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
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 ?
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

<table>
<thead>
<tr>
<th>Main Category</th>
<th>Firm</th>
<th>Product &amp; Description</th>
<th>FAP</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIV Single Finger Capture Devices</td>
<td>Safran Morpho</td>
<td><strong>Finger On The Fly / Morphowave Desktop</strong>&lt;br&gt;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</td>
<td>PIV</td>
<td></td>
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</tbody>
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From https://www.fbiospecs.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
2- FIDELITY – TEST ON 3D TARGETS

A finger is a non flat 3D object

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?
3- ASSESSMENT OF QUANTITY OF INFORMATION

The area of the fingerprint captured is between slap and rolled.

Captures up to 60°
Statistical measures of FiOTF fingerprint areas are closer to rolled than slap

- Image width slightly smaller than rolled
- Image height larger (fingertip, phalanx)
- Ergonomics has impact on data:
  - In real database, rolled images are sometimes smaller than expected
4- INDEPENDENT TESTING

Contact

Contactless

CFPr2 Match Run Results


Contactless

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4- SAME DATASET, DIFFERENT SCENARIOS ...

**Scenario 1: use 4 fingers**
- Capture time not critical
- User experience not critical
- 4 Rolled > 4 Slaps
- 4 Contactless ~ 4 Slaps

**Scenario 2: one single capture move**
- Capture time critical
- User experience critical
- 4 Slaps ~ 4 contactless
- 4 Contactless > 1 Rolled
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
- Careful design of lighting, resolution and 3D shape estimation
- Independent certification (PIV) and independent 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
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
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 / distortion
  - 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?
DIRECT VIEW - NEXT STEPS

- Possible application
  - Mobile ID verification, standard access 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 contactless 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 constraint
  - 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?