IDloop®

IT'S A MATCH!

3D Fingerprint Recognition

Dr. Tom Michalsky

IFPC2025

2025, April 2nd

3D Fingerprint Recognition

- Why 3D?
- Inter- and Intraoperability

  vs. contact-based and Smartphone solutions
- Performance Metrics (NFIQ2.2, MCLFIQ, NFRaCT)
- Current Use Cases

Contact-Based Issues

- Dirty and Scratched Surfaces, latent prints/ghost images
- Slow Acquisition (dry skin)
- Unhygienic

and

VULNERABLE TO SPOOFING

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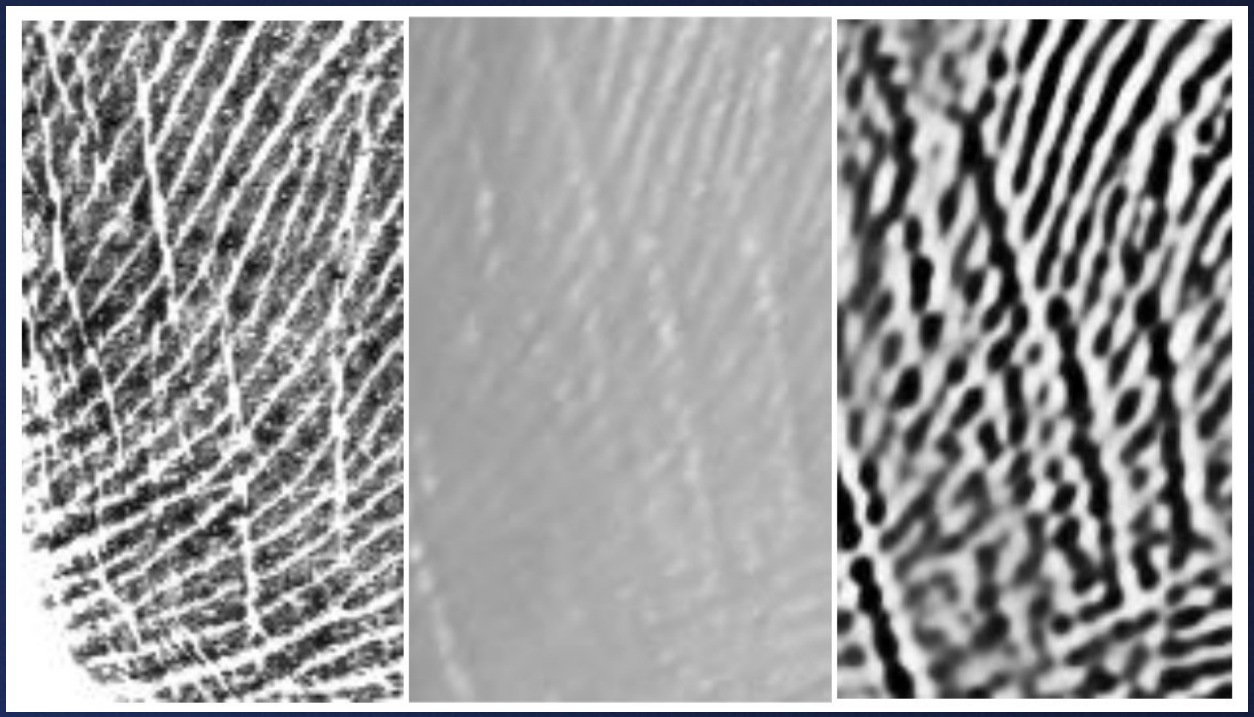
Contactless: Smartphone Captures

Contact-based | Contactless: Image | Image-Enhanced



https://www.dermalog.com/products/software/fingerprint-identification

J. Libert *et al.*: NIST Special Publication 500-305, Guidance for Evaluating Contactless Fingerprint Acquisition Devices

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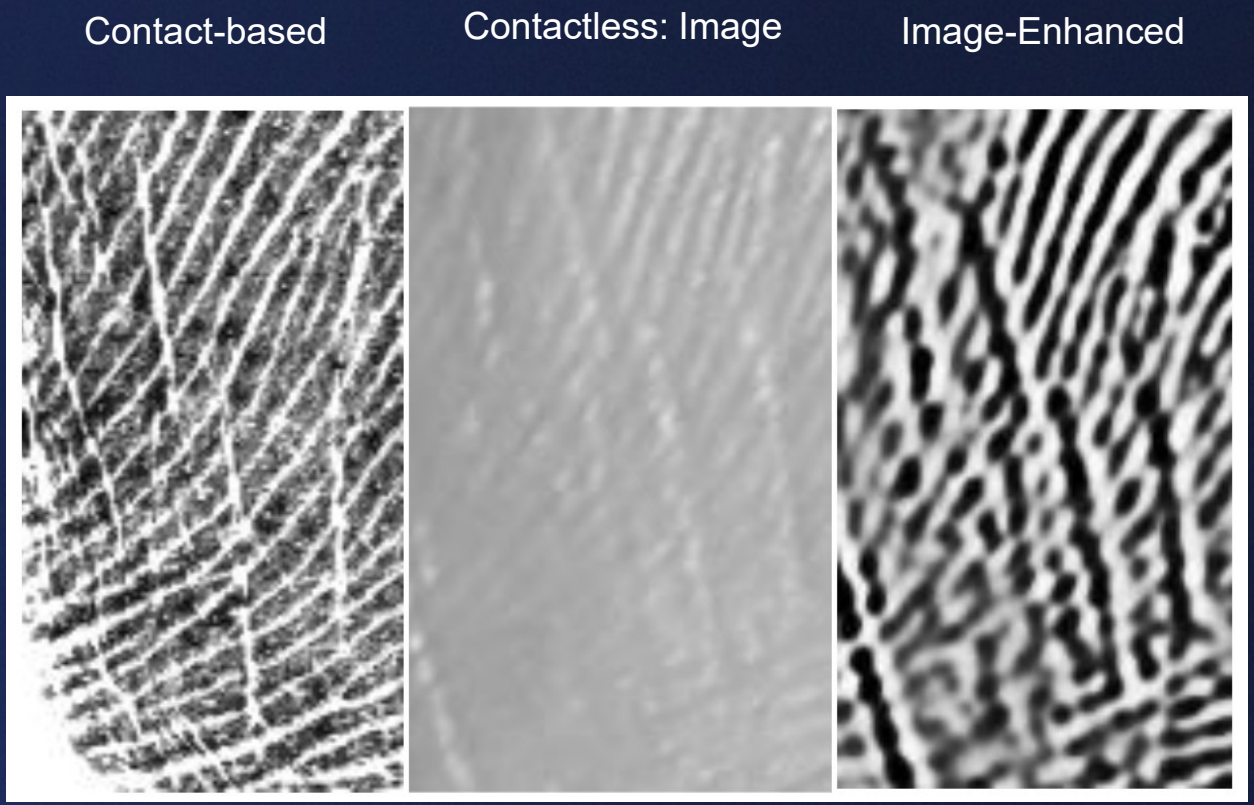
Contactless: Smartphone Captures

2D Imaging Problems

- Scale Ambiguity
- Ridges and Valleys not clearly distinguishable: False Minutiae possible
- Perspective Distortions
- Motion



https://www.dermalog.com/products/software/fingerprint-identification
J. Libert *et al.*: NIST Special Publication 500-305, Guidance for Evaluating Contactless Fingerprint Acquisition Devices

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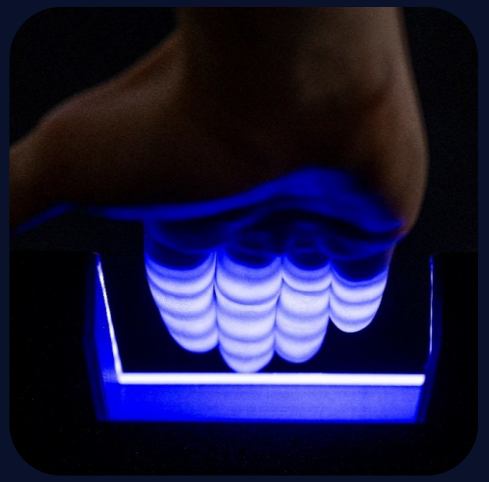
3D Output

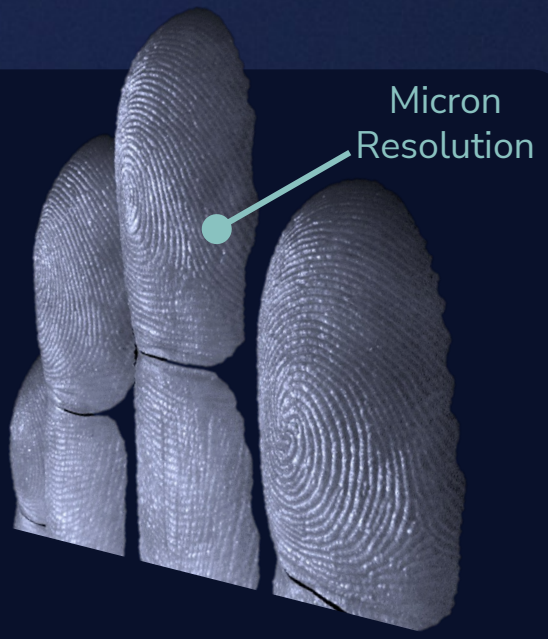
- 10 µm depth resolution
- No scale ambiguity
- No perspective distortions
- No cleaning or latent prints
- All skin colors and finger conditions (dry, wet)
- 3D fake detection

Patented technology



3D Scan With Structured Light

For highest quality contactless capturing



3D Data

For next
level biometric standards

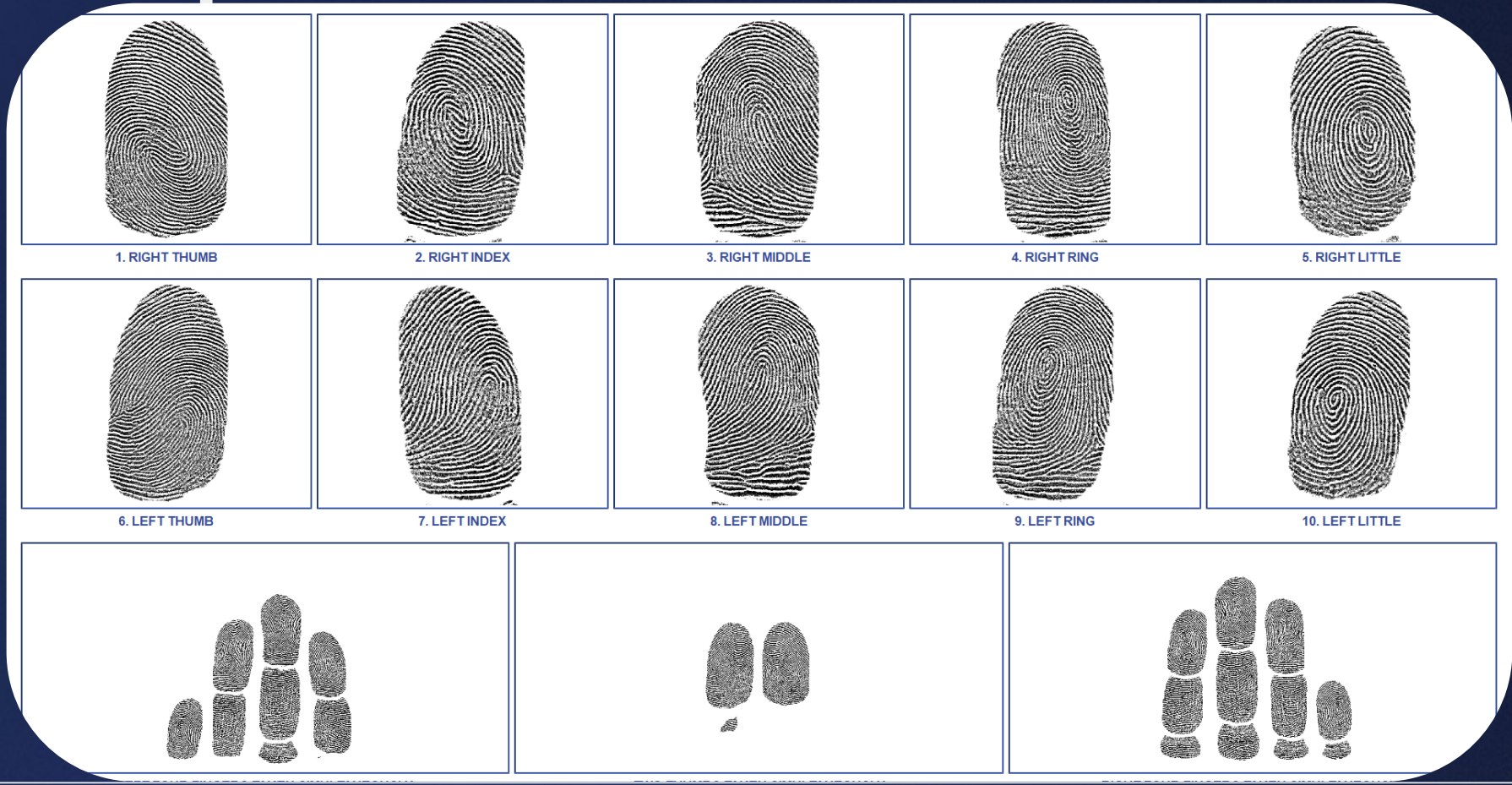
2D Output

For compatibility
with current biometric standards

IDloop CFS flats

- High-secure 4-Finger Scanner (FAP60)
- Government Standard (500 ppi)
- FBI PIV certified

2D output like contact-based scanners



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FINGERPRINT QUALITY

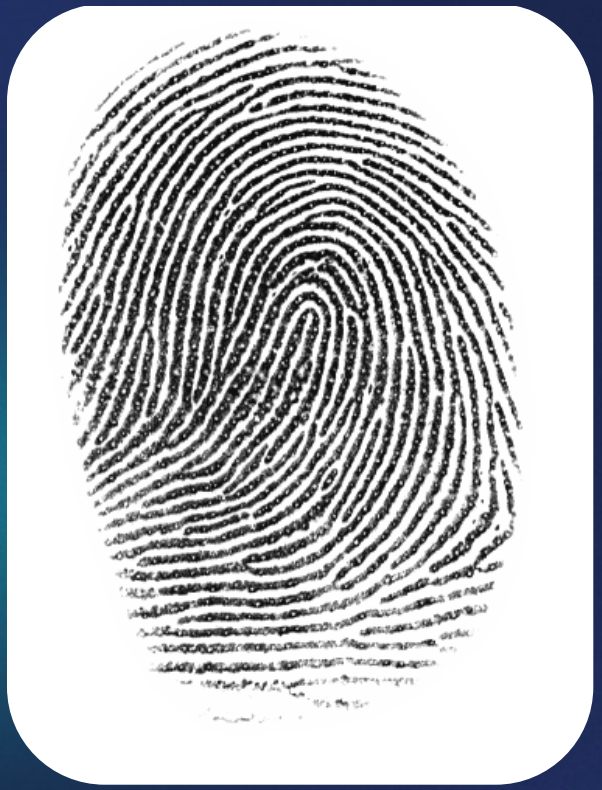
Interoperability

contact-based

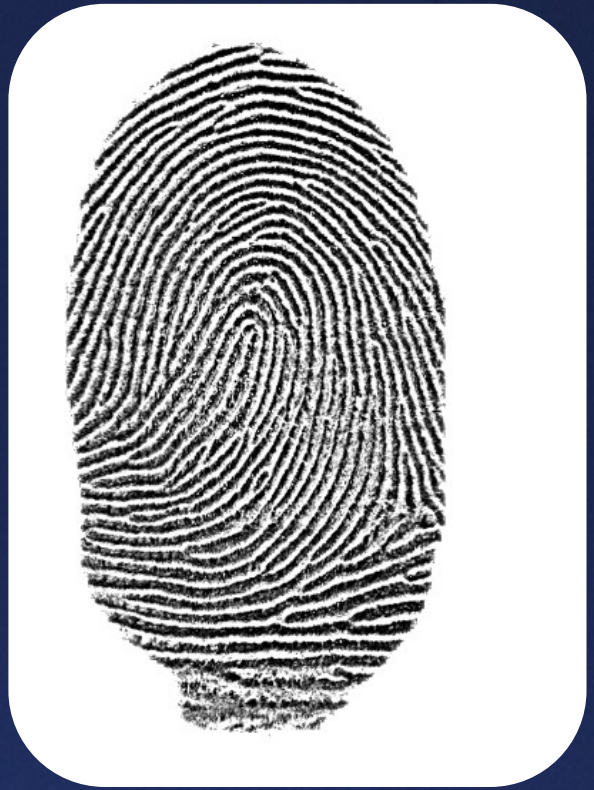
FINGERPRINT QUALITY

Interoperability

contact-based



CFS: contactless



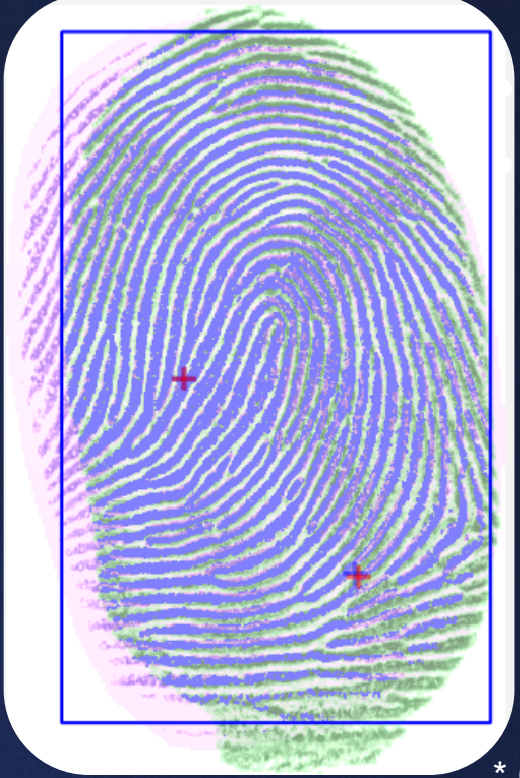
FINGERPRINT QUALITY

Interoperability

contact-based

3D: contactless

Comparison*



Matching Scale
Matching Structure

* Created with NFRaCT: www.nist.gov

FINGERPRINT QUALITY

Repeatability

2x contact-based

FINGERPRINT QUALITY

Repeatability

2x contact-based

FINGERPRINT QUALITY

Repeatability

2x contact-based

CFS flats: 2x contactless

Contact-based: high variability due to variable pressure, torsion, moisture

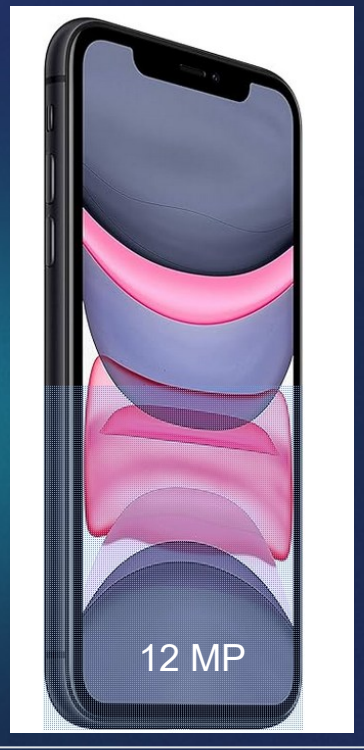
FINGERPRINT QUALITY

MATCHING

- 20 subjects

Same commercial, state-of-art Fingerprint App

Contactless iPhone



Contactless Android

Same commercial, state-of-art Fingerprint App
(NIST mFIT Challenge winner)

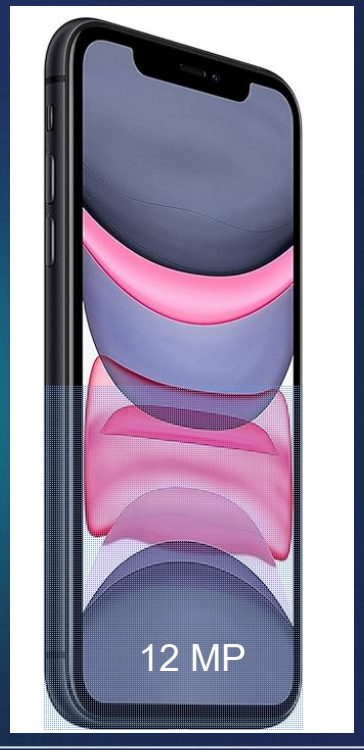
FINGERPRINT QUALITY

MATCHING

- 20 subjects, 4 Devices

Same commercial, state-of-art Fingerprint App

Contactless iPhone



Contactless Android

Contactless 3D (IDloop CFS flats)

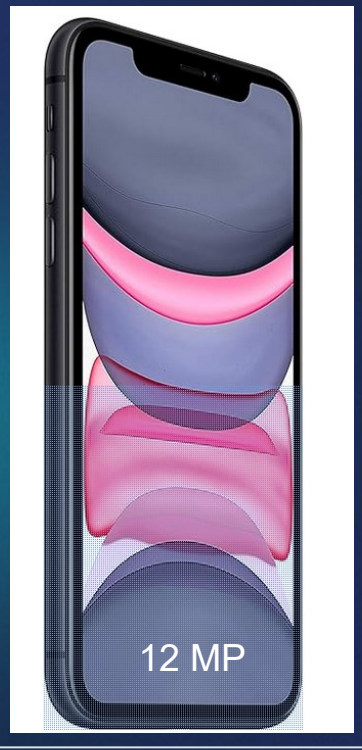
FINGERPRINT QUALITY

MATCHING

- 20 subjects, 4 Devices

Same commercial, state-of-art Fingerprint App

Contactless iPhone



Contactless Android

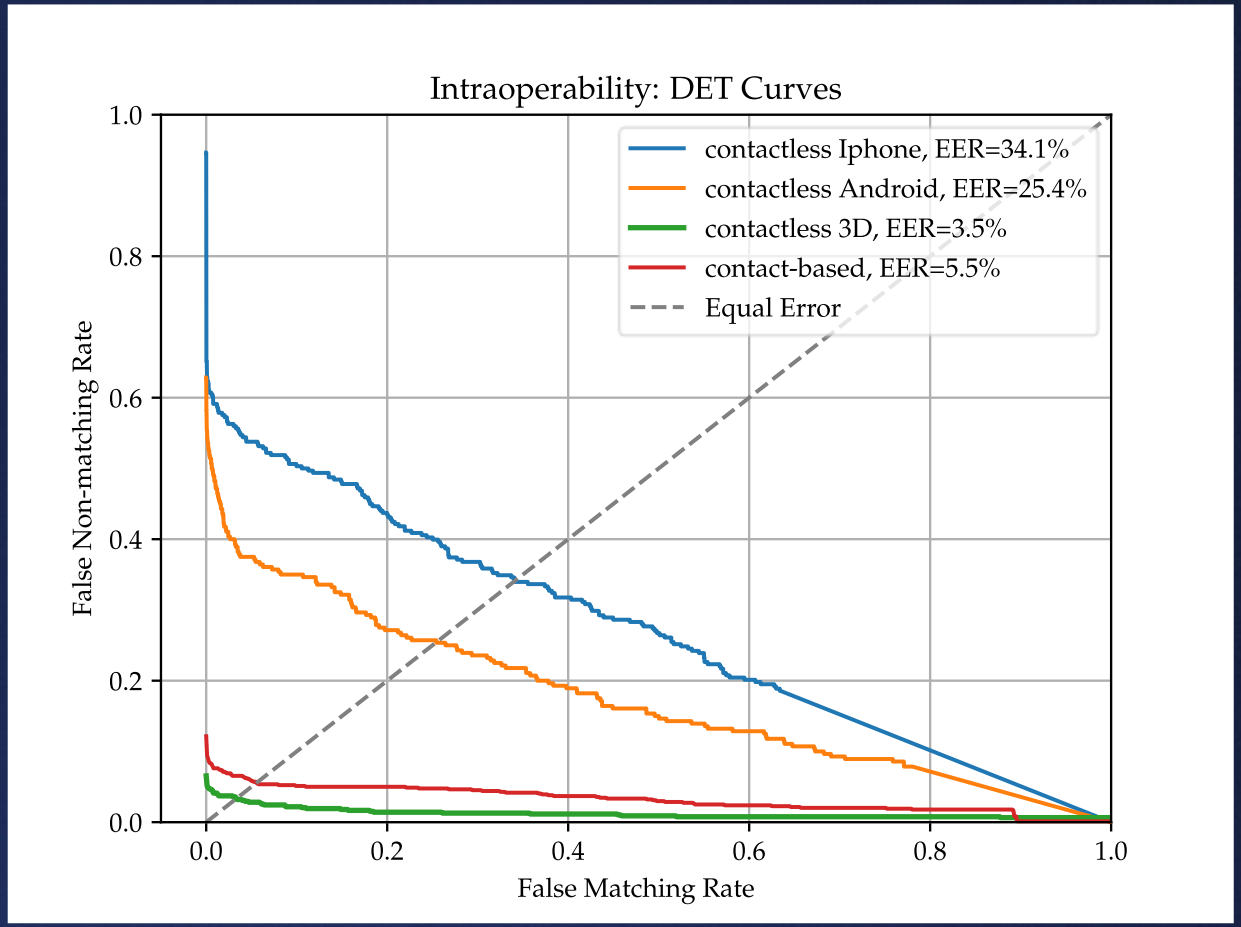
Contactless 3D (IDloop CFS flats)

Contact-based (Crossmatch Guardian)

