Palm Vein Biometrics Based on Infrared Imaging and Complex Matched Filtering

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Motivation

Problem

• Identity fraud
• Linking physical person to a digital identity

Solution

• Biometrics
Why Palm Veins?

• Invisible in daylight
• Hard to falsify
• Unique structure
• Allow distinguish twins
• Easy to use
Outline

Image acquisition  Processing  Recognition  Results
Outline

Image acquisition → Processing → Recognition → Results
Outline

- Image acquisition
- Processing
- Recognition
- Results

Diagram: Image acquisition and Processing are connected with Recognition, which leads to Results.
Outline

- Image acquisition
- Processing
- Recognition
- Results

Diagram:

- False accept rate
- False reject rate
- Equal error rate
- Sensitivity
- Errors
Imaging Methods

Reflection
- Frosted glass
- IR LEDs
- IR filter
- Camera

Transmission
- IR SOURCE

Advantages
- Low power consumption
- Compact design

Disadvantages
- Some wrinkles visible

Advantages
- Slightly better palm vein visibility

Disadvantages
- High power consumption
- Bulky design
Acquired Images

Visible light  Reflection method  Transmission method
Vessel Analysis

Cross section

Vessel cross section can be approximated with Gaussian function
Matched Filtering

\[
g_\phi(x, y) = -\exp\left(-\frac{x'^2}{2}\sigma_x^2\right) \\
x' = x \cos \phi + y \sin \phi
\]
Matched filtering

\[ g_\phi(x, y) = -\exp\left(-\frac{x'^2}{2\sigma_x^2}\right) \]

Matched filtering - SLOW
Complex Matched Filtering

\[ CMF(x, y) = \left[ \sum_{l} e^{j2\varphi_l} \cdot G(x, y, \varphi_l) \right] \]

For further information:
CMF Result

Advantages:
- Filtering with one complex mask
- Additional information about the vessel’s orientation

Drawback: Halo effect

CMF
Building Vector Sets

After CMF we can construct the most significant vector set

240x320 pixels

128 bytes
Building Vector Sets

Iterative execution of the following steps:
• Find max response
• Save the vector
• Exclude neighbor vectors from further processing
• Continue
Building Vector Sets

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Comparison of Vectors

Calculation of similarity:
1. Pair of longer vectors have greater influence on similarity
2. Closely oriented vectors have greater impact
3. Closer the vectors – more considerable contribution

3 Impact factors:
- **magnitudes**
  \[
  s_{nk}(AB) = |\vec{v}_n| \cdot |\vec{v}_k| \cdot \exp\left(-\frac{r_{n,k}^2}{\sigma^2}\right)
  \]
- **angles**
  \[
  \cos \angle(\vec{v}_n; \vec{v}_k)
  \]
- **distance**
Comparison of Vector Sets

Similarity index of two vector sets:

\[ s(B, A) = \sum_{n=1}^{N} \sum_{k=1}^{K} s_{n,k}^{(BA)} \]

\[ S(B, A) = \frac{s(B, A)}{\sqrt{s(B, B) \cdot s(A, A)}} \]

Drawbacks:
1. Index is influenced by image contrast
2. Neighborhood vessel impact on similarity

Advantages:
1. