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TOMORROW TODAY

Smartphone-based Fingerprint Recognition

Scientific Vision Days 2016

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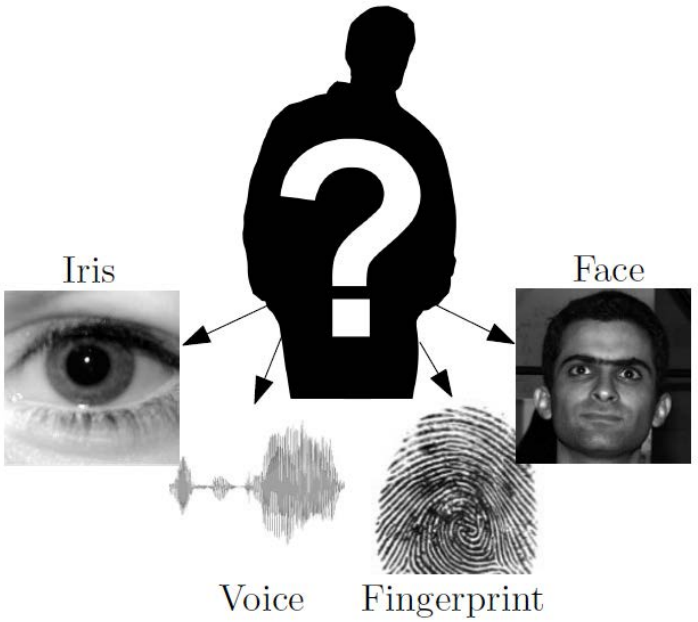
What is this Talk About?

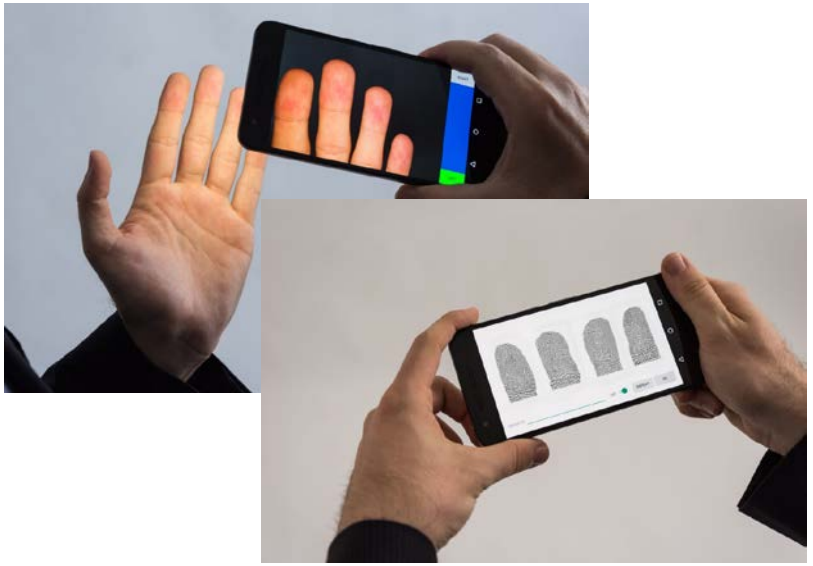
Biometrics

“science of establishing the identity of an individual based on the physical, chemical or behavioral attributes of the person” (Jain & Ross)



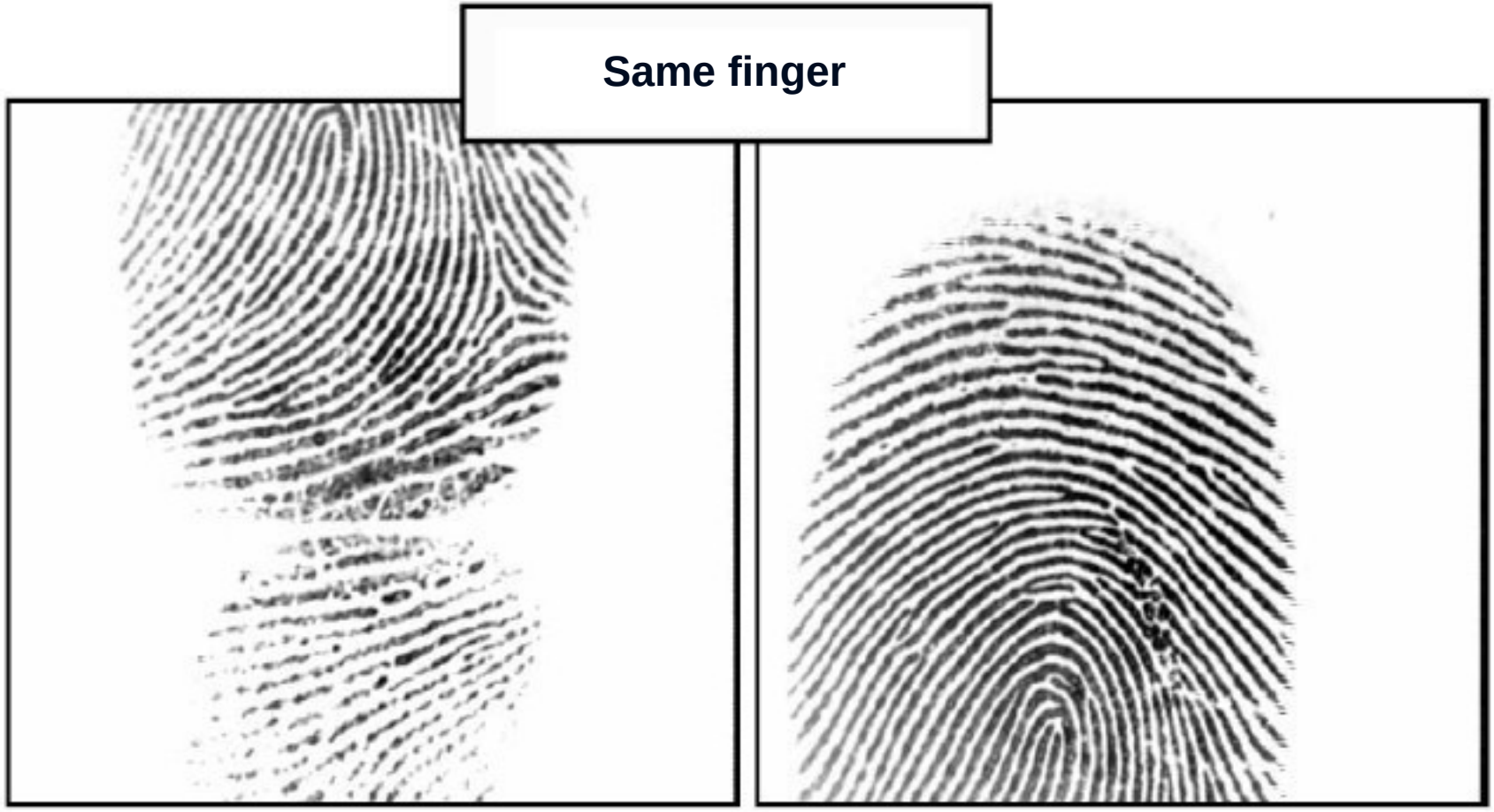
Why Fingerprints?

- Highly distinctive and unique
- Do not change for the lifetime of a person
- Publicly accepted as reliable (court evidence)
- Identical twins have different fingerprints



Same or Different?

Same or Different?



Same or Different?

Same or Different?

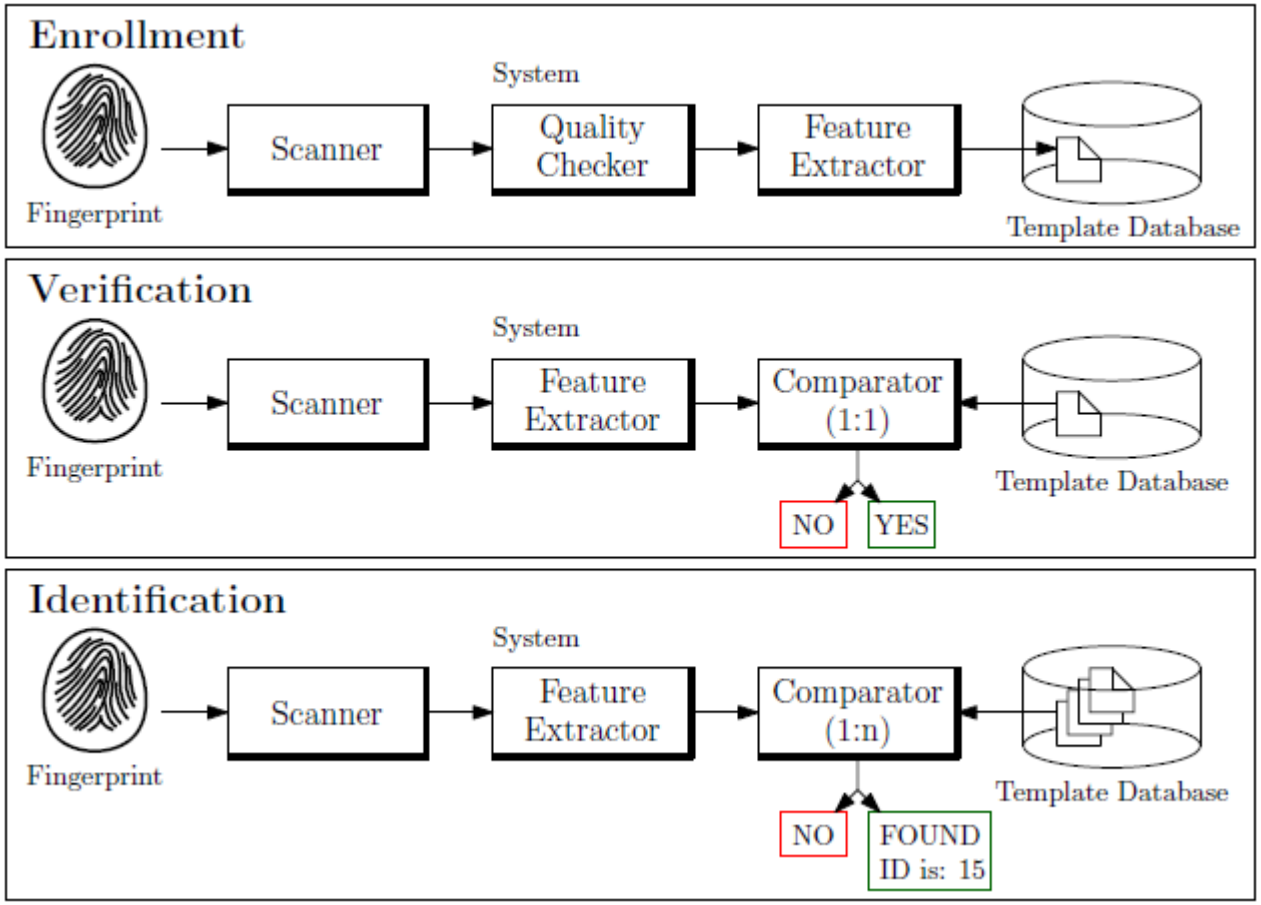
Same finger

Same or Different?

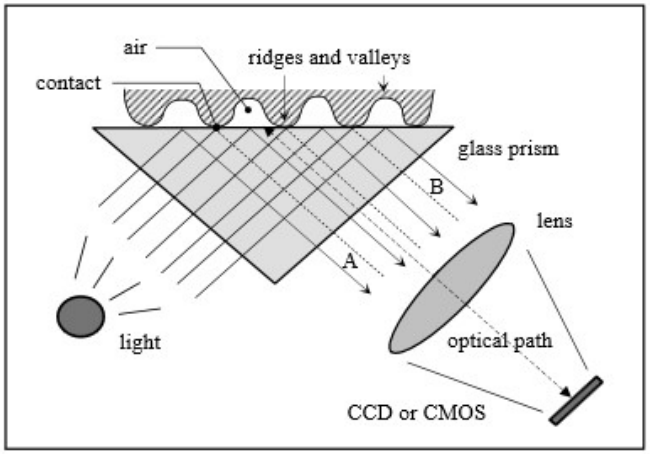
Same or Different?

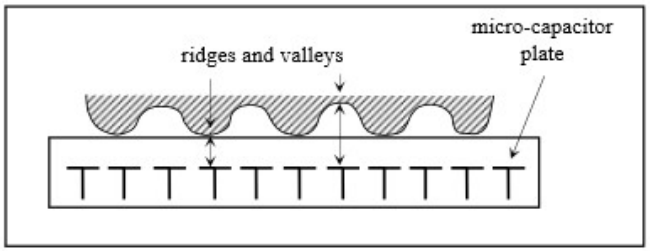
Different finger

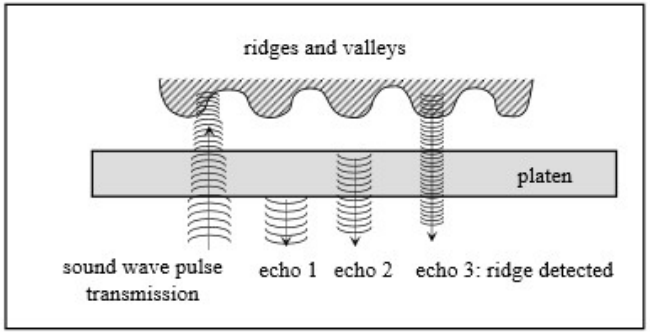
How does (Fingerprint) Biometric Recognition work?



Fingerprint Sensing







Optical sensors (FTIR)

- Light entering the prism is reflected at the valleys, and absorbed at the ridges.

Capacitative sensors

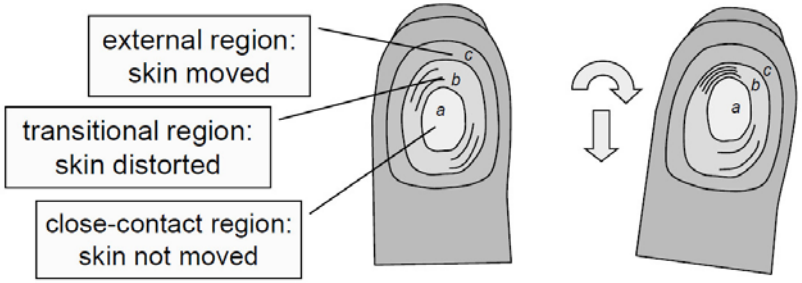
- Two-dimensional array of micro-capacitor plates
- Electrical charges are created between the surface of the finger.

Ultrasound sensors

- Capturing the echo signal to compute ridge structure.

Challenges for Touch-based Sensors

- High displacement & rotation

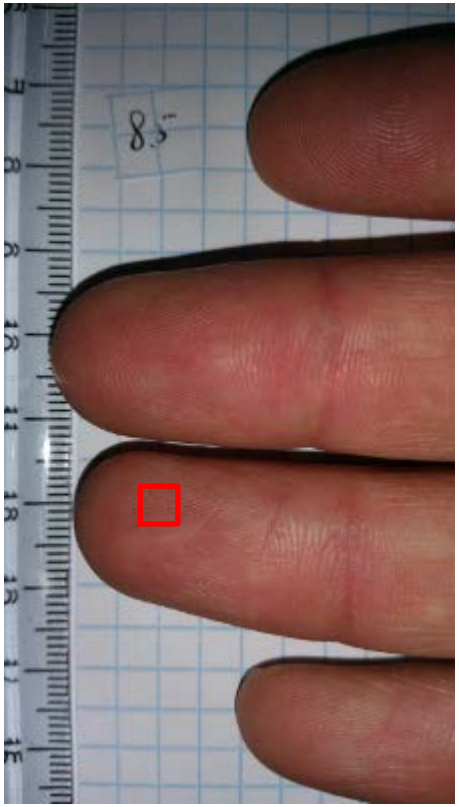


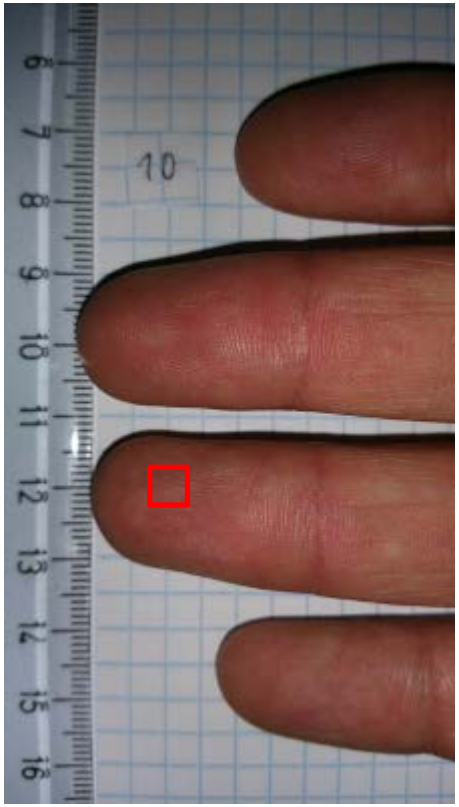
- Non-linear distortion: 3D surface - 2D sensing

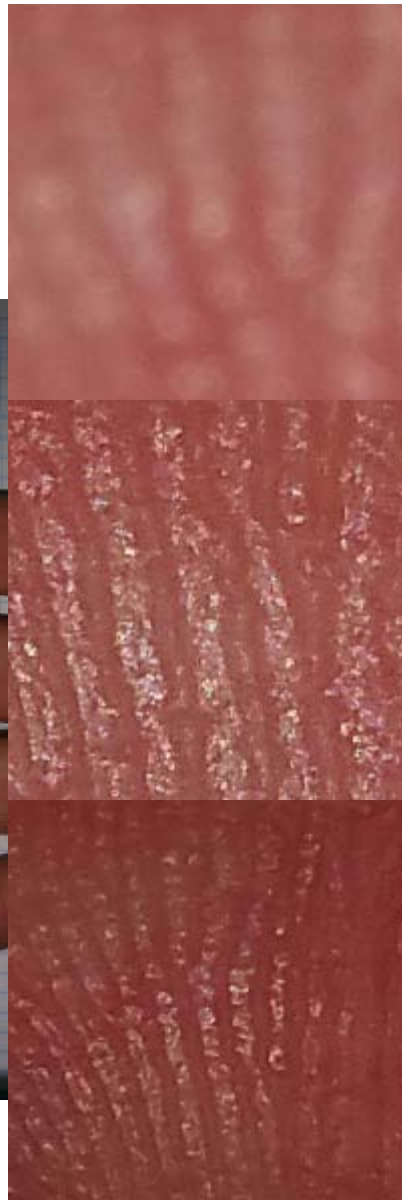
- Different pressure and skin condition
- Latent fingerprints on the sensor
- Hygienic issues
- Labati et al. (2016): 96.7% of users prefer touchless capture

Smartphone-based Fingerprint capture as ultimate solution?

- Close: 8.5cm – Far: 16.5cm -Ideal: 10cm
- Focus vs. Illumination vs. Resolution







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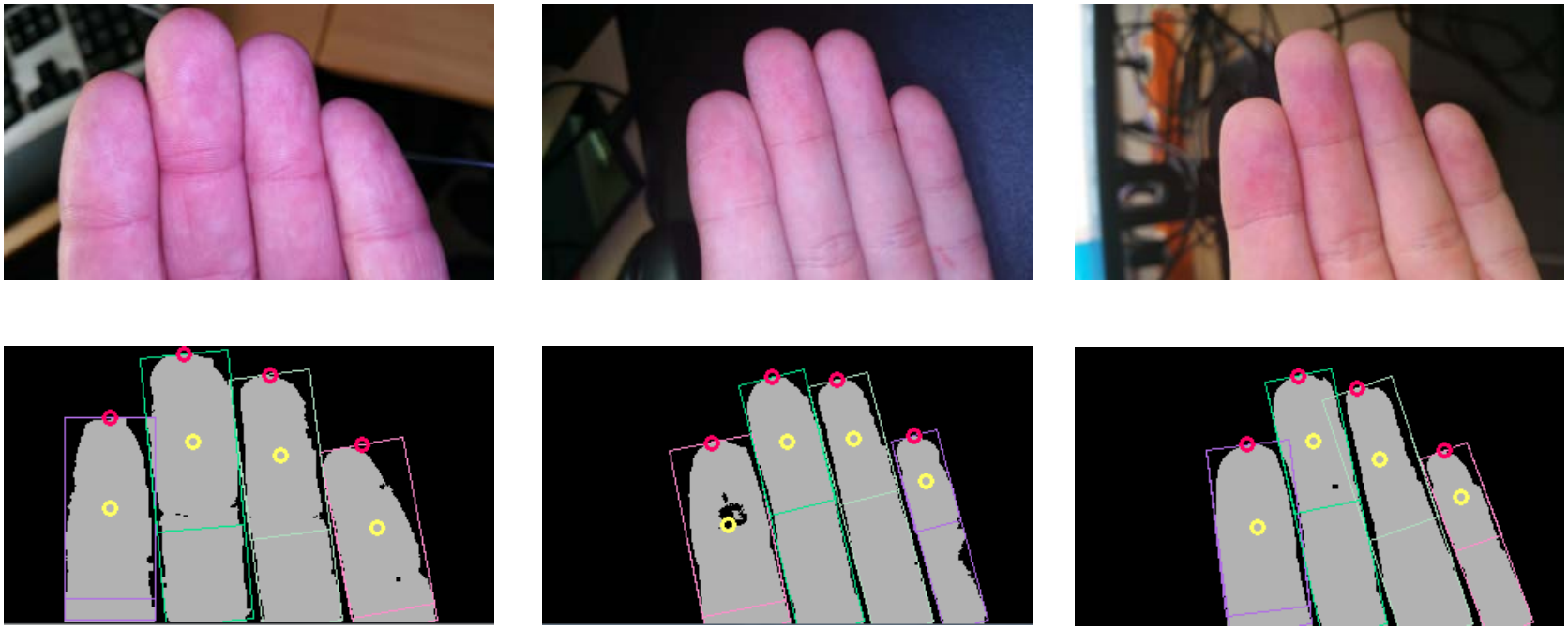
Properties of developed Smartphone-based Solution

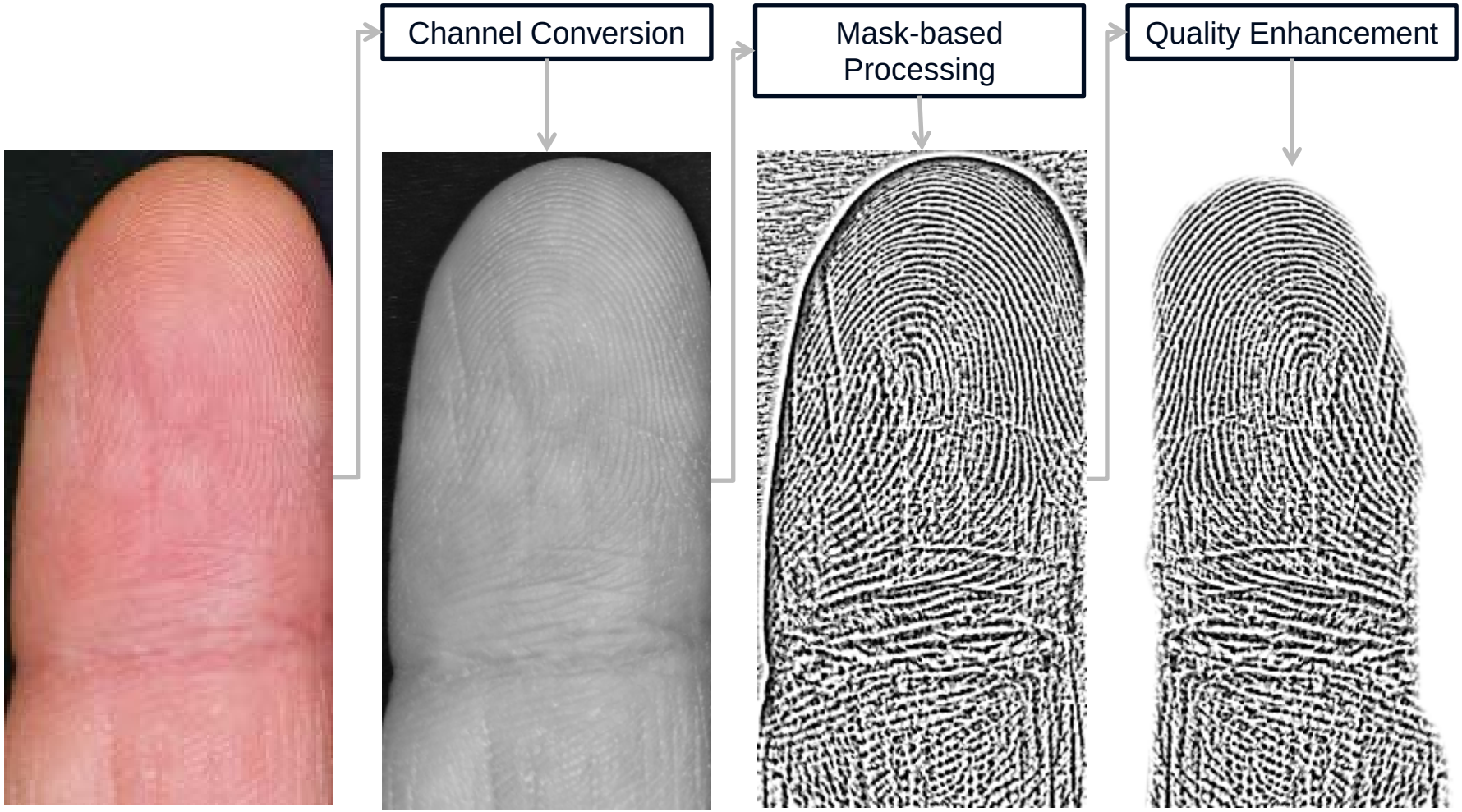
- **Fast Capture**
  - Multi-Finger „Fingerphoto“ Capture with Android Smartphones
- **Freeform Acquisition:**
  - Flexible distance supporting 4-Finger, 2-Finger (Thumbs) & 1-Finger
- **Robust Image Segmentation:**
  - Support of different Cameras, Background, Out-of-Focus…
- **Modularity:**
  - Embedded in identity check application
  - C++/OpenCV, avoiding external dependencies
  - Integration with NBIS mindtct / bozorth / nfiq (Quality)
  - Control of processing chain

Segmentation Examples

- Touching fingers supported
- Different illumination conditions
- Inhomogeneous background