FINGERPRINT QUALITY

MATCHING: Intraoperability

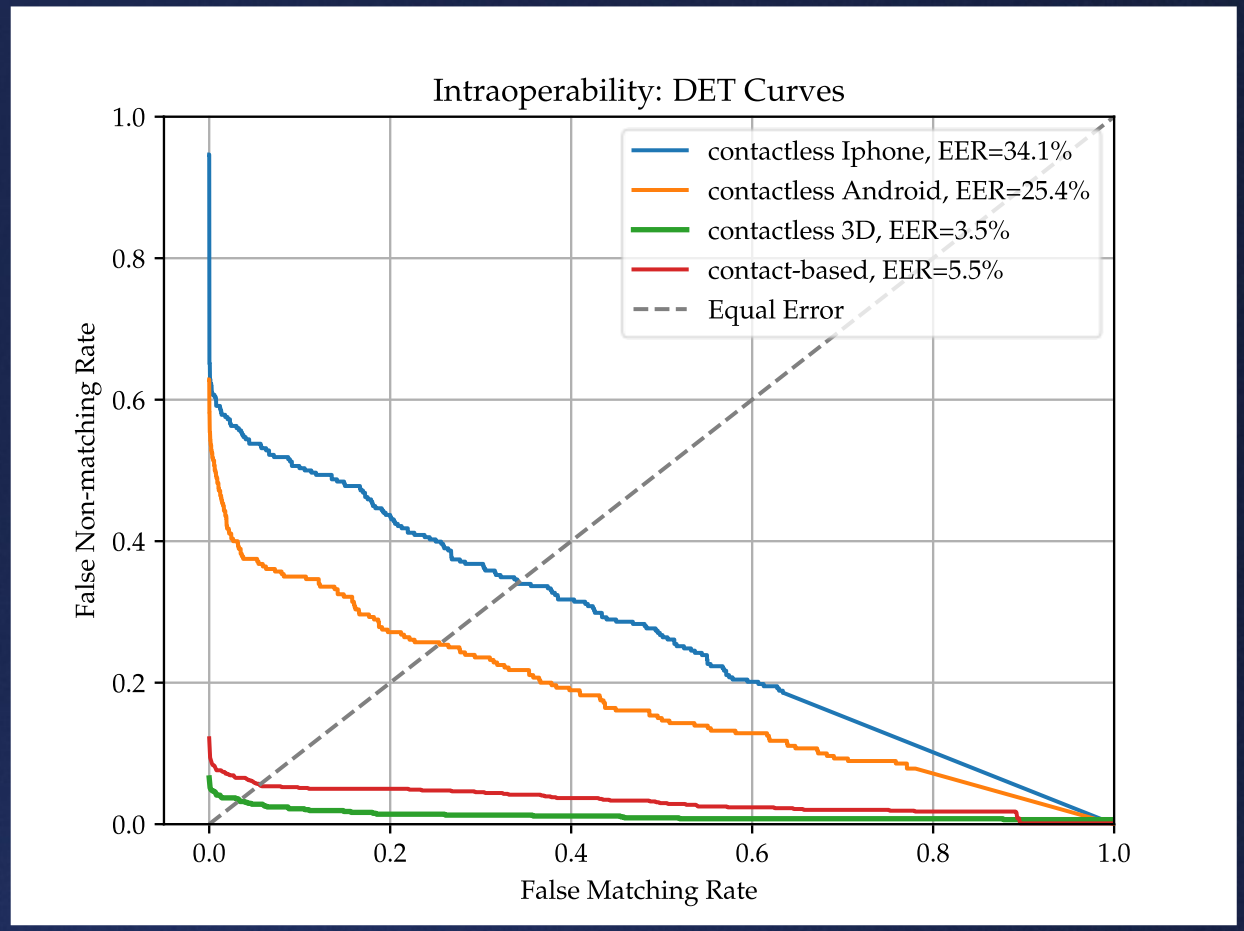
*Matcher: SourceAFIS



FINGERPRINT QUALITY

MATCHING: Intraoperability

*Matcher: SourceAFIS



2x contact-based

3D: 2x contactless

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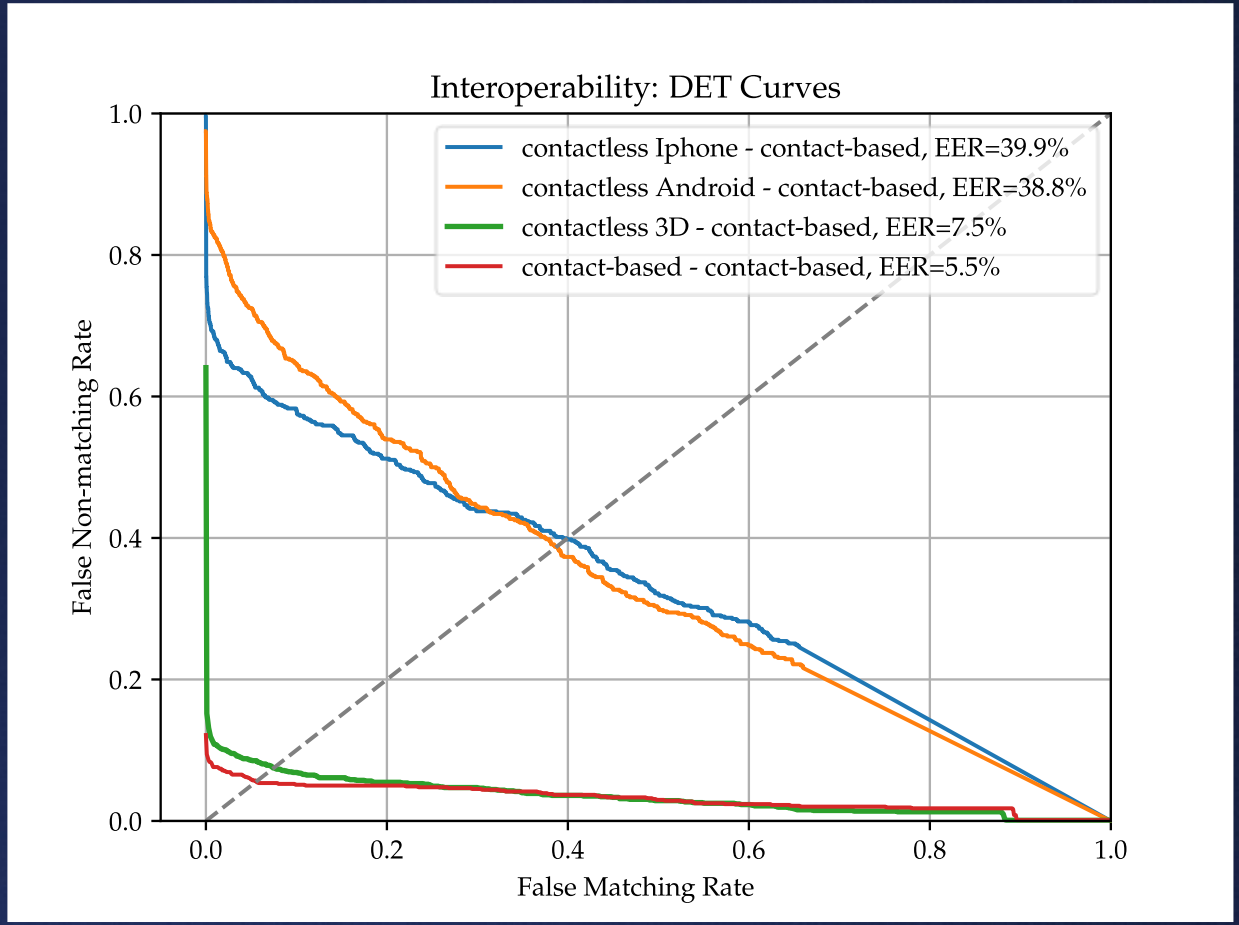
FINGERPRINT QUALITY

MATCHING: Interoperability to contact-based

*Matcher: SourceAFIS

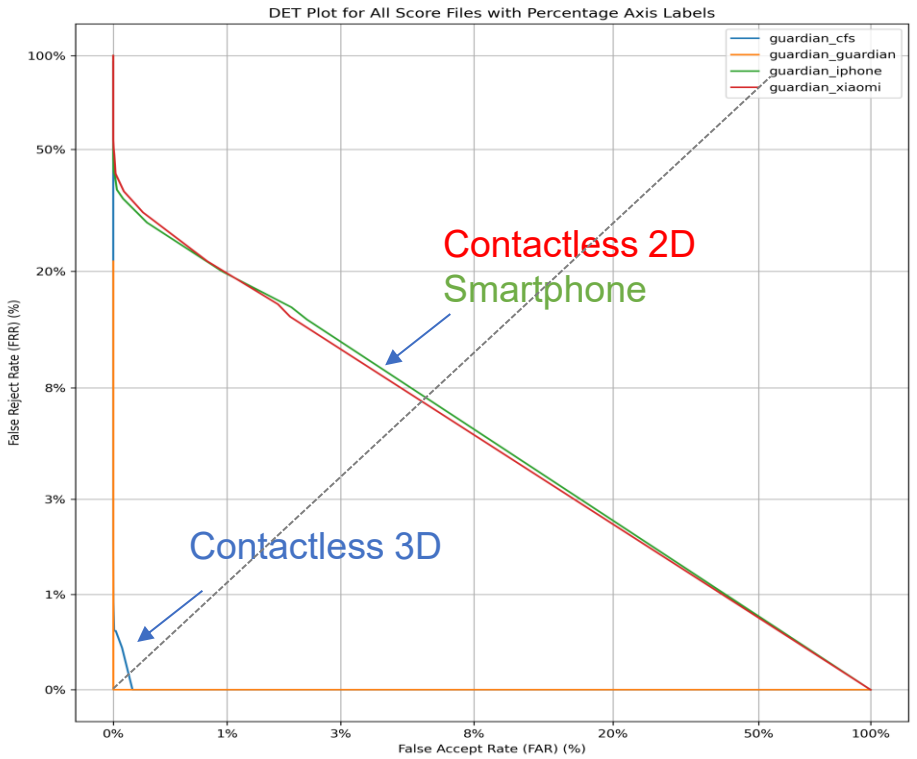


FINGERPRINT QUALITY

MATCHING: Interoperability to contact-based

*Matcher: Innovatrix

Interoperability



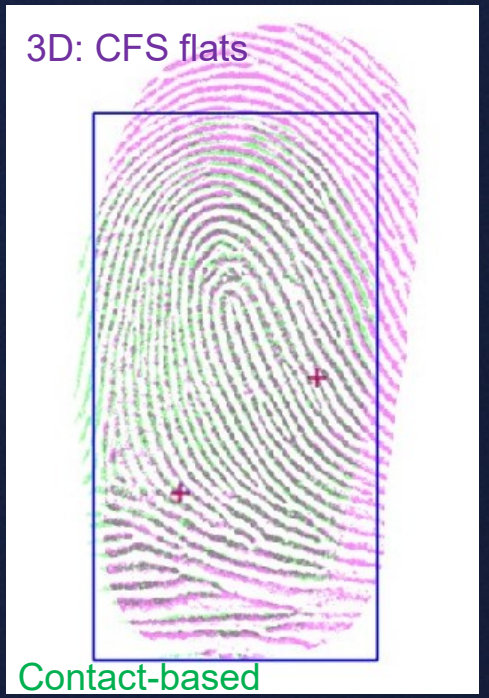
Conclusion Interoperability

Contactless 3D comparable to contact-based prints

Contatcless Smartphone Solutions significantly worse

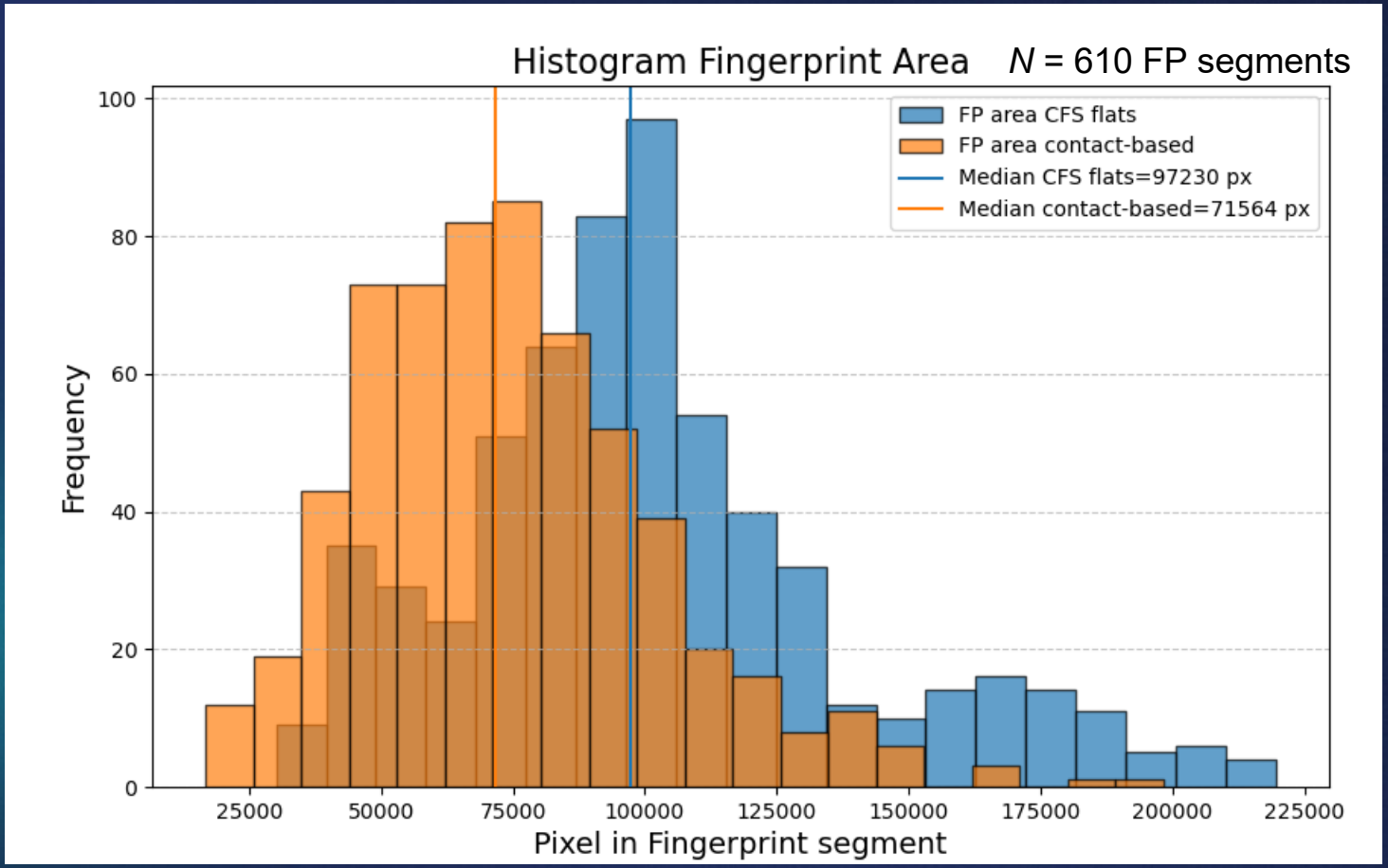
FINGERPRINT QUALITY

AREA & #MINUTIAE



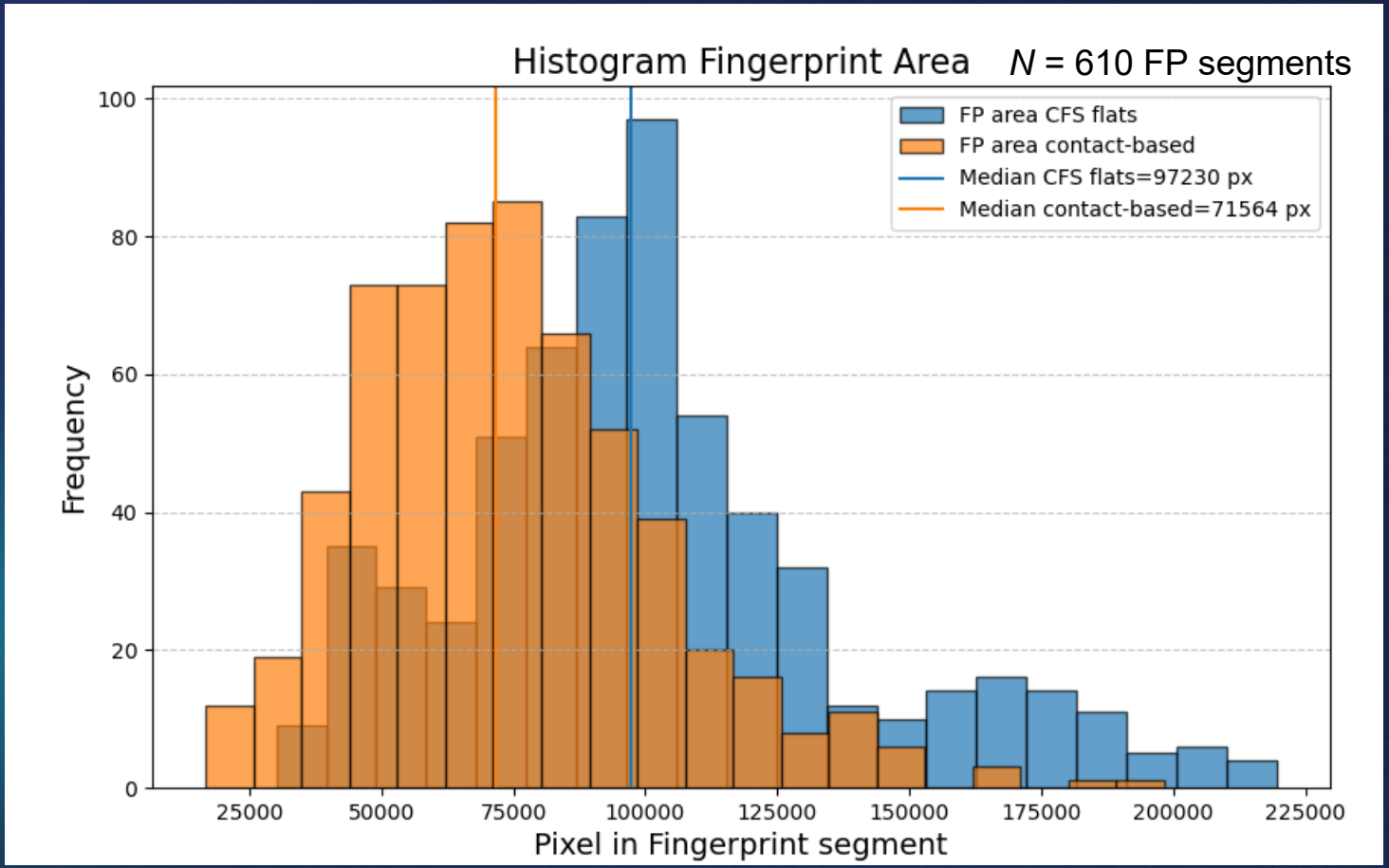
FINGERPRINT QUALITY

AREA & #MINUTIAE



FINGERPRINT QUALITY

AREA & #MINUTIAE



- CFS flats: +36% FP AREA (median)
- Found minutiae (NFRaCT)

  contact-based: ~49

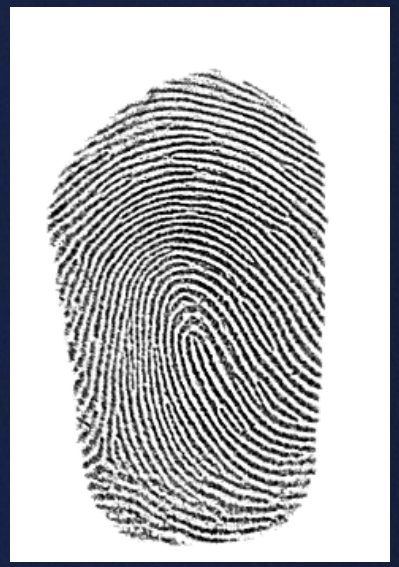
  CFS flats: ~67

FINGERPRINT QUALITY

CONTRAST

- Contact-based:
  - optical contact skin-glass critical
  - dry areas low contrast
- Contactless 3D with CFS flats:
  - dry/wet finger plays no role
  - contrast given by depth ridges and valleys
  - more homogenous FP contrast

3D contactless: CFS flats



Contact-based

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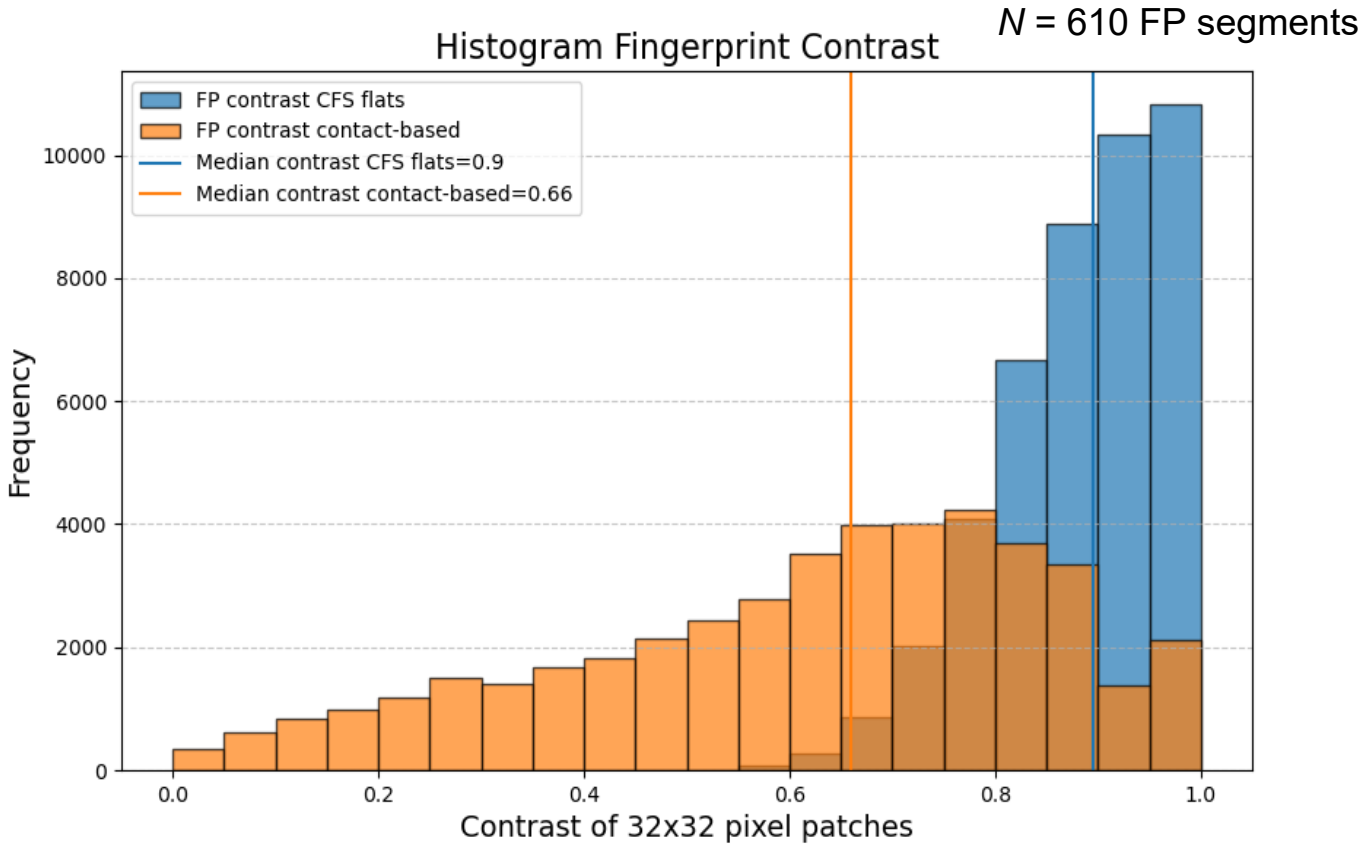
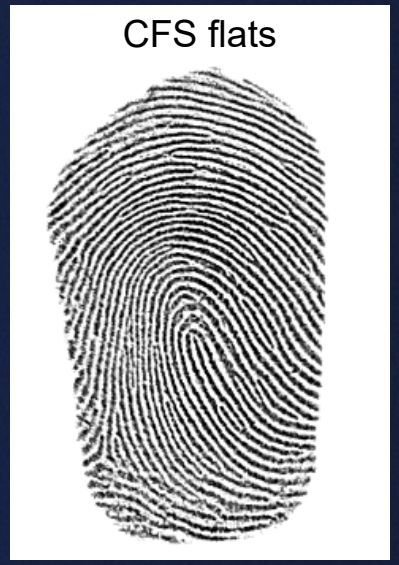
FINGERPRINT QUALITY

CONTRAST

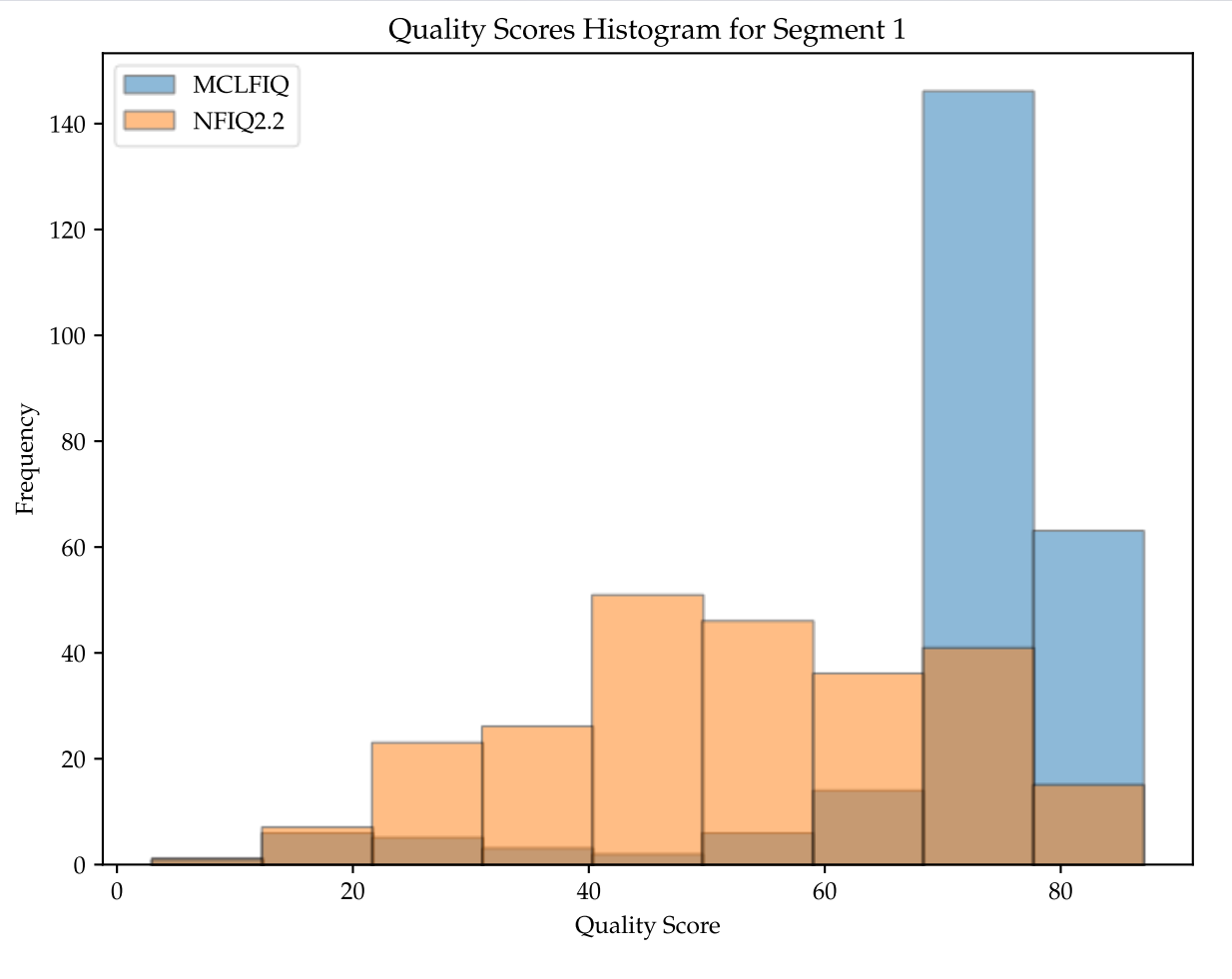




- CFS flats: +36% FP contrast
- contact

FINGERPRINT QUALITY

Quality Scoring: MCLFIQ vs NFIQ2.2

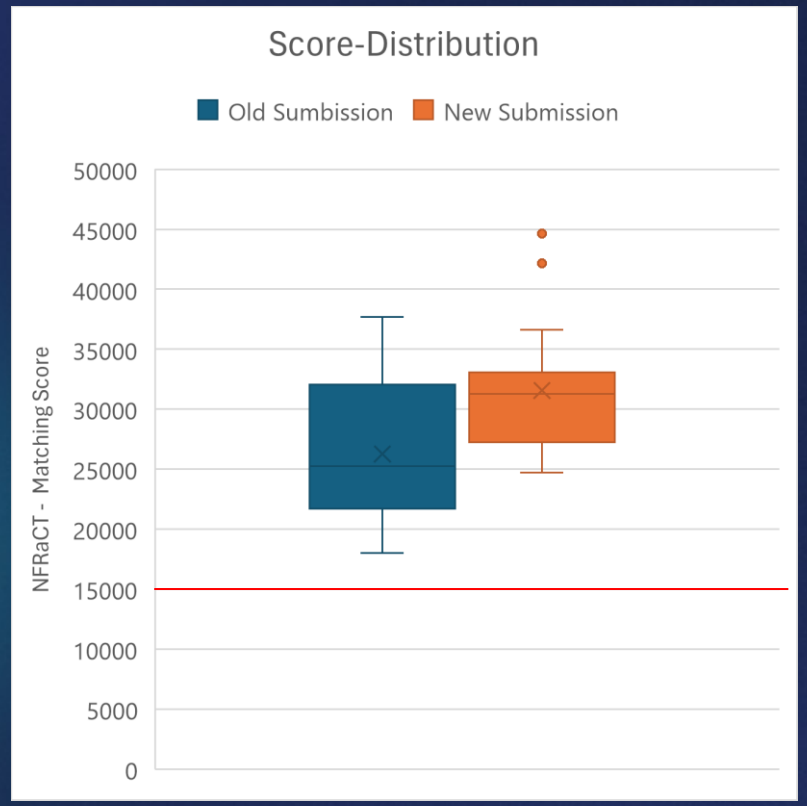


Median_NFIQ2.2 = 52
Median_MCLFIQ = 76

Higher Scores with MCLIFQ than NFIQ2.2

MCLFIQ gives Double peak structure

QUALITY: CRADA SUBMISSION



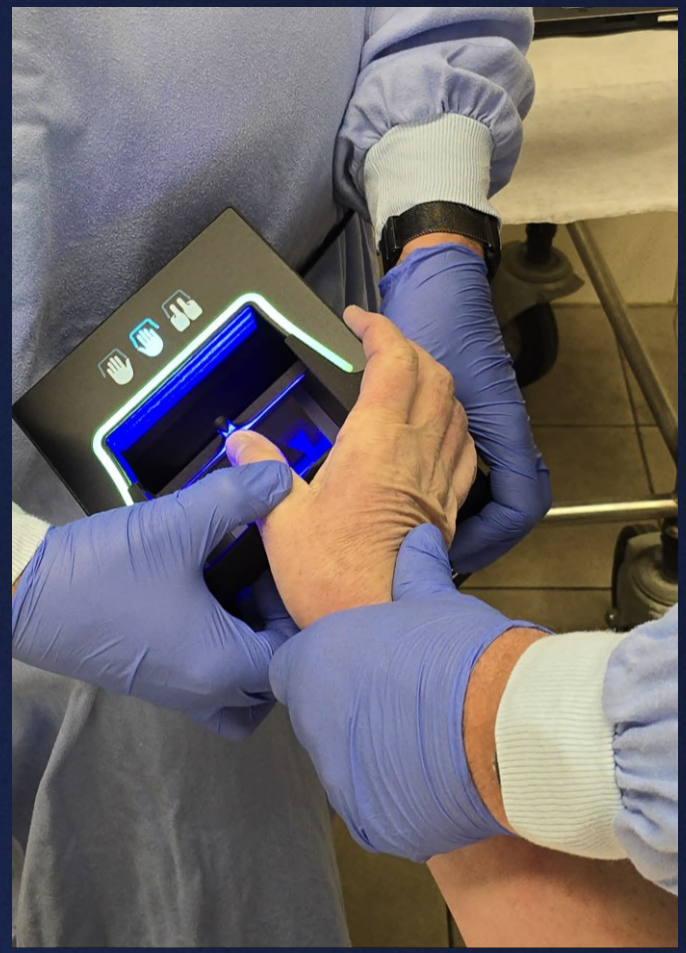
- Matching of contactless prints with contact-based prints via NIST's NFRaCT tool
- NIST SP 500-339
- Unbound matching scores
- NIST accepts matches, if matching score >15k
- Newest submission: median score = 31k

USE CASES: BORDER CONTROL

- Faster capturing
- External tests with *N*=130 untrained subjects
- CFS flats 40% faster to capture FP

USE CASES: CORPSES

- Avoids excessive pressure, no further degradation of the skin
- Works with skin in advanced decomposition, water exposure or burns
- If needed, multiple images can be taken without affecting the fingerprint's integrity
- Summary: safer, more accurate, and less invasive



USE CASES

Nail-to-Nail rolled: contact-issues

Source: http://www.officialinvestigations.com/index.php/rolled-fingerprinting

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Nail-to-Nail rolled: contact-issues

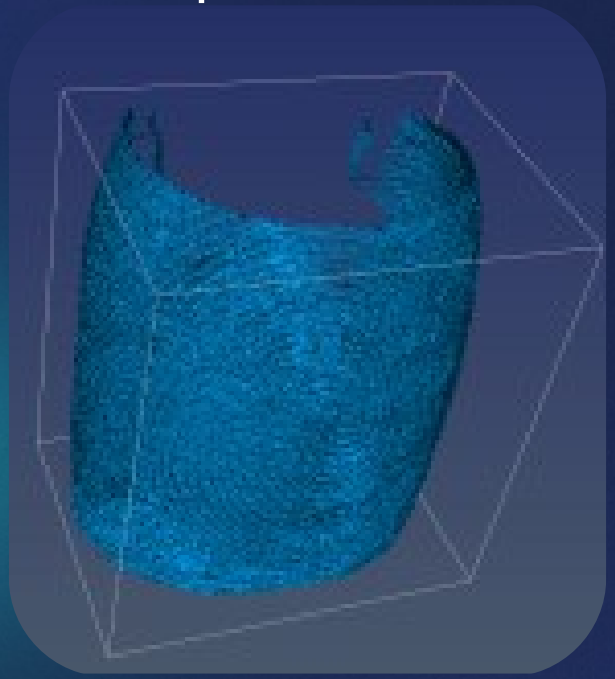
Contact-based rolled

Smeared areas

- Slow acquisition
- Many iterations
- Smeared areas
- Inconvenient

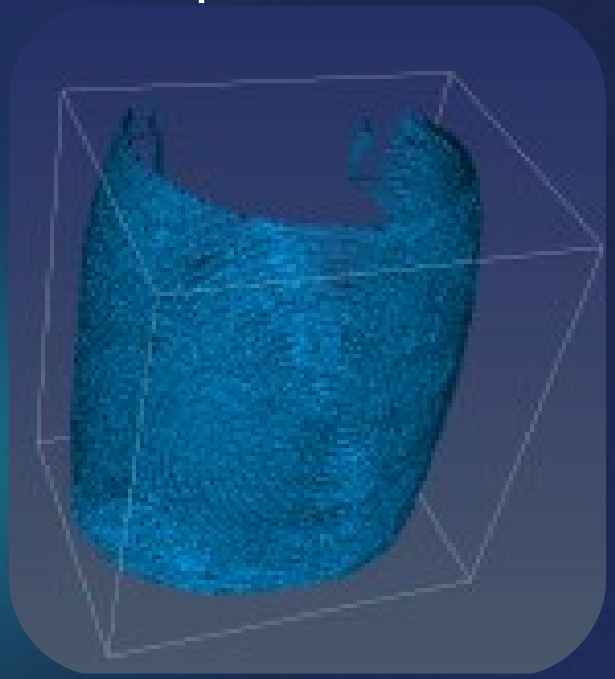
Nail-to-Nail rolled

3D point cloud



Nail-to-Nail rolled

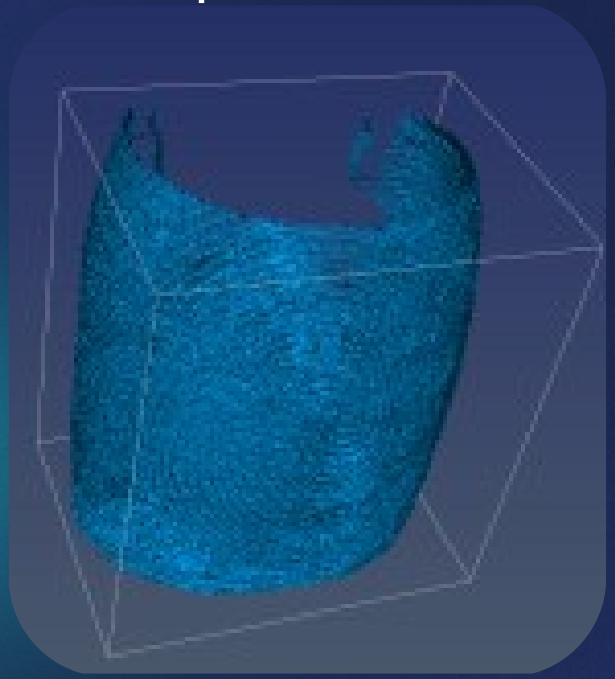
3D point cloud



Contactless rolled

Nail-to-Nail rolled

3D point cloud

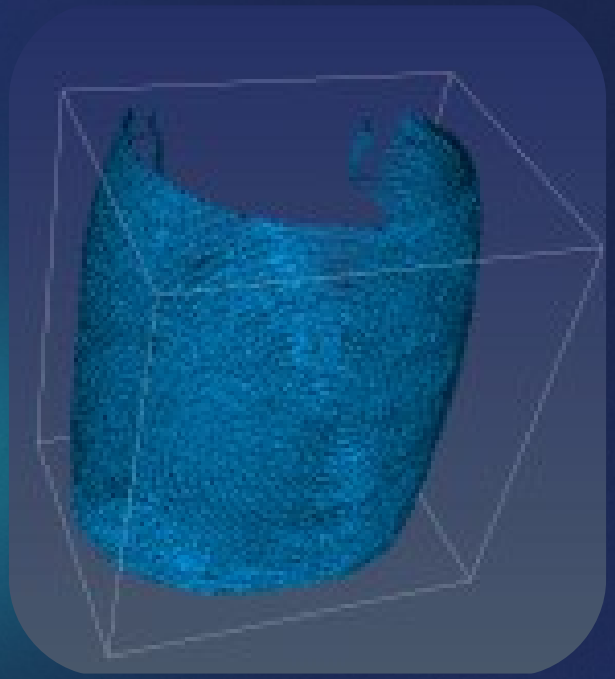


Contactless rolled

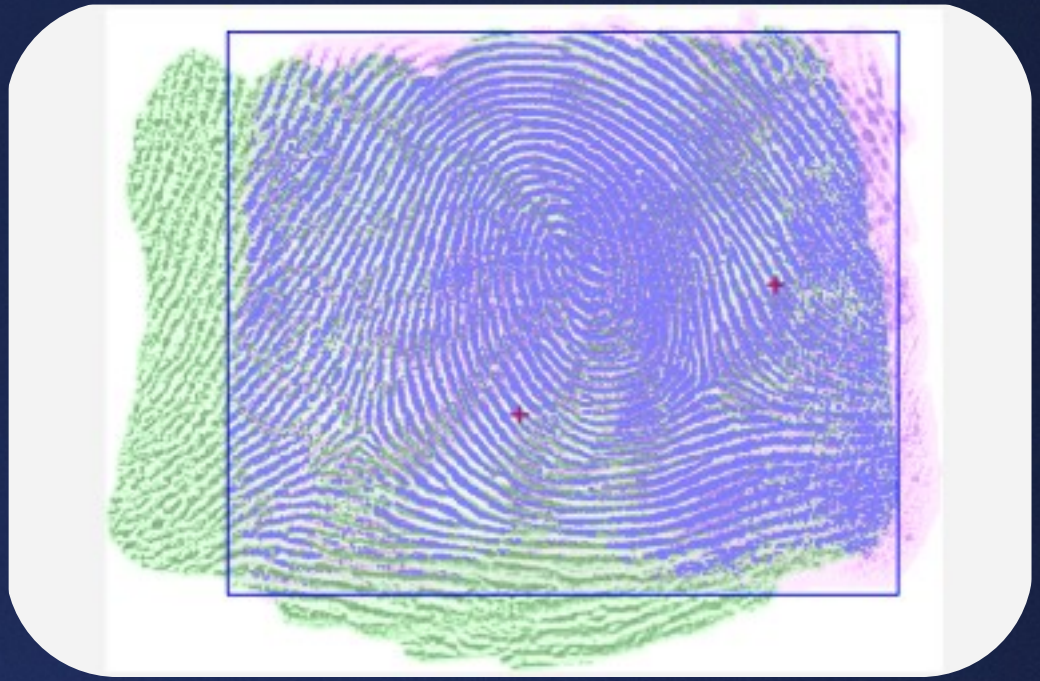
Contact-based rolled

Nail-to-Nail rolled

3D point cloud



Comparison*



contactless contact-based

- Faster acquisition
- No smearing
- More skin area
- More convenient

* Created with NFRaCT: www.nist.gov

Nail-to-Nail rolled

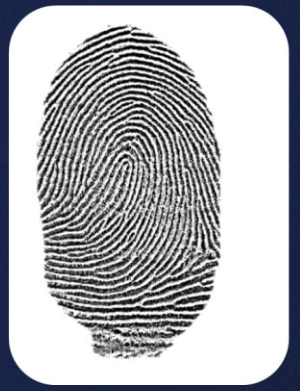
LAST SLIDE!

Summary

- Contactless 3D Fingerprints
- Fingerprint Quality
- Matching + Metrics
- Further Developments

contact-based

3D: contactless



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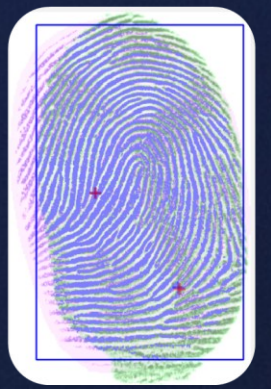
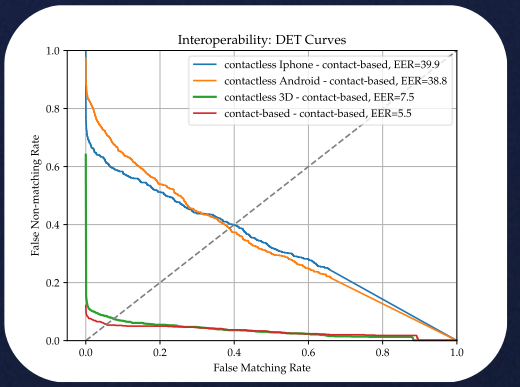
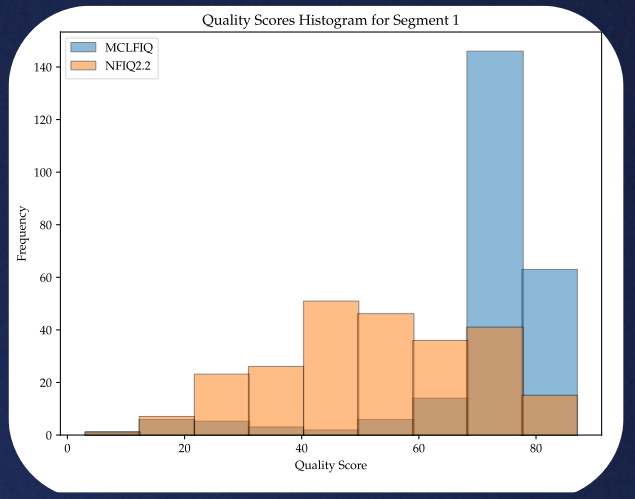


Statistics: DET



Quality Metrics



Rolled print

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THANK YOU!

t.michalsky@idloop.com
contact@idloop.com

ESF EUROPE FOR THURINGIA
EUROPEAN SOCIAL FUND

EUROPEAN UNION
European Social Fund

Supported by the Free State of Thuringia
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- 2022 -

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GERMAN ACCELERATOR
Financed by Federal Ministry for Economic Affairs and Climate Action
05/2023–06/2023

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QUALITY: Biometric Features

- 1st level features: global fingerprint patterns
- 2nd level features: minutiae
- 3rd level features: pores

TECHNOLOGY

Beyond 500ppi 2D Prints

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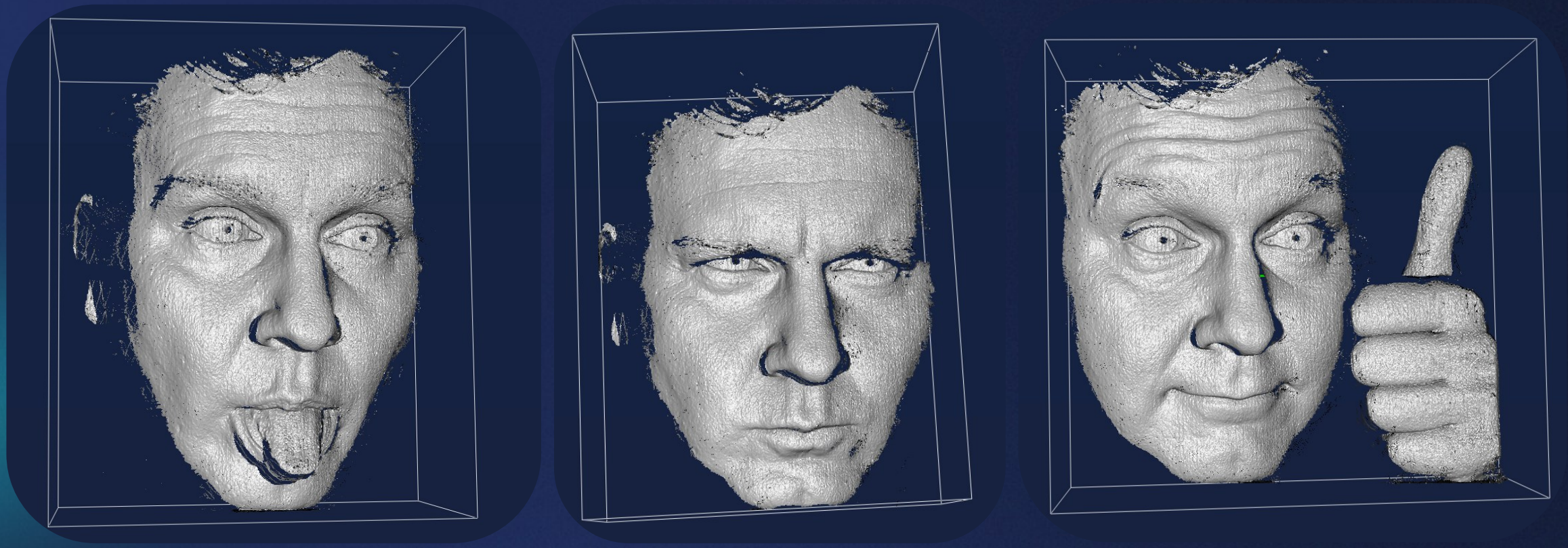
TECHNOLOGY

Beyond 2D Prints: 3D Face

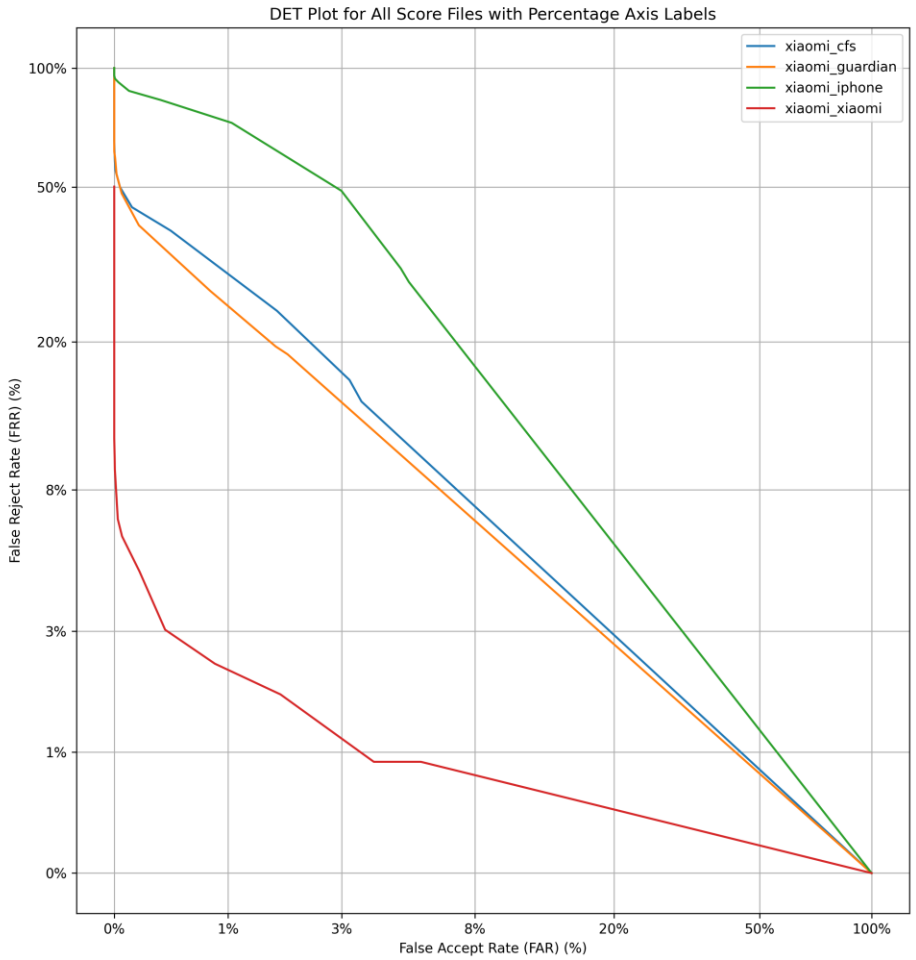


Utilizing 3D for high-quality 2D images

- Peaks and valleys clearly differentiable
- No scale ambiguity, perspective distortion
- No false minutiae

