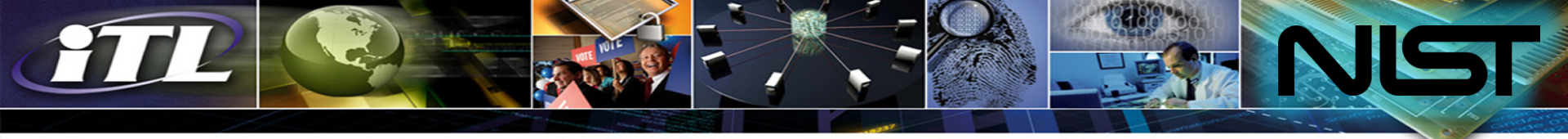


NIST
Contactless Fingerprint Metrology Project

Michael Garris

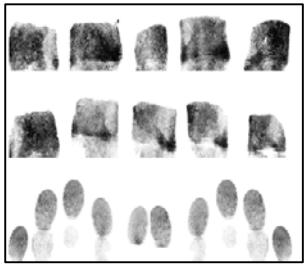
(for John Libert)

ITL/Information Access Division

NIST
National Institute of
Standards and Technology
U.S. Department of Commerce

Evolution of Fingerprint Technologies

- Inked Tenprint
- Livescan Tenprint
- ID-Flats
- Contactless Fingerprint

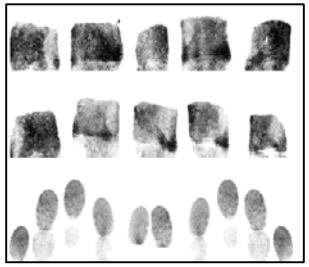


Credit: ©Axstokes/Shutterstock.com

History of Technology Validation & Adoption

Ink to Livescan

Livescan to ID-Flats



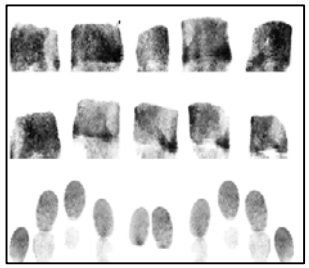
Livescan/ID-Flats to Contactless

1. Ink to Livescan

- Ink impressed from tops of ridges and absorbed by paper fibers

versus

- Light frustrated from tops of ridges touching the glass platen (FTIR *)

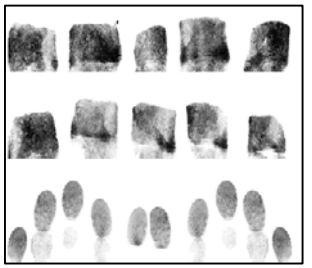


- <u>Road to Adoption</u>
  - Studies, demonstrations, pilots
  - Appendix-F IQS*, Certified Products List

*Frustrated Total Internal Reflection
*Image Quality Specification

2. Livescan to ID-Flats

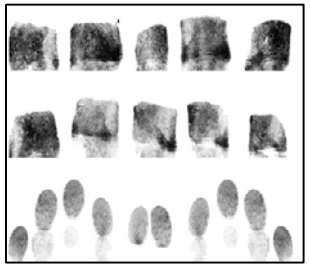
- FTIR versus FTIR
- Rolled versus Plain



