Integration of Pore Characteristics into the Evaluation of Fingerprint Evidence

Alexandre Anthonioz & Christophe Champod
Objectives of the research

Design a model to assess the contribution of pores in the fingerprint comparison process

Account for both within and between fingers variability

Using an approach based on Likelihood Ratios (LRs) to carry out the integration of pores in a framework including 1st and 2nd level details
What is the probability of the evidence ($E$) if (|$\mid$) the mark and the print have a common source ($H_p$)?

What is the probability of the evidence ($E$) if (|$\mid$) an unknown person left the mark ($H_d$)?

**Within source variability of marks/prints**
- Time, substrate, clarity, distortion

**Between sources variability of marks/prints**
- Selectivity of the features among friction ridge skin impressions
Objectives of the research

> Design an algorithm to automatically extract pores
> Define a metric able to highlight the similarities and dissimilarities between sets of pores
Data acquisition

> Acquisition of databases for within and between variability

about 2700dpi resolution
Data acquisition

- L3 database for between variability (L3BSDB)
  - 54 donors for 1,728 fingerprints
  - 4 impressions of eight fingers
  - Captured without distortion

- L3 database for within variability (L3WSDB)
  - 14 donors for 756 fingerprints
  - Recorded under various distortion and pressure conditions
  - 3 fingers / 9 distortions / 2 sessions
Level 3 characteristics extraction

> Pores extraction based on pore types:
  > Open (on one or two sides of the ridge) or Closed

- Open 1S
- Open 2S
- Closed
Level 3 characteristics extraction

> Closed pores
  > Edge detection (Canny filtering)
  > Heuristics applied to remove falsely detected pores
Level 3 characteristics extraction

Open pores

- Based on the skeletonization of the valleys
- Detection of end and bifurcation pixels
- Heuristics applied to remove falsely detected pores
Level 3 characteristics extraction
Metric for pores

>Masures on pores on a single ridge without any reference point were not effective
>Adding a reference point increased efficiency
  >One ridge poorly discriminating
  >Consecutive ridges considered

On adjacent ridges with a reference point
Metric for pores

> One metric based on three scores:
  > Based on distances between each pore and the minutia
  > Based on angles between each pair of consecutive matching segments
  > Based on the centre of mass of the remaining segments
Metric for pores

> Fusion of the three scores in a single score

or
LR computation

Samples from a zone

<table>
<thead>
<tr>
<th>WI 1</th>
<th>WI 2</th>
<th>WI 3</th>
<th>WI 4</th>
<th>WI 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>WI 6</td>
<td>WI 7</td>
<td>WI 8</td>
<td>WI 9</td>
<td>WI 10</td>
</tr>
<tr>
<td>WI 11</td>
<td>WI 12</td>
<td>WI 13</td>
<td>WI 14</td>
<td>WI 15</td>
</tr>
<tr>
<td>WI 16</td>
<td>WI 17</td>
<td>WI 18</td>
<td>WI 19</td>
<td>WI 20</td>
</tr>
<tr>
<td>WI 21</td>
<td>WI 22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Within-variability

210 scores computed pairwise

The density is estimated using a Gaussian Mixture Model
LR computation

Between-variability

$n$ scores computed against samples coming from different sources

The density is estimated using a Gaussian Mixture Model
LR computation

>When $H_p$ is true:

The mark is compared against a corresponding sample. We call them $LR_{Hp}$.

>When $H_d$ is true:

The mark is compared against a print taken at random in the non-related samples. We call them $LR_{Hd}$. 
LR computation
Results

RECIEVER-OPERATING CHARACTERISTICS (ROC) CURVE

**TRUE POSITIVE RATIO**

**FALSE POSITIVE RATIO**

- **PS3: 0.87**
- **SS3: 0.877**
Results

\[ LR \text{ true min } = 0.019897 \]
\[ LR \text{ true max } = 1.76 \times 10^9 \]
\[ RMEP \quad 23.44\% \]

\[ LR \text{ false min } = 0.033731 \]
\[ LR \text{ false max } = 5.95 \times 10^{-1} \]
\[ RMEP \quad 0.00\% \]
Results

LR true min = 0.048403
LR true max = 7.28e+06
RMED 24.16 %

LR false min = 0.0022517
LR false max = 2.56e+06
RMED 4.81 %
Results

> When using the product score
  > The Rates of Misleading Evidence in favor of the Prosecution (RMEP) are extremely low (0 to 0.5%)
  > The magnitude of the LRs under $H_p$ is difficult to interpret (up to $10^{300}$)

> When using the sum score
  > The RMEP are higher but still low (around 5%) and with small LRs
  > The magnitude of the LRs remains more reasonable

> For both scores rules, the Rates of Misleading Evidence in favor of the Defense (RMED) have values contained between 20% and 25%
Illustration

Mark

Reference

(Sum Score)
Conclusions

> The metric developed enables the interpretation of distances between pore configurations (when used in conjunction with a 2\textsuperscript{nd} level feature)

> It could be integrated into a model taking into account information about the three levels of features