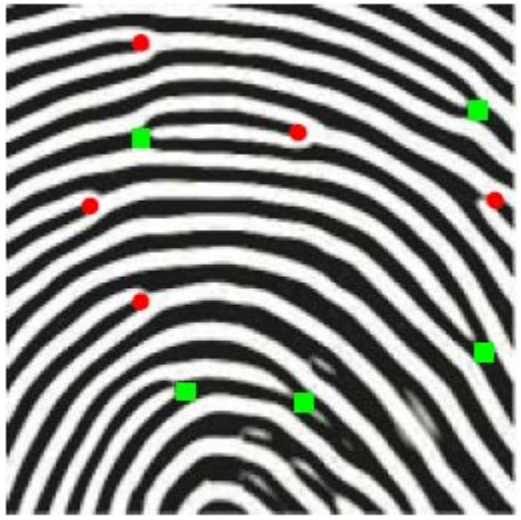


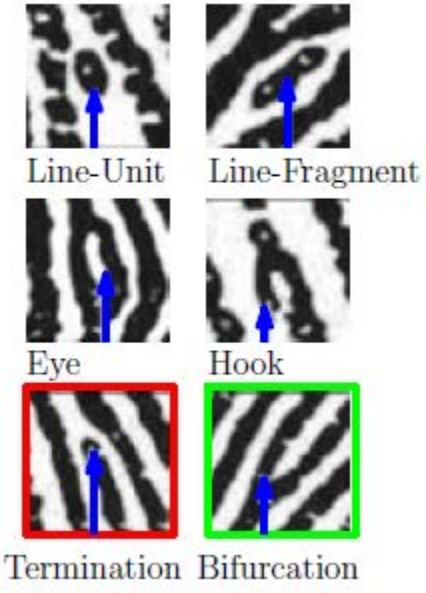
Enhancement Algorithm



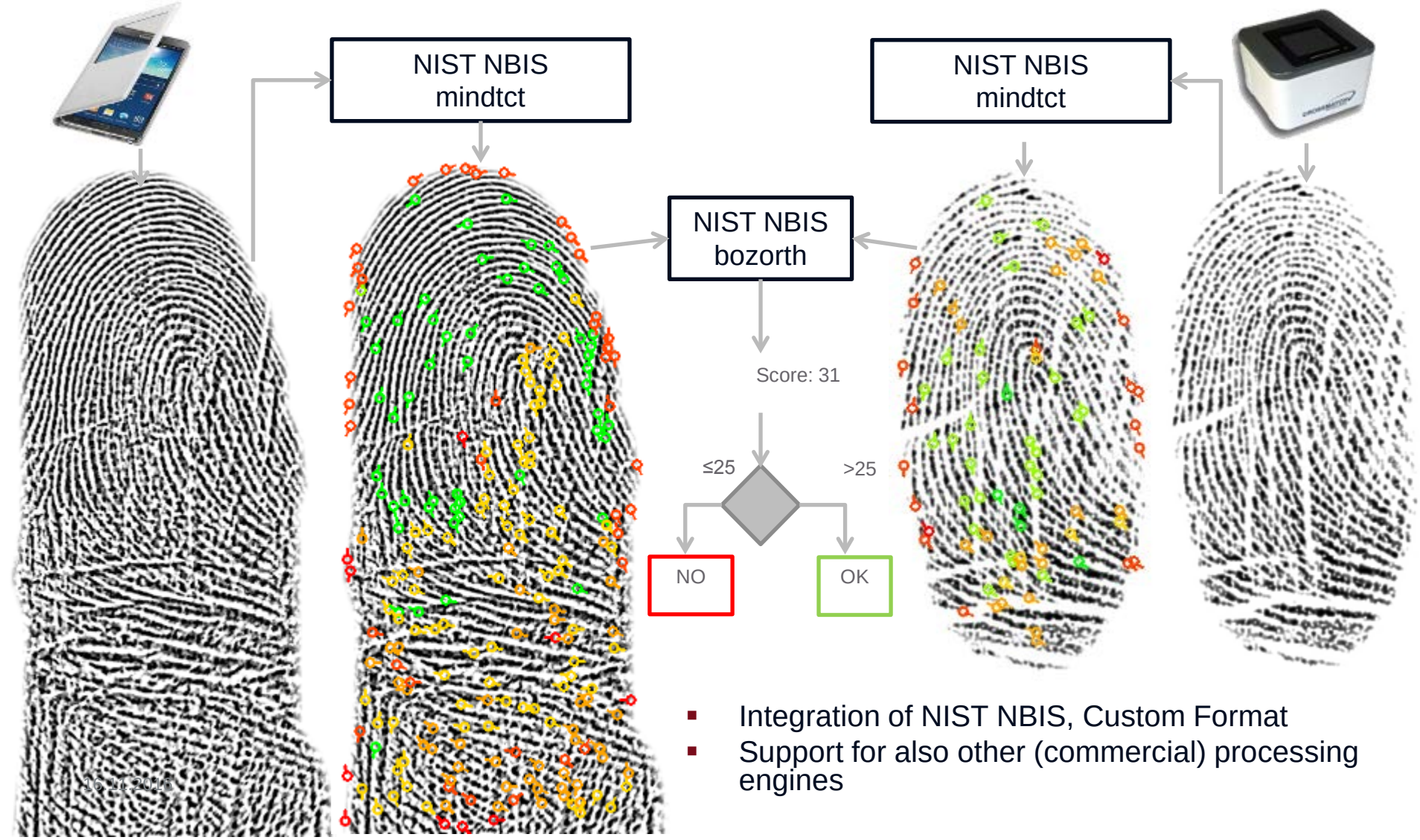
Anatomy: Level 2 Characteristics: 500 dpi

- **Minutiae**, or Galtons characteristics, are determined by the termination or the bifurcation of the ridge lines
- Each minutia is denoted by its class, the x- and y-coordinates, and local orientation;





Feature Extraction & Matching



- Integration of NIST NBIS, Custom Format
- Support for also other (commercial) processing engines

Evaluation

- Cross-Device Comparison
- Database with 4310 Fingerprints (109 Users, 5 Sensors, 8 Fingerprints per User)

Examples after Processing

ARH

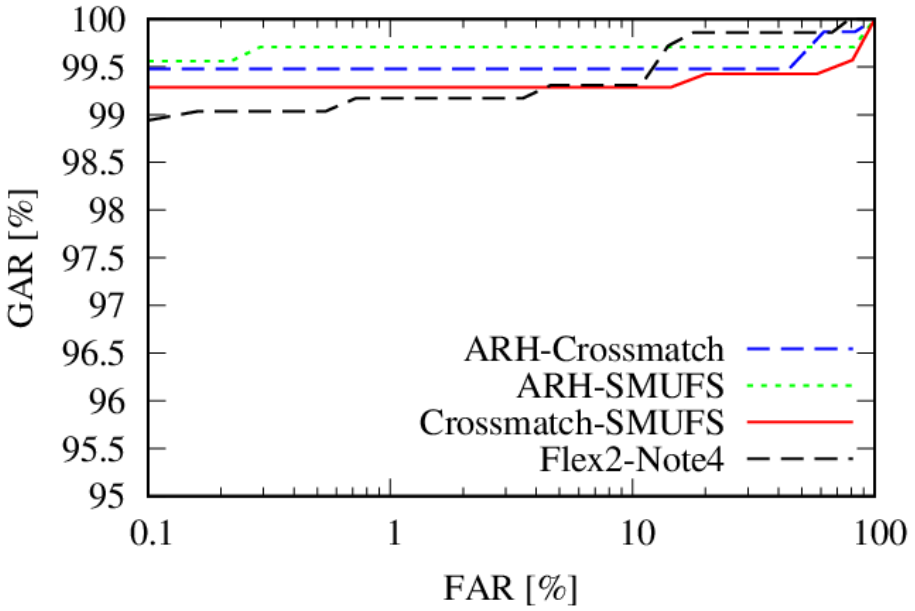
SMUFS

Crossmatch

Flex2

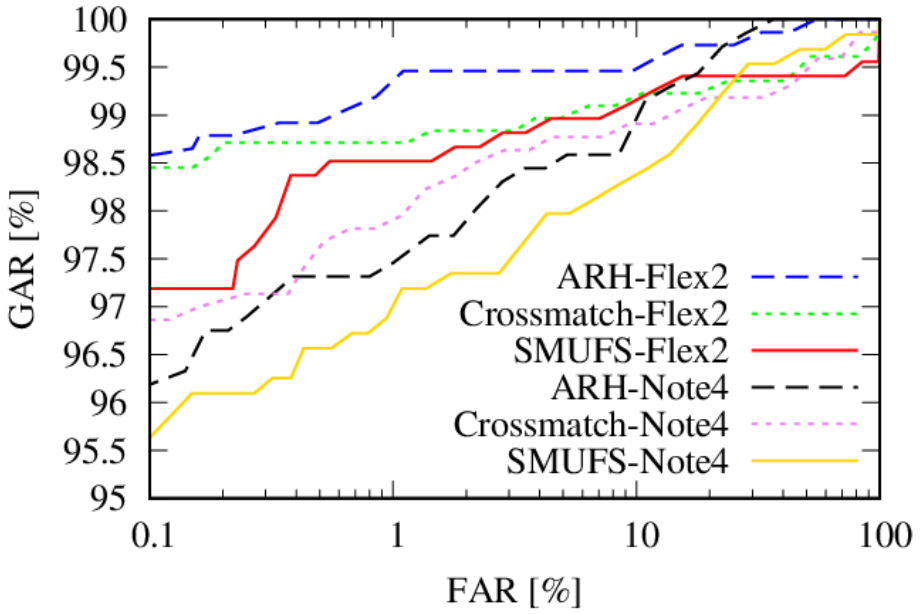
Note4

Performance within Sensor Group



- **Setup:** Quality > 30 (NFIQ-2), commercial extractor/matcher engine
- **Result:** At 0.1% False Acceptance Rate (FAR) more than > 99% are correctly verified (GAR).
- ICAO-Recommendation: 97%
- Also Touchless-Sensors Note4 - Flex2 deliver excellent results

Performance across Sensor Groups - Touch vs. Touchless



- **Setup:** Quality > 30 (NFIQ-2), commercial extractor/matcher engine
- **Result:** At 0.1% False Acceptance Rate (FAR) 95.5-98.5% are correctly verified (GAR).
- Flex2 delivers better results than Note4 (above ICAO threshold)
- High overall results (best: 0.83% EER, compare smartphone chains 3.65% EER in Sankaran‘15, 3.33% EER in Tiwari‘15)

Summary

Achievement

- New fingerprint processing chain for smartphones
- Comparable accuracy to touch sensors
- Fulfils recommended ICAO threshold (97% GAR @ 0.1% FAR) for specific phone

Advantages

- Fast multi-finger capture
- Employs COTS hardware for sensing

Ongoing Challenges

- **Towards even faster acquisition methods combining information from multiple shots**
- Adapting configuration for specific phones
- Further improving processing speed (embedded)

Future Work

Enhancement
- Unrolling / sensor-specific improvement

Quality
- Quality indicators for touchless devices - relative importance of device characteristics

Fusion
- Combine series of acquisitions and create best representation

Novel Methods
- Photometric Stereo, Lightfield for Biometrics, etc.

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