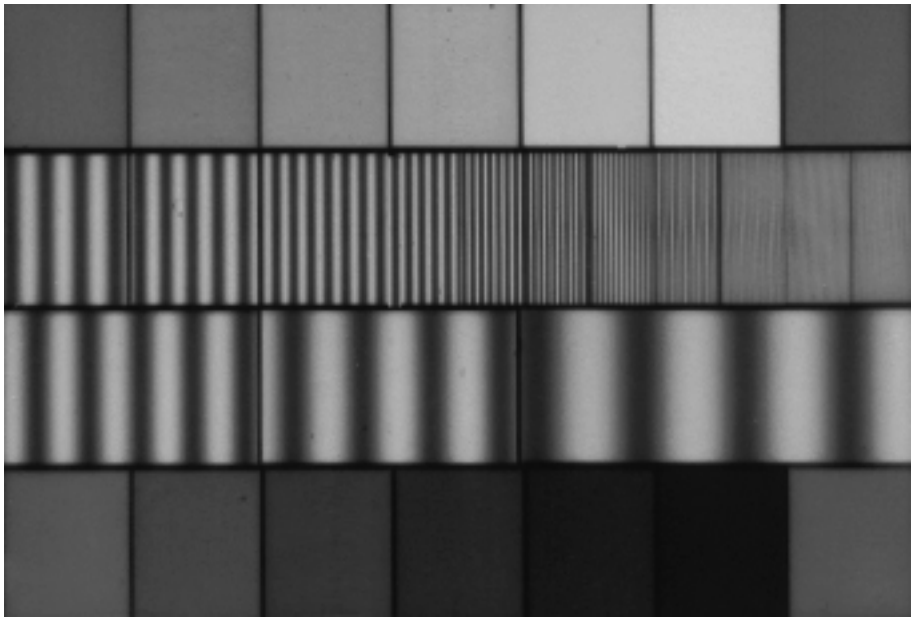
- Road to Adoption
  - Studies, demonstrations, pilots
  - Personal Identify Verification (PIV) IQS, Certified Products List

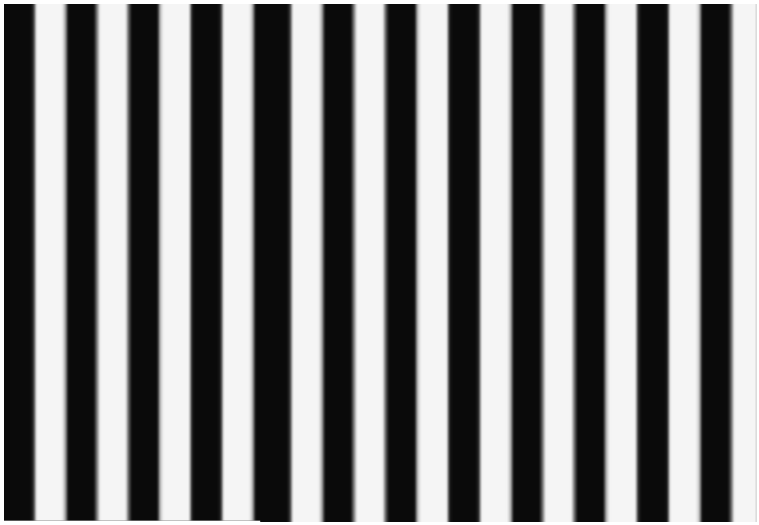
3. Livescan/ID-Flats to Contactless

- FTIR versus Touchless
  - + Z-axis freedom
  - + Direct sensing
    (sides of ridges in-light / in-shadow)
  - + Unwrapping?
  - + Under motion?
- Unlike FTIR, sensor solutions differ between contactless fingerprint technology developers
- Touchless fingerprints must be matchable to the hundreds of millions of touch-based fingerprints on file
- Road to Adoption?
  - Studies, demonstrations, pilots
  - New Testing Methods and Metrics for New Certified Products List
    - Not a simple extension of Appendix-F or PIV IQS



PIV 2D Test Targets



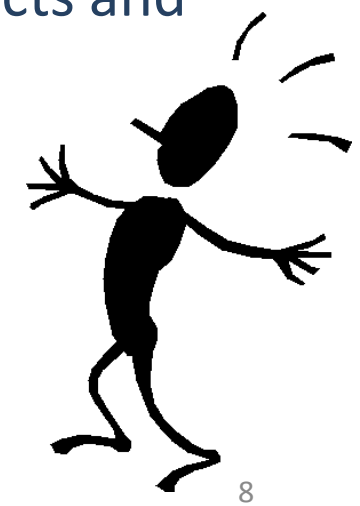


The FBI has granted PIV Certification to two vendors of contactless devices with caveat: ***Note: Device images a 3-dimensional object, but testing was only 2-dimensional - Not for use with CJIS systems.***

