Advances, challenges and opportunities in Contactless fingerprint capture

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OVERVIEW

➔ Introduction

- Contact / contactless
- Use of dedicated sensor
- Contactless technologies:

➔ Two different design choices for contactless technologies

- MorphoWave (formerly called « Finger-on-the-fly »)
  - Principle, usage & benefits, challenges
  - Performance / Certification / interoperability
- Direct view on smartphone
  - Principle, usage / benefits, challenges
  - Performance / Certification / interoperability

➔ Conclusion, next steps

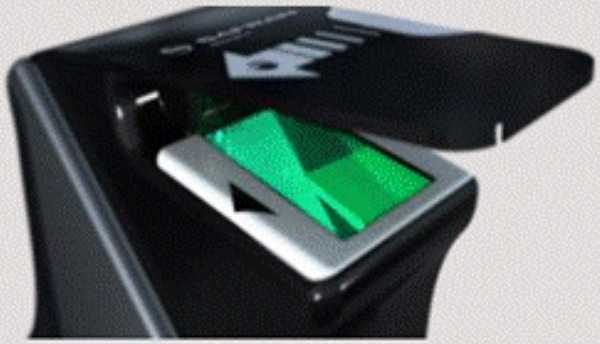
MORPHOWAVE TECHNOLOGY

➔ Acquisition of four fingers in a single swipe of the hand

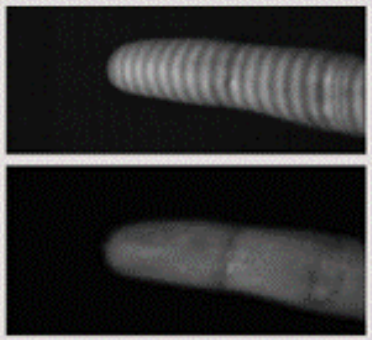
- Fast : Capture of 4 fingers in less than a second
- Accurate: Large capture area and robustness to difficult fingers (wet and dry fingers)
- Interoperable: PIV certified sensor (500dpi)
- Contactless & easy to use

➔ MorphoWave design choices

- 3D modeling of finger shape (not ridge shape) using structured light technology
- Contrast enhancement by directional lighting
- Interoperable 2D image generated by unwrapping the texture image using the 3D model



DUAL CHANNEL OPTICAL SYSTEM
TO CAPTURE THE LARGEST BIOMETRIC AREA



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APPLICATIONS, BENEFITS & CHALLENGES

➔ Possible applications

- Border control
- Access control
- Rapid enrolment & ID verification
- …/…

➔ Many operational advantages

- Speed
- Ergonomics & user experience
- Hygien
- …/…

➔ But several legitimate questions:

- What is the accuracy ?
- Is it interoperable with legacy databases and legacy sensors ?
- How does it compares to traditional rolled and slaps ?

And how can we validate this ?

1- FIDELITY - PIV CERTIFICATION (SINGLE FINGER)

Adaptation of PIV certification procedure to MorphoWave Technology

⇒ **Same reference documents**

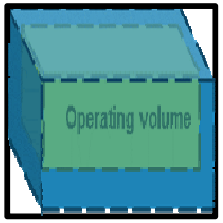
⇒ **Same set of targets**

⇒ **Same metrics & tools**

⇒ **Measure of metrics within the volume area**

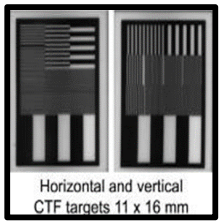
Main Category	Firm	Product & Description		FAP	Specification
PIV Single Finger Capture Devices	**Safran Morpho**	**Finger On The Fly / Morphowave Desktop** Model Finger On The Fly / Morphowave Desktop contactless, up to 4-finger, livescan capture device at 500ppi (PIV-071006). Note: Device images a 3-dimensional object, but testing was only 2-dimensional - Not for use with CJIS systems			PIV

