridges, or dots

- Concerns about consistency
2g: Dots

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

- Readily definable and detectable
- Concerns about consistency
Pores are distinctive in several ways:
- Size
- Shape/form
- Position on the ridge
- Number or frequency

Not always visible, especially in inked prints

Resolution
- Requires 1000ppi+ for full clarity
- Can be useful as supporting evidence at 500ppi

- Definition and detection are practical given enough resolution
- Concerns about consistency
- 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
  - indentations
  - protrusions
  - discontinuities
  - usable at 500 ppi (though obviously better at 1000+ppi)
- Edge features can be defined using Chatterjee’s edge feature classification

- Concerns about consistency
- Major deviations and discontinuities:
  - Definition and detection are probably both practical
- Other features:
  - Definitions can be based on Chatterjee
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
- Concerns about consistency
4a: Ridge Height /Valley Depth

- Is this beyond scope? Is 3d capture mature enough to define this yet? We should assume that this will need to be defined at some point.
- Concerns about consistency
Next Steps

- Determining which features should be defined in the addendum
- Evaluation of consistency of presence/definition
- End products:
  - ANSI/NIST Addendum: Extended Fingerprint Features
  - White paper on lessons learned
  - Data sets with marked up examples (similar to NIST SD27)