Research Strategy

Guiding Principles

- Simply taking pictures of flat, stationary optical targets is insufficient
- Test each contactless capture device under conditions for which designed
  - Integrated device rather than camera performance
  - At distance, under motion, with finger-like artifacts and actual fingers
- Turn off as little functionality as possible (ideally, none)

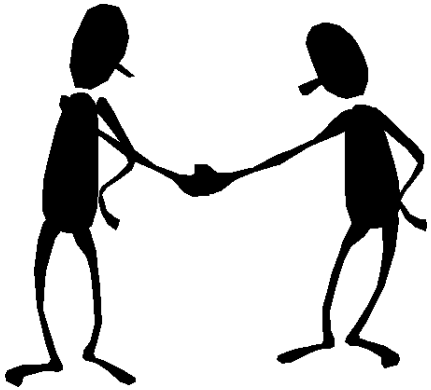


CRADA Program

(Contactless Fingerprint Capture Device Measurement Research)

http://www.nist.gov/itl/iad/ig/crada_contactless.cfm

- NIST working with industry to develop common criteria, testing methods and metrics to ensure new contactless devices produce fingerprint images that are reliable and appropriate for intended applications
- Image Accuracy, Repeatability, and Reliability
- Toward compliance testing for future procurements
- CRADA = Cooperative Research and Development Agreement



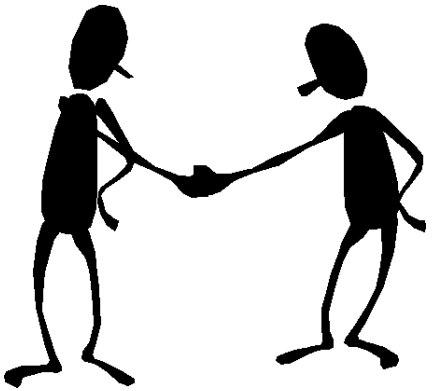
CRADA Partners

- MorphoTrak
  - MorphoWave/Finger-on-the-Fly
- 3M Corporation
  - Prototype device provided on loan
- Advanced Optical Systems (AOS)
  - ANDI/OTG

Portal/Kiosk

- Diamond Fortress
  - iOS/Android
- Hoyos Labs
  - iOS/Android
- Sciometrics
  - Android
- MorphoTrak
  - iOS/Android

Mobile



NOTE: In no case does identification of any commercial product imply endorsement by the National Institute of Standards and Technology, nor does it imply that the products and equipment identified are necessarily the best available for the purpose.

Key Measurement Questions
(Image Accuracy?)

1. Does contactless image precisely represent real finger?

2. How different is a contactless image to a livescan fingerprint?

Latest Targets (Gen 8)