From https://www.fbibiospecs.cjis.gov/Certifications



Define 3D capture volume

2D Ronchi target for resolution/distortion



2D CTF targets

2D Uniform targets for GLU, SNR and uniformity

Gray range on fingers and comparison with inked images

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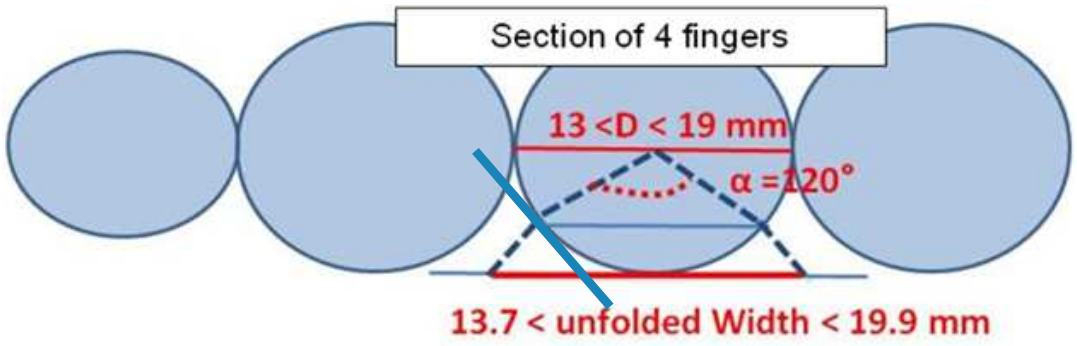
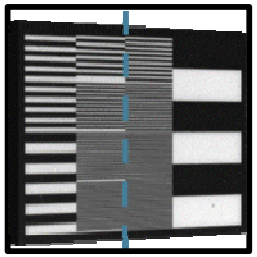
2- FIDELITY – TEST ON 3D TARGETS

➔ **A finger is a non flat 3D object**



3D « Ronchi » target to check 3D->2D fidelity

2 diameters (14-17 mm) to take finger size into account



Tilted targets to ensure fidelity on side

1) Ensure optical properties on non horizontal area

- Geometry
- Resolution

2) Correct projection distortion to ensure compatibility with legacy databases

- Unwrapping from 3D shape
  - E.g « 3D touchless fingerprints: compatibility with legacy rolled images" by Chen, Parziale2, Diaz-Santana, and Jain
- Impact on distortion > 2% on the side of the finger. Can it be neglected ?

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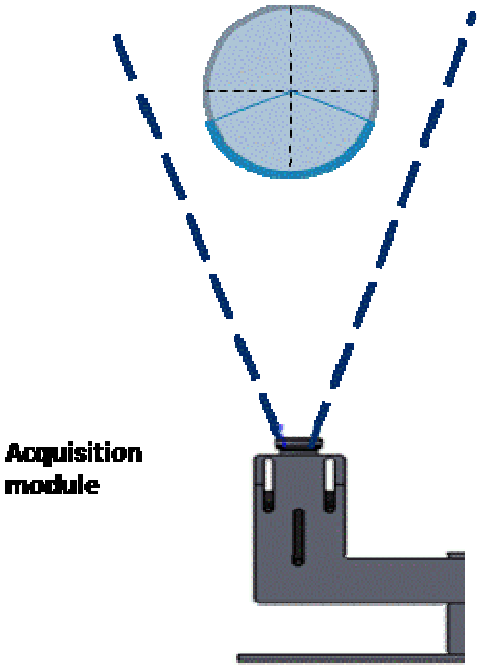
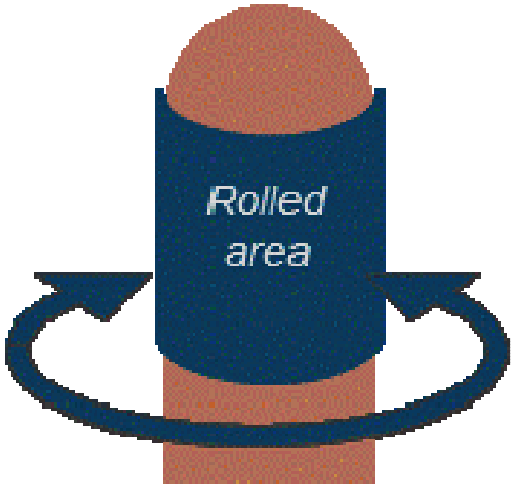
3- ASSESSMENT OF QUANTITY OF INFORMATION

