Evaluation of 3-D Fingerprint Image Capture Devices
(1/14/08)

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Headline News

DHS announces foreign visitors to have 10 print biometric (instead of 2 index fingers) starting Thursday (November 29, 2007) at Dulles Airport.

Washington's Dulles Airport on Thursday will begin a new DHS scheme to acquire ten fingerprints from each visitor to the United States; system will be implemented at all land crossings by the end of 2008.

1. Time taken?

2. Flat vs. Rolled?

Question: Should we live with live scanners forever?

Answer: No! “There’s Gotta Be A Better Way”.

Disadvantages of live scanners:

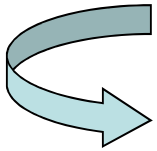
1. Noise from the valley due to hard pressure.

2. Noise from residues of previous usages.

3. Speed and flat of obtaining ten prints.

4. Distortion of the surface of fingers.

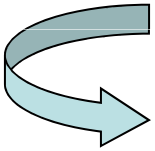
Live scanners:



2-d object

2-d image

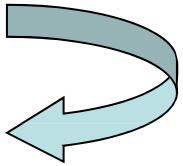
3-D fingerprint image capture devices:



3-d object

3-d image

2-d rolled-equivalent image



As a result, things are much more complicated.

Note: We are only interested in the 2-d rolled-equivalent images for evaluation and interoperability purposes.

Accomplishments

1. A website has been set up at http://fingerprint.nist.gov/3Dcapture to activate and facilitate all kinds of networking activities, such as discussion, making recommendations and suggestions, announcing the status and news, etc.

2. Established the framework of our project such as absolute measurement and relative measurement, etc.

3. Presented the framework of our project at the Biometric Consortium Conference in Baltimore in September 07.

4. Did numerous relative-measurement analyses on Phase I and Phase II devices from TBS. Praised by TBS CEO.

5. Communicated with FBI and other vendors.

Framework:

I. Absolute Measurement:

1. Stipulate the specifications.

2. Design targets to implement spec.

II. Relative Measurement - interoperability:

Compare with those collected from live scanners in terms of both accuracy and speed.

III. New Discoveries

I. Absolute Measurement

Here is a good start:

1. Personal Identify Verification (PIV) Image Quality Specifications for Single Finger Scanners (July 2006)
http://www.fbi.gov/hq/cjisd/iafis.htm
http://www.fbi.gov/hq/cjisd/iafis/piv/pivspec.htm

2. Test Procedures for Verifying Image Quality Requirements for Personal Identity Verification (PIV) Single Finger Capture Devices (December 2006)
http://www.mitre.org/work/tech_papers/tech_papers_07/06_1384/

3. APPENDIX F: IAFIS IMAGE QUALITY SPECIFICATIONS (January 1999)
http://www.fbi.gov/hq/cjisd/iafis/efts70/appendixf.htm

Geometric Accuracy **!!Extracted from their publications!!**

Spatial Frequency Response

- **CTF: Contrast (square wave) Transfer Function**
- **MTF: Modulation (sine wave) Transfer Function**

Gray Level Uniformity

- **adjacent row, column uniformity**
- **pixel to pixel uniformity**
- **small area uniformity**
- **noise**

Fingerprint Image Quality

- **fingerprint gray range (dynamic range)**
- **fingerprint abnormalities**
- **fingerprint sharpness & detail rendition**

(Note: NFIQ, MITRE, Cogent, NEC, etc.) ⌧ Partly extracted.

3-D Fingerprint Image Capture

The 2-D rolled-equivalent fingerprint image is obtained by converting the 3-D fingerprint image that is captured by the device.

Therefore, this is a process from 3-D manifold (simplified to be a surface) to 2-D plane rather than from 2-D plane to 2-D plane for live scanners.

As a consequence, things are much more complicated.

Geometric Accuracy:

1. Systematic Errors and Measurement Errors, which are for both “2-D to 2-D” and “3-D to 2-D”.
2. Differential Geometry Issue, that is only for “3-D to 2-D”.