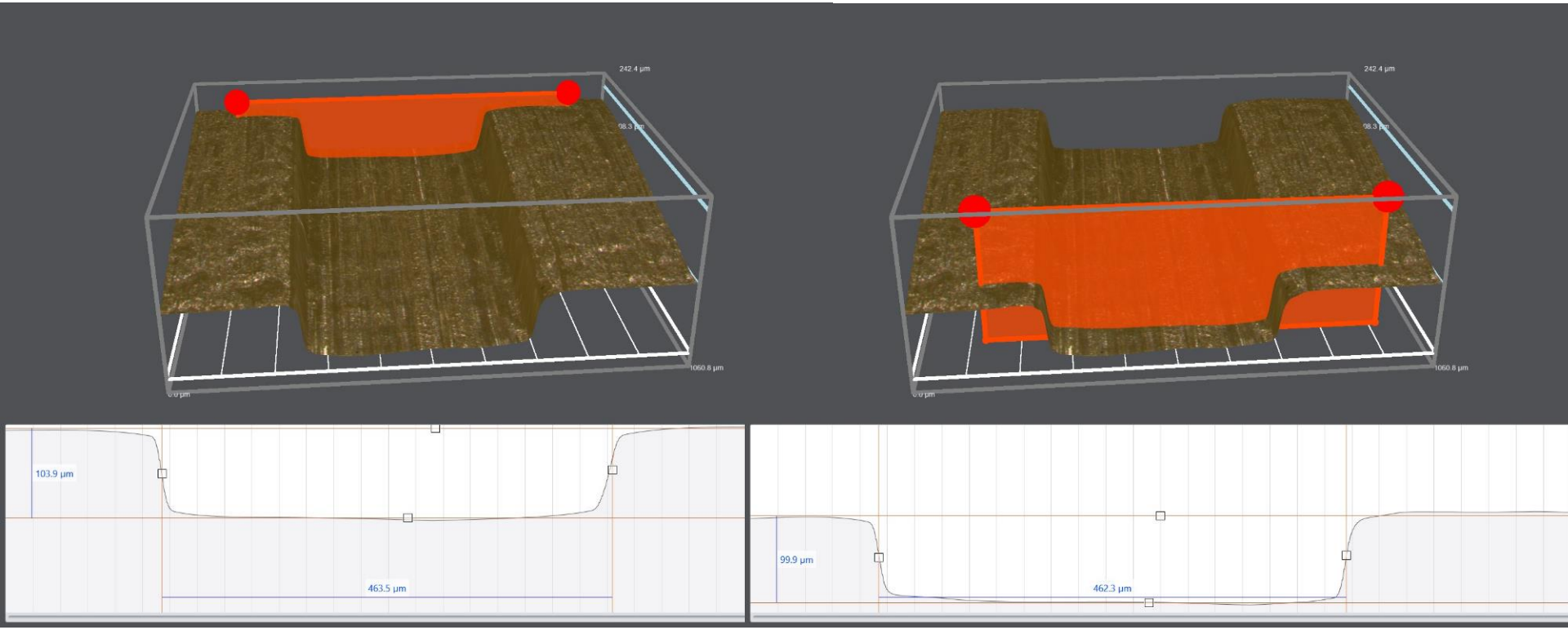
Fingerprint (Multiple Impressions)

Vertical Ronchi (Glossy)

Horizontal Ronchi (Glossy)

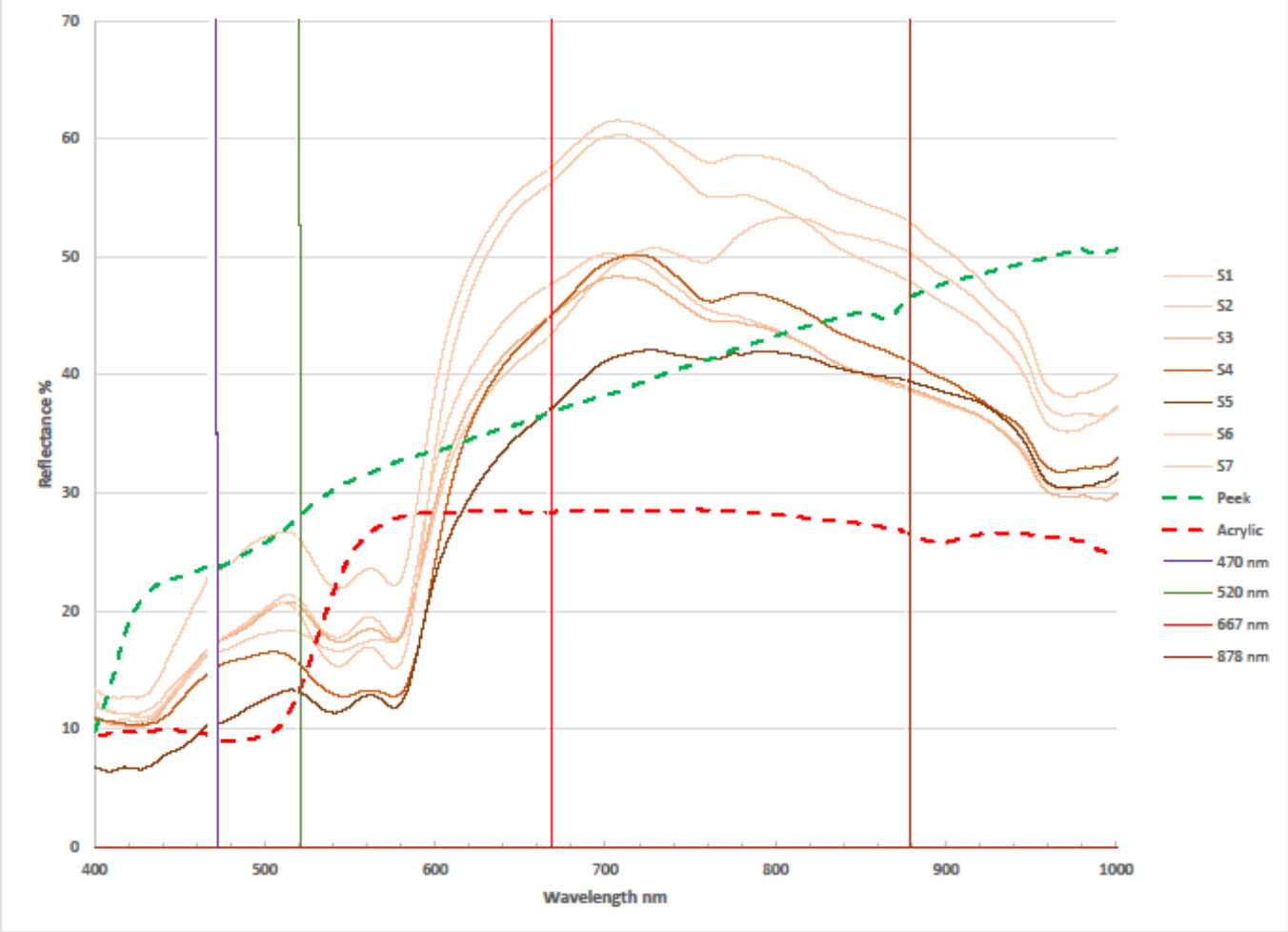
Horizontal Ronchi (Matte)