➔ **The area of the fingerprint captured is between slap and rolled**



Captures up to 60°



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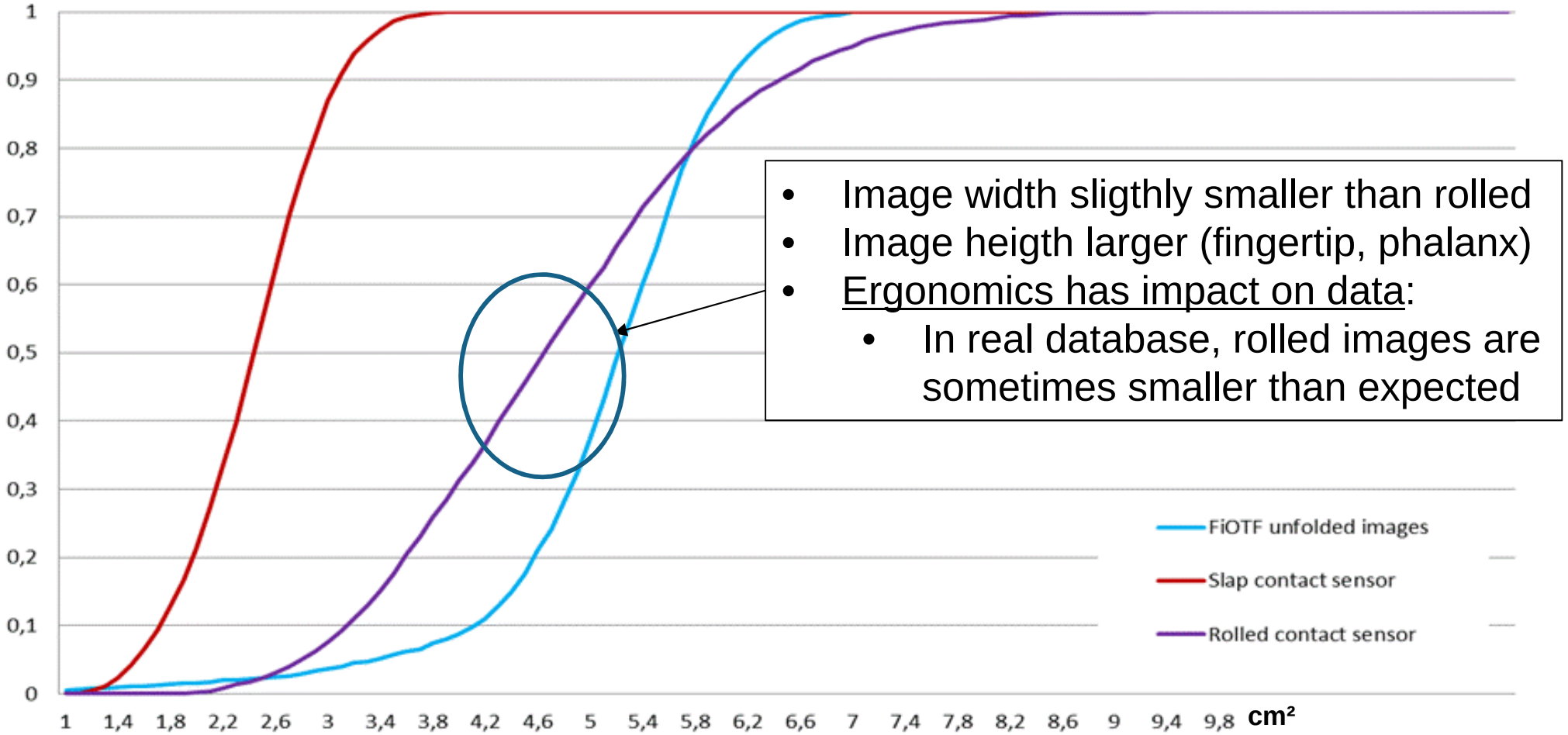
3- ASSESSMENT OF QUANTITY OF INFORMATION

➔ **Statistical measures of FiOTF fingerprint areas are closer to rolled than slap**



- Image width sligthly smaller than rolled
- Image heigth larger (fingertip, phalanx)
- Ergonomics has impact on data:
  - In real database, rolled images are sometimes smaller than expected

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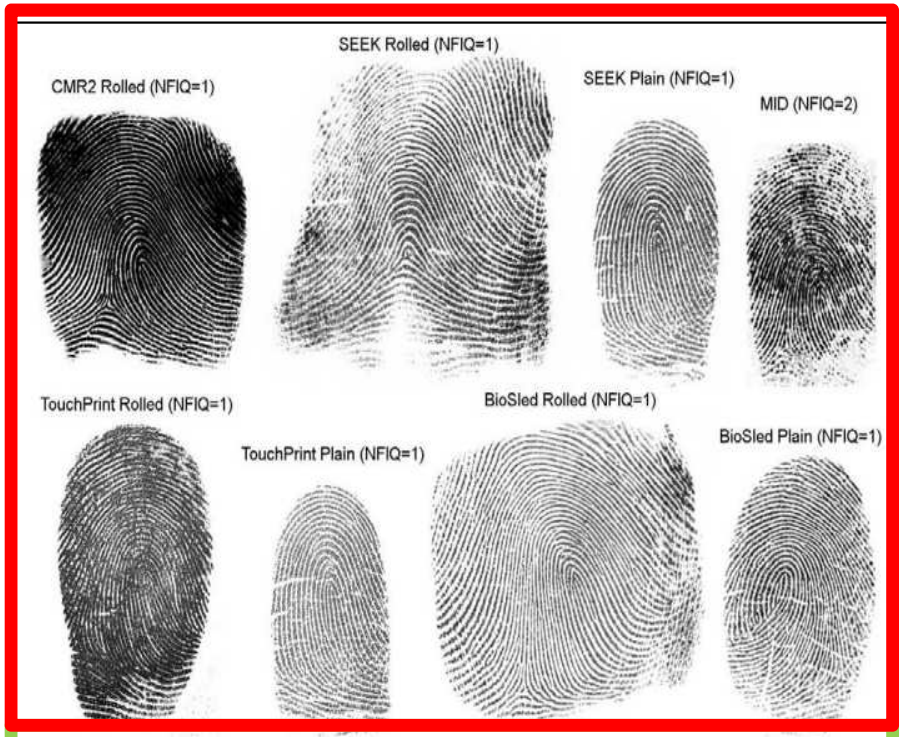
4- INDEPENDENT TESTING

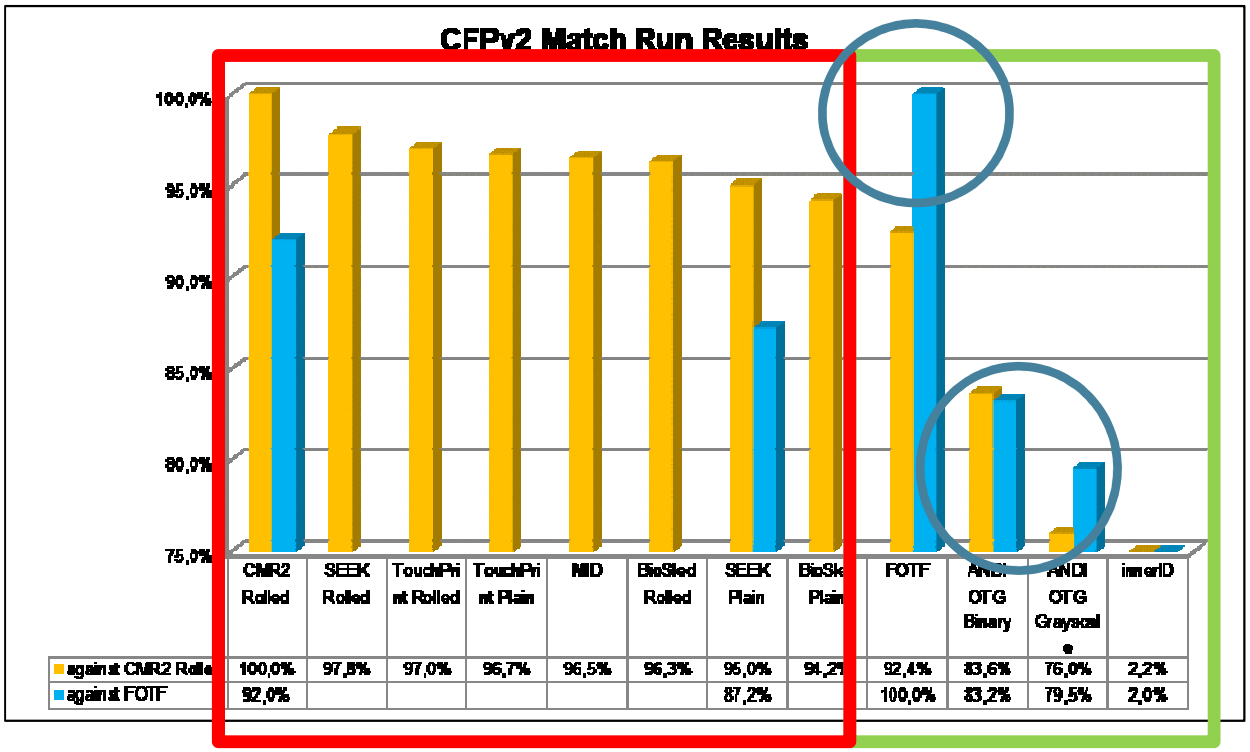
"NON-CONTACT MULTI-SENSOR FINGERPRINT COLLECTION – PHASE II, 11/2014 - 4/2015 »

From https://www.ncjrs.gov/pdffiles1/nij/grants/249552.pdf

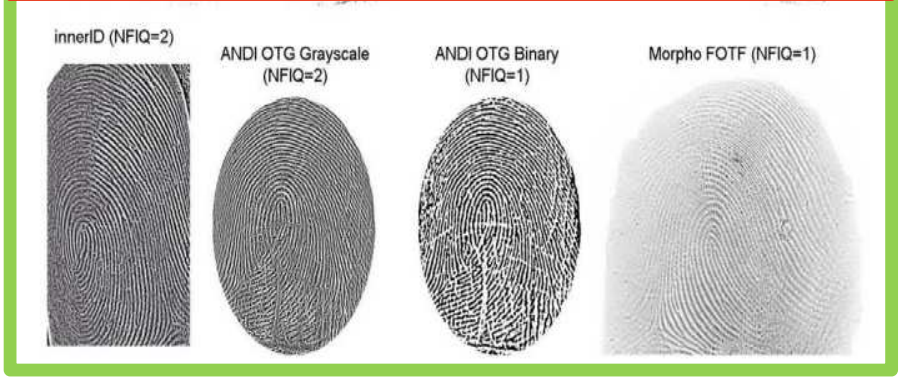
Contact

Contactless





	CMR2 Rolled	SEEK Rolled	TouchPrint Rolled	TouchPrint Plain	MID	BioSled Rolled	SEEK Plain	BioSled Plain	FOTF	ANDI OTG Binary	ANDI OTG Grayscale	innerID
against CMR2 Rolled	100,0%	97,8%	97,0%	96,7%	96,5%	96,3%	95,0%	94,2%	92,4%	83,6%	76,0%	2,2%
against FOTF	92,0%						87,2%		100,0%	83,2%	79,5%	2,0%



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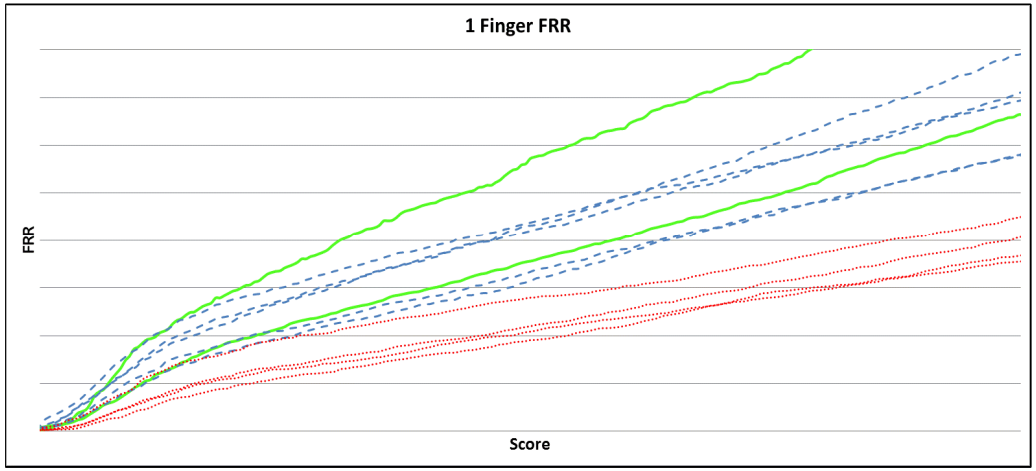
4- SAME DATASET, DIFFERENT SCENARII …

➔ Scenario 1: use 4 fingers

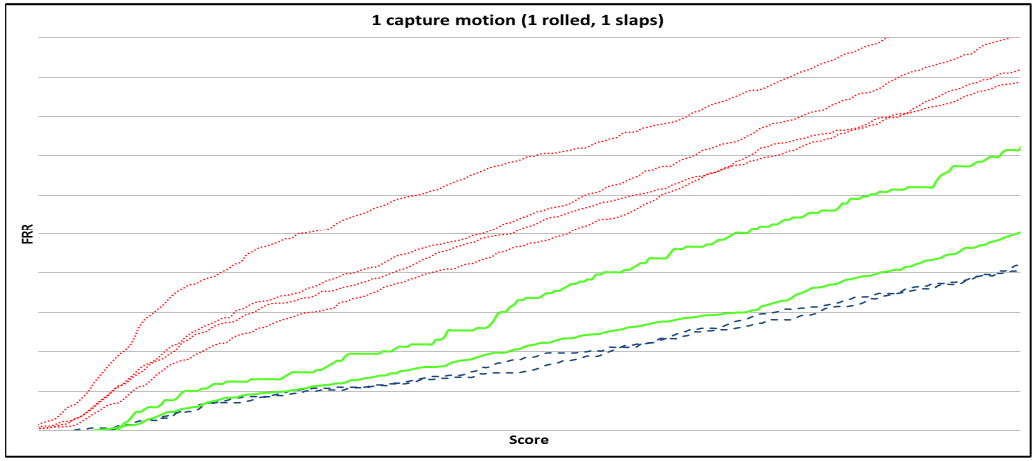
- Capture time not critical
- User experience not critical
- 4 Rolled > 4 Slaps
- 4 Contactless ~ 4 Slaps



4 Contactless
4 Slaps
4 Rolled

➔ Scenario 2: one single capture move

- Capture time critical
- User experience critical
- 4 Slaps ~ 4 contactless
- 4 Contactless > 1 Rolled



1 Rolled
4 Contactless
4 Slaps

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MORPHOWAVE - NEXT STEPS

➔ High end applications

- Border control, enrollment, high end access control, …

➔ Those applications require

- High image quality (geometry, distortion, resolution, …)
- Full interoperability with legacy systems (sensors, databases, algorithms)
- Importance of user experience and speed

➔ … calling for

- Carefull design of ligthing, resolution and 3D shape estimation
- Independant certification (PIV) and independant testing

➔ Next steps

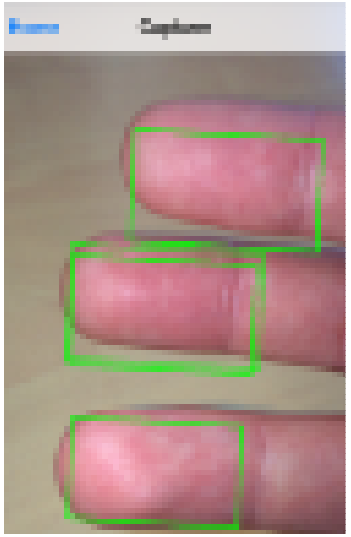
- Is there a need for higher level of compliance verification ?
  - 4 fingers (FAP xxx)? 3D considerations ? Forensic applications (forensic expert) ?
- Or shall we rather keep PIV compliance level and go for more field testing ?