- 500ppi standard, FAP60
- 8bit gray scale images
- FBI compliant image quality

Interoperability: iPhone vs Android



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FINGERPRINT QUALITY

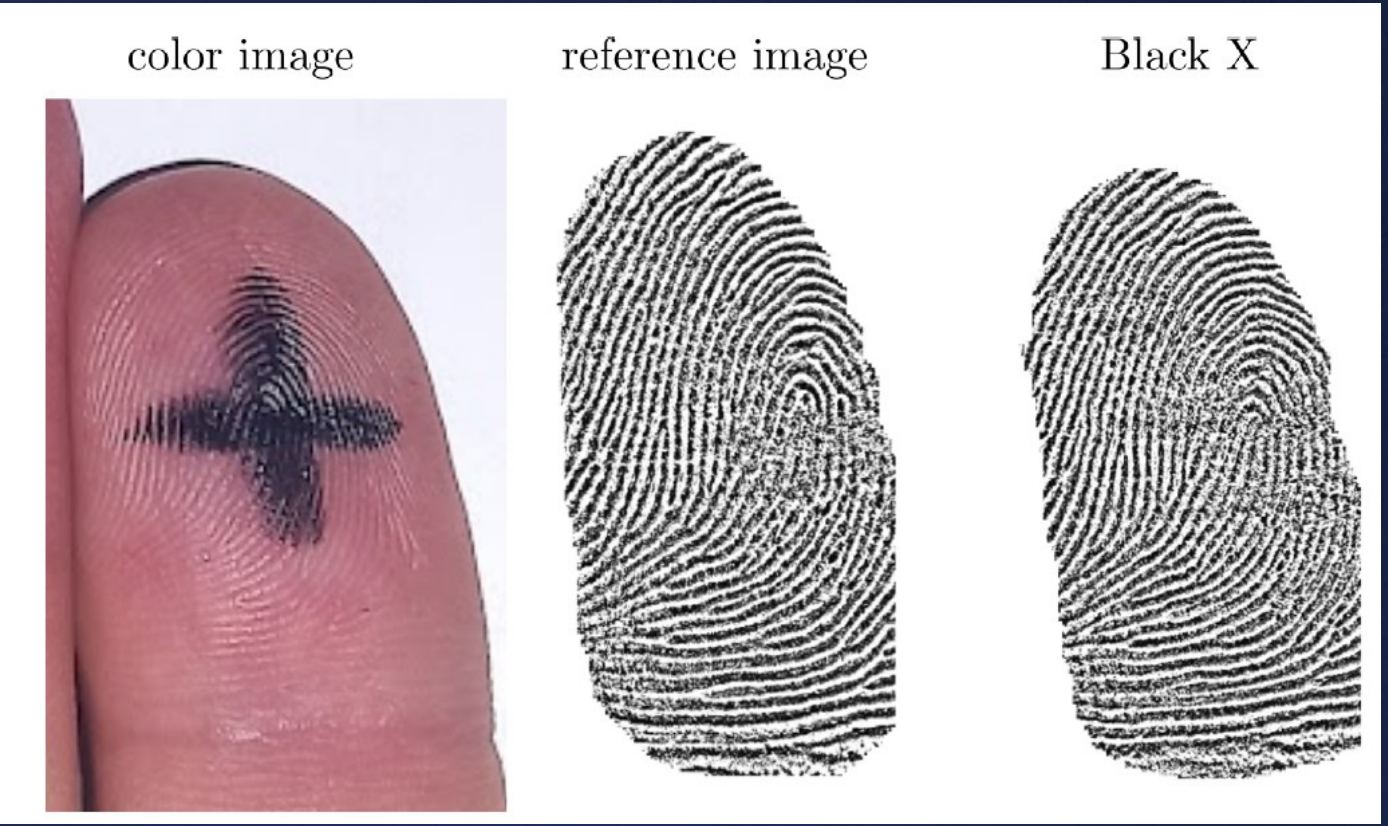
Quality Scoring: MCLFIQ vs NFIQ2.2

IEEE TRANSACTIONS ON BIOMETRICS, BEHAVIOR, AND IDENTITY SCIENCE, VOL. 6, NO. 2, APRIL 2024

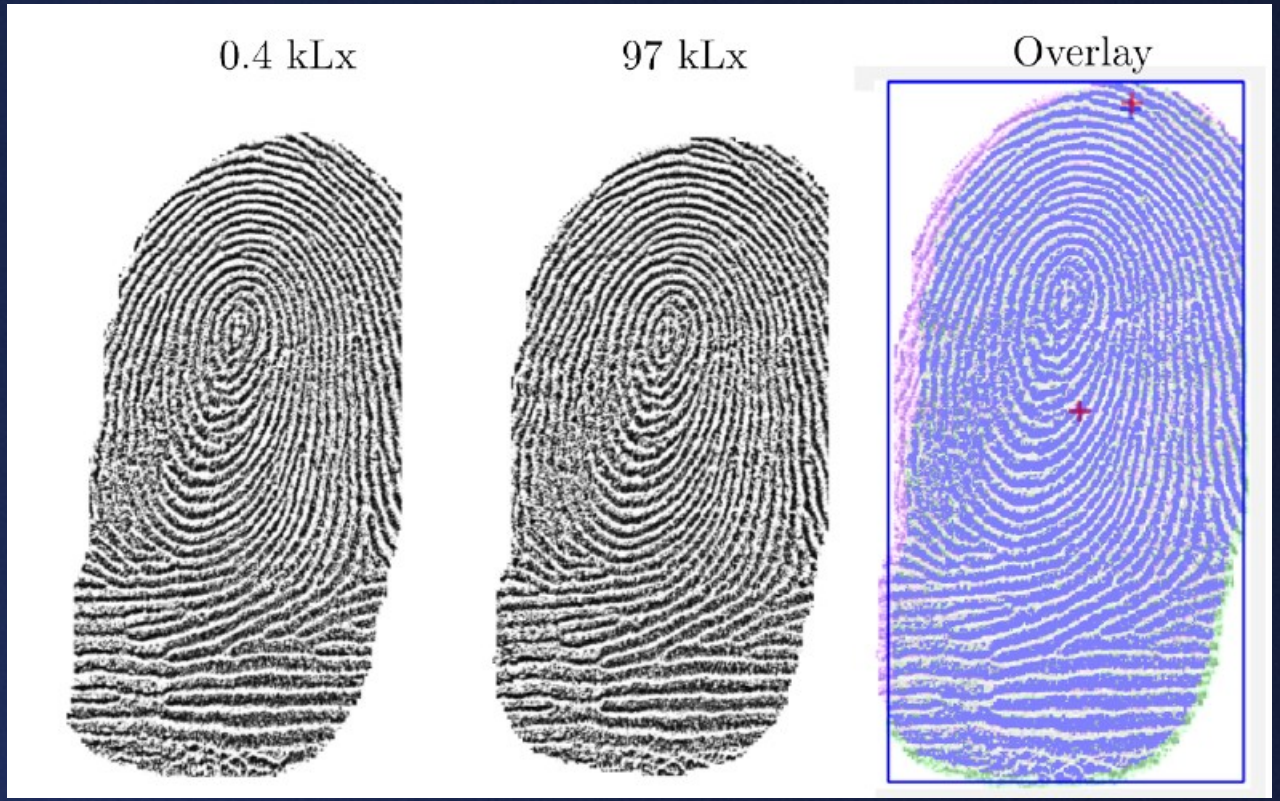
MCLFIQ: Mobile Contactless Fingerprint Image Quality

Jannis Priesnitz, Axel Weißenfeld, Laurenz Ruzicka, Christian Rathgeb, Bernhard Strobl, Ralph Lessmann, and Christoph Busch, *Senior Member, IEEE*

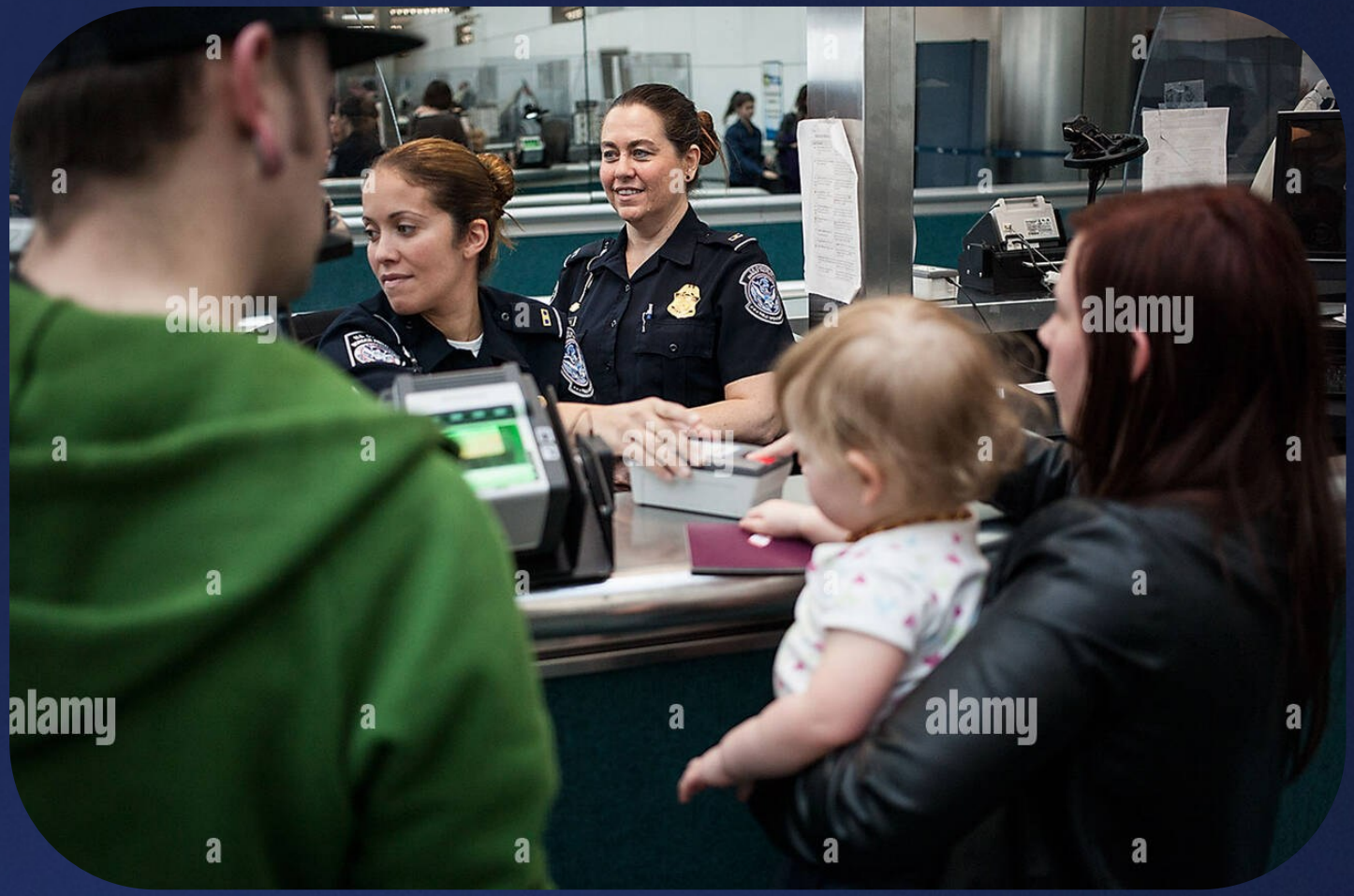
Quality: Skin conditions



Quality: Ambient Light



USE CASES: INFANTS



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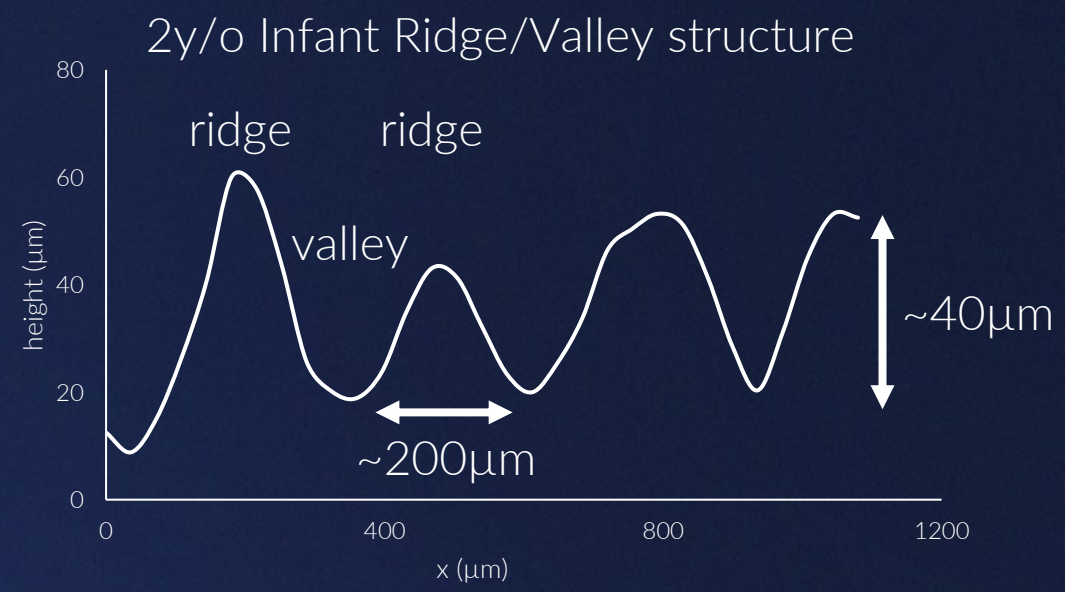
USE CASES: INFANTS

- Infants: fainter ridge structure
- Hard to capture with contact-based scanners

USE CASES: INFANTS



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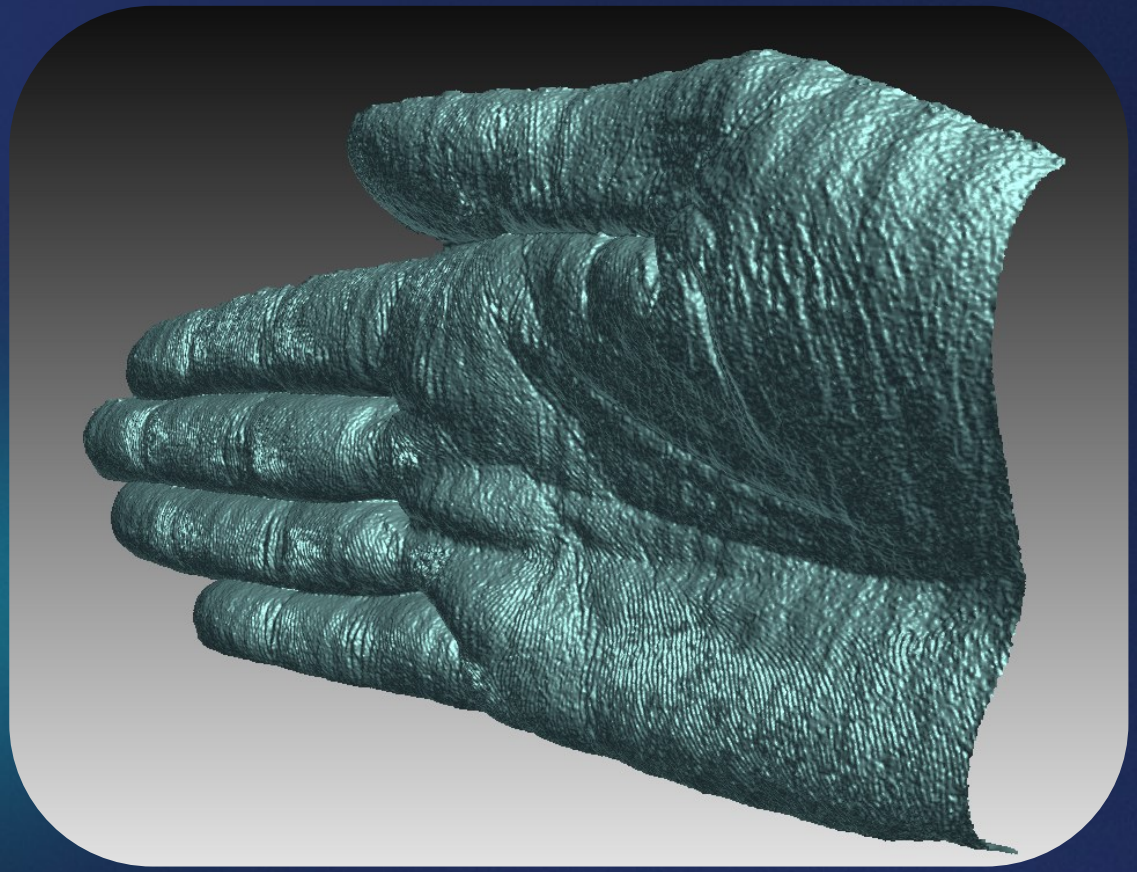
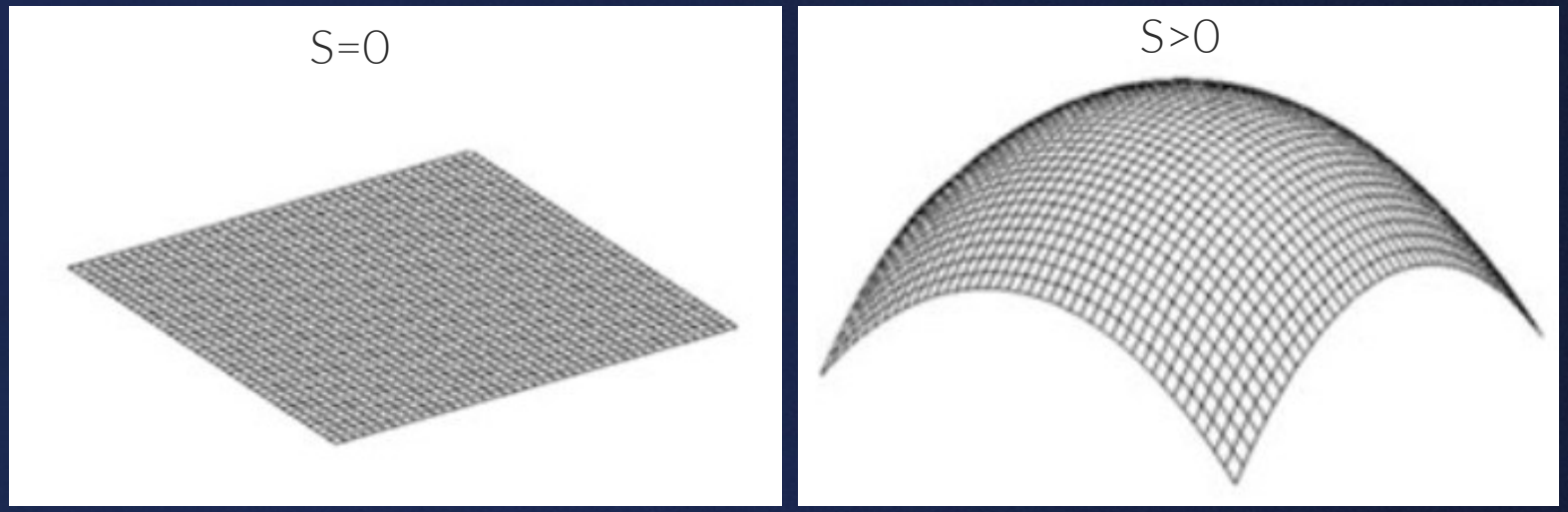
TECHNOLOGY

Beyond 2D Prints: Hand & Palm



Beyond 2D Prints: 3D features

(Mean) Curvature: Independent of Rotation, Translation



Shape and curvedness analysis of brain morphology using human fetal magnetic resonance images in utero

Hui-Hsin Hu · Hui-Yun Chen · Chih-I Hung · Wan-Yuo Guo · Yu-Te Wu

Brain Struct Funct (2013) 218:1451–1462
DOI 10.1007/s00429-012-0469-3

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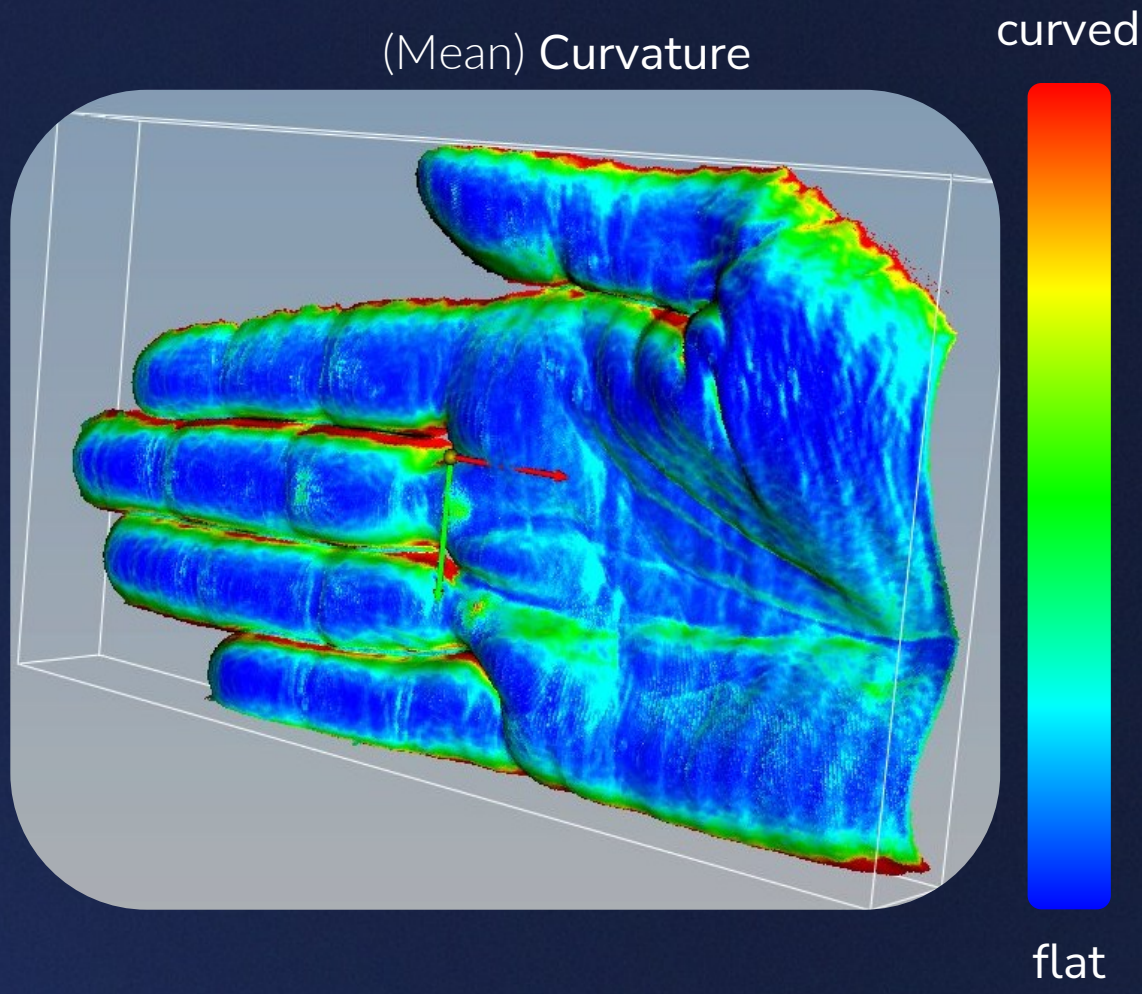
Beyond 2D Prints: 3D features

- Curvature: Independent of Rotation, Translation
- Combining features/minutiae with local curvature
- More detailed information template



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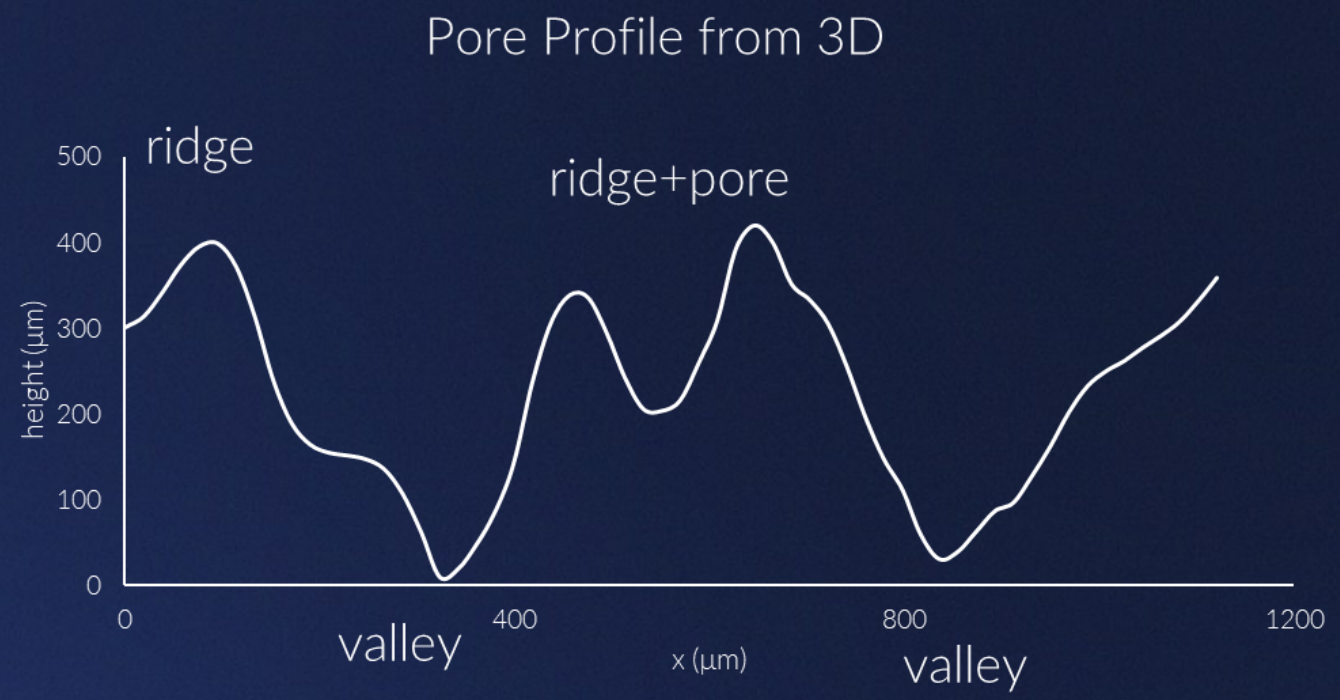
Future steps: 1000 ppi 3D Fingerprints

3D point cloud

Depth map
1000ppi+



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TECHNOLOGY

Beyond 2D Prints: Palm

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