Gen 8 Horizontal Ronchi Target Measurements



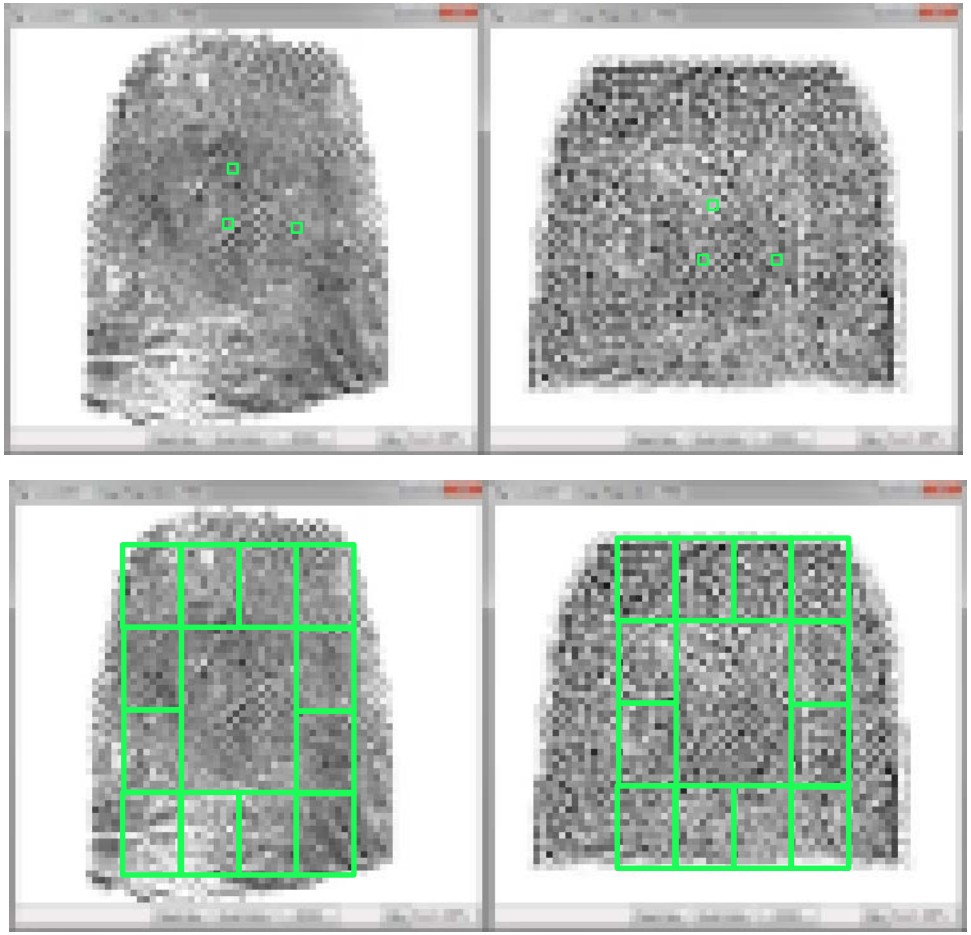
- 3D profile measurements of HorizontalRonchi Target using zoom Microscope & Latest Software
- Average Depth = 105 µm, Average Width = 458 µm

Spectral Reflectance of Skin and Artifacts



Spectral data and absorption specs provided to supplier in order to produce custom bio-optical phantom material

Automated Comparison Tool



Analysis Workflow:

1. Load two images to be compared (contact/contactless or otherwise)
2. Register using 3 points
3. Registered images are then binarized
4. Both binarized and unprocessed are divided into ROI grid based on FAP sizes (10/20/30/40)
5. Metrics are computed for each grid box and entire FAP ROI

Contactless to Contact Image Comparison Metrics

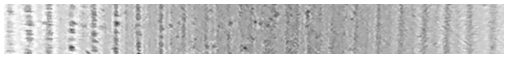
Already Implemented:

- SIVVDIff (Difference of SIVV signals)
- IMSD (Image Mean Squared Difference)
- SSIM (Structural Similarity Index)
- Pixels Changed (number, magnitude, average of changes)
- Dynamic Range

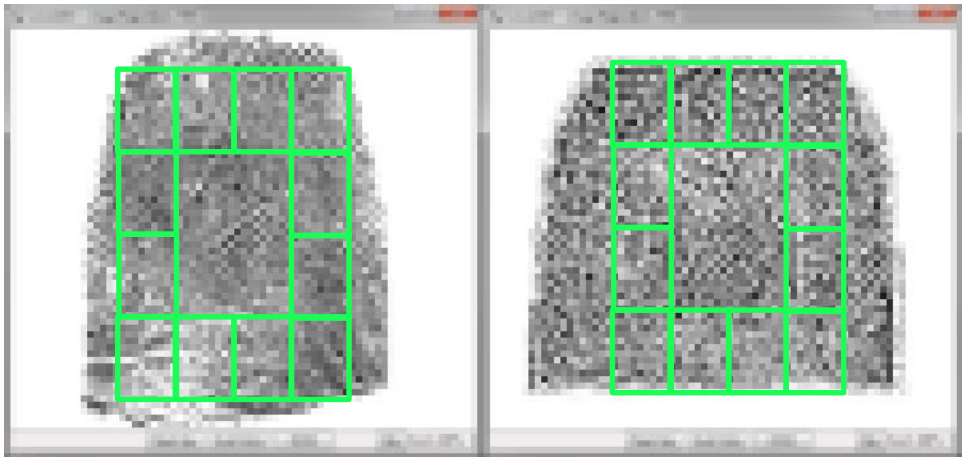
In progress:

- Measurement of Ronchi pattern consistency (width/height of bars)
- Minutiae correlation measurements using feature extractors

Vertical Ronchi (Guardian)



Vertical Ronchi (Contactless)

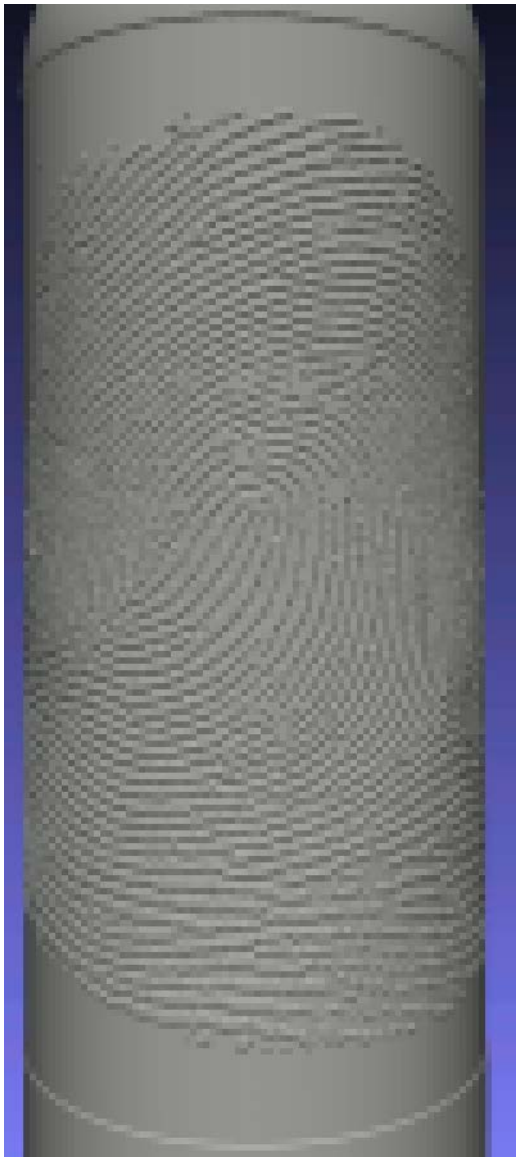


General Observations

Not singling out any specific device under CRADA …

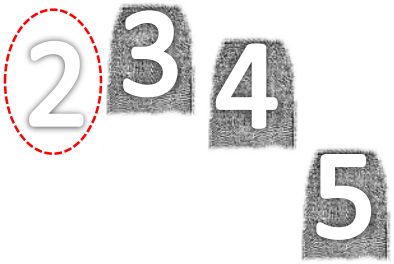
1. Ridge Polarity
2. Acquisition and Sequence
3. Image Details
4. Sample Rate Control

Lighting and Ridge Polarity Issue

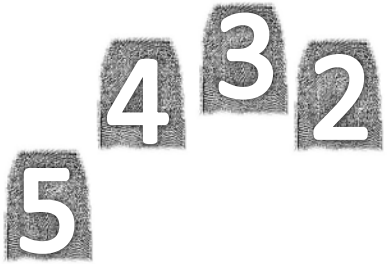


Acquisition and Sequence Errors

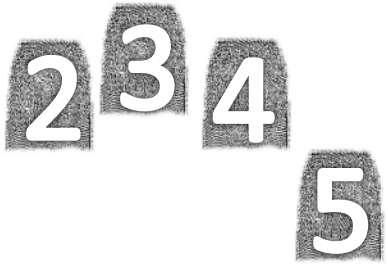
Duplicate Ring/Pinky Finger



Missing Index Finger



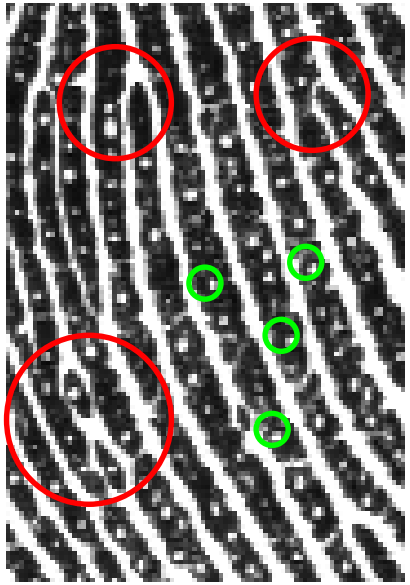
Mirrored/Reversed order

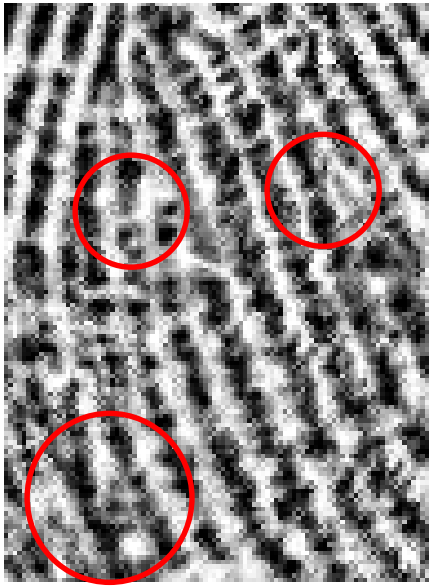


Correct order

- Failure to acquire any fingers (no fingers present)
- Failure to acquire all fingers (fewer than four present)
- Duplicate fingers (one appearing more than once)
- “Ghost” noise/background artifact in place of finger
- Incorrect order (sequence) of fingers
- Mirroring (transposing hands)
- More than one error can occur in each image

Detail in Imagery





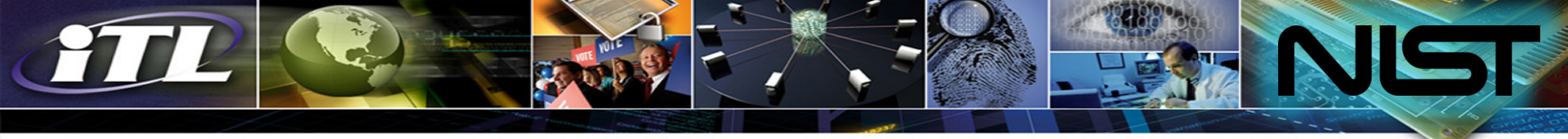
- Pores clearly visible in livescan captures @ 500 PPI, not visible in example of touchless capture (GREEN)
- Some ambiguity in ridge flow/minutiae such as bifurcations and ridge endings (RED)

Sample Rate Control with Mobile Applications

- Contactless Mobile App #1 allows for single finger captures between ~200 and 500 PPI
- Contactless Mobile App #2 allows for four-finger captures between ~300 and 600 PPI
- These mobile applications do not use fixed focal length and allow fingers to be within large range of depth from sensor
- In some cases, images appear to be downsampled from native sample capture rate to lower rate (targeting 500 PPI)

NIST's Goal

- Help industry bring contactless fingerprint devices to market quickly and responsibly
  - Thank you, CRADA partners!
- Capabilities of the device properly matched and validated to the requirements of the intended application
- There is a lot of work ahead
  - E.g., Forensic impact and comparison



NIST
Contactless Fingerprint Metrology Project

John Libert

john.libert@nist.gov

http://www.nist.gov/itl/iad/ig/crada_contactless.cfm

NIST
National Institute of Standards and Technology
U.S. Department of Commerce