SMARTPHONE FINGERPRINT DIRECT CAPTURE

➔ **Using back camera of smartphone to capture fingerprint**

➔ **Possible applications:**

- Mobile ID check
- User authentication



➔ **Benefit:**

- Fast capture of 4 fingers
- Compatible with existing high end smartphone
- No need for dedicated sensor, as simple as deploying an App

⇒ Very large scale deployment is possible

➔ **But several legitimate questions:**

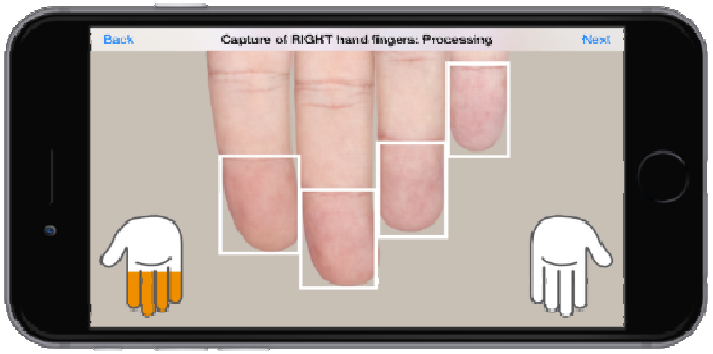
- What is the accuracy ?
- Is it interoperable with legacy databases and legacy sensors ?
- Performance on a variety of phones ?

And how can we validate this ?

DIRECT VIEW TECHNOLOGY

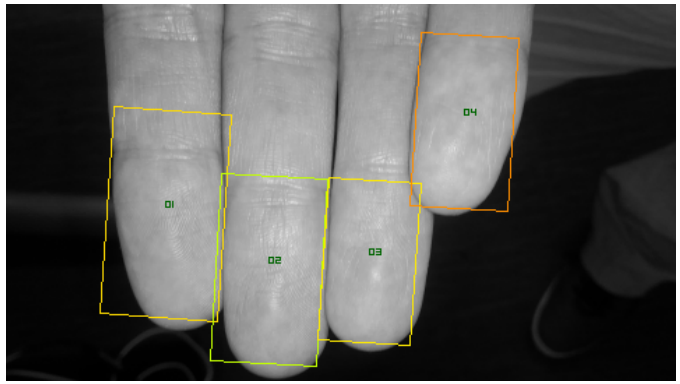
➔ Typical HW setting

- Use back camera of phone to capture 4 slaps
- Torch mode of flash to enhance contrast
- Auto focus / gain control



➔ Typical SW setting

- Auto capture for convenience and speed
- Finger segmentation and sequence check
- Coding/matching



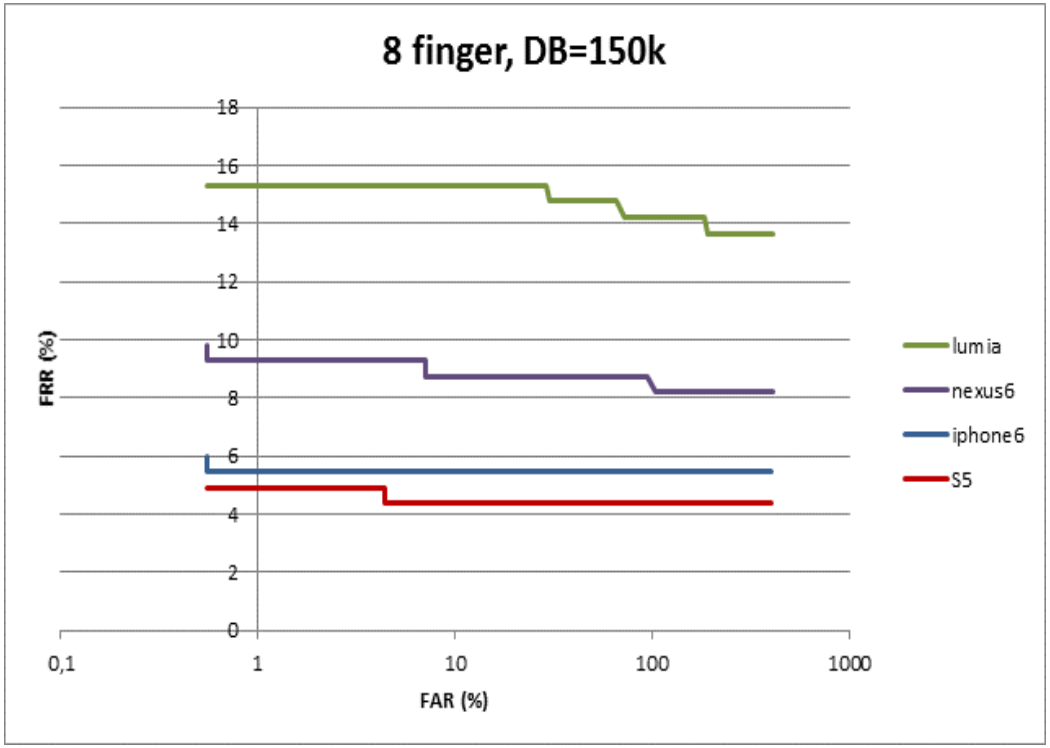
➔ Several variations

- Local / remote matching
- Estimation of resolution or resolution-insensitive matcher

1 – INTERNAL TESTING

➔ Internal testing

- 183 persons, (right+left hands)
- 2 use cases: self enroll / operator
- In door
- 150K of legacy data (500dpi slaps)
- Traditional matcher with built in tolerance to scale



➔ Performances is phone dependent

- S5 ~ Iphone6 > nexus6 > lumia

➔ Accuracy can be higher than 95%

- Main causes of failure: Autofocus, finger detection & segmentation, hand labelling

➔ When fingers are correctly captured, performance scales very well

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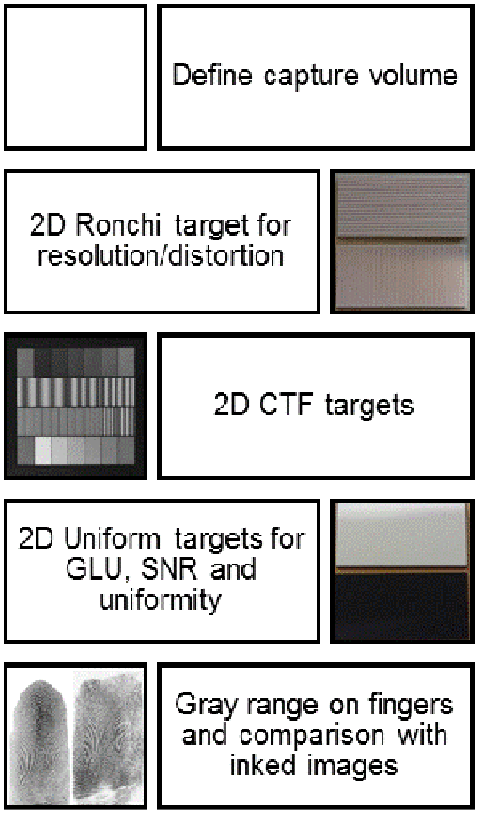
2- PIV CERTIFICATION OF DIRECT CAPTURE ?

➔ Image quality of high end phones is very good

- Low intrinsic distortion, increasingly good auto focus/gain control
- … thanks to a lot of under the wood image processing

➔ Open questions for PIV certification

- How to define capture condition for certification
  - Capture volume, external light, …
- How to accurately control resolution / distorsion
  - Scale factor, Finger position&tilt, Finger 3D shape
  - Each of these factor alone can bring more than 2% error
- How to reach native high contrast
- How to relate certification and phone model
  - Inter phone variation - New models every week
  - Intra phone variation Same model can have different camera modules



➔ What level of certification is needed for field deployment ?

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DIRECT VIEW- NEXT STEPS

- **Possible application**
  - Mobile ID verification, standard acces control
- **Need to define the requirements**
  - Image quality, interoperability, resolution control
- **What shall be handled at algorithm level versus sensor level**
  - Most modern algorithms can be set to be robust to uniformity, resolution, …
- **Especially as we can have 4 fingers per capture**
  - Unlike with single finger sensors
- **How to measure image quality (PIV certification)**
  - Adaptation of methodology ?
  - Or new level (FAP xxx) for that type of capture devices ?

CONCLUSION

- **New contacless technologies have strong operational potential**
  - Ease of use, ease of deployment
- **Performance/interoperability requirements can be handled at various level**
  - Sensor, image enhancement, matching algorithm, system
  - This has strong impact on design choices / cost / time to market
    - 3D measurement in Morphowave to ensure full image interoperability
    - Resolution independant matcher in direct view
- **Impact of usability on operational accuracy are not to be ignored**
  - Ease of use, Speed constrainst
  - Lab performance is not field performance
- **Validation by standard compliance (e.g PIV) or field testing?**
  - Need to find the « right » balance
- **Question of use by forensic experts needs to be further discussed**

Thank you !

Any questions ?