Dynamic Range:

1. The probability distribution needs to be taken into account.
2. This is probably due to from “continuous” function to “step” function.
3. Impose some threshold.

Design 3-D targets

different targets for different devices ?

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II. Relative Measurement

This is extremely important in terms of interoperability between images captured by new devices and a huge amount of images now existing in our systems.

1. No flip-flop image:

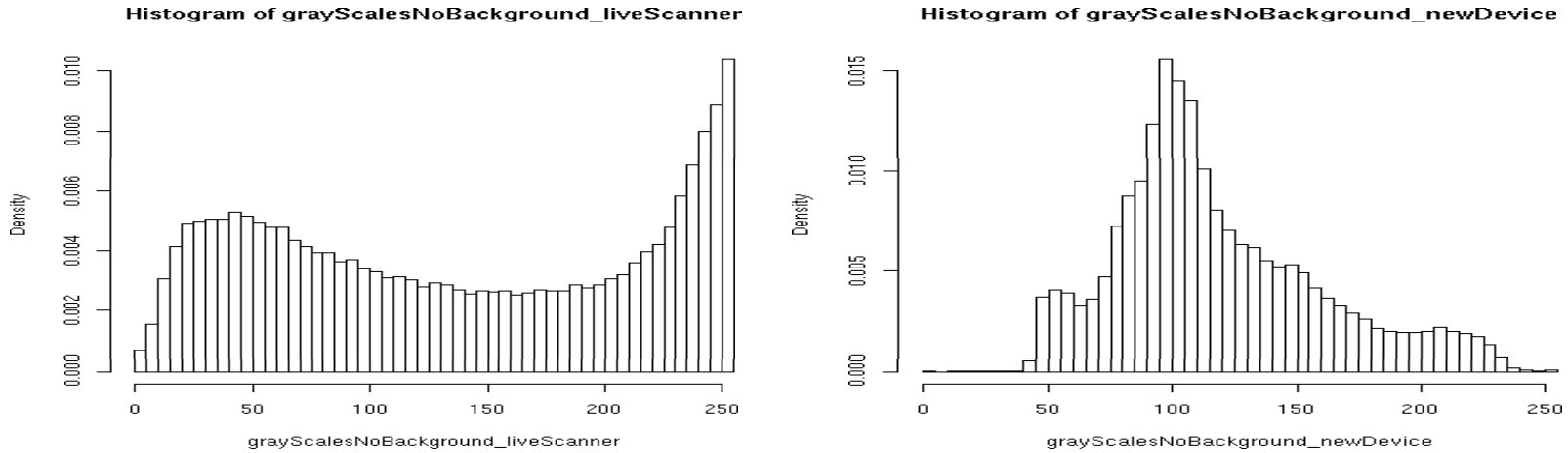
It is caused by the combination effects of the illumination directions inside the device and the orientations of ridges and valleys that are different between those at the upper part (generally vertical) and those at the lower part (mostly horizontal) of human's fingers.

Absolutely no algorithm can effectively and efficiently extract minutiae from such kind of fingerprint image.

2. Mirror image as opposed to front-view image

All images obtained using live scanners are mirror images.

3. Bimodal distribution of grayscales of all pixels in an ROI



4. The issue of the variance from software tools

5. Speed

The real time of one transaction = the time of positioning fingers into the right position (the issue of usability; in reality most are the 1st time users) + the capture time executed by the system (hardware & software)

6. A primitive test

Using the same subject, 1) get an image from a certified live scanner, 2) get an image from your device, 3) then compare in terms of minutiae using eyes and/or software.

Planning

1. Establish an “Evaluation” Steering Committee

The Committee will consist of about five to ten members, and will have meetings from time to time until “the mission has been accomplished”.

Please make recommendations!

2. Hold a workshop, if we have sufficient number of attendees.

3. Stipulate specifications.

4. Design targets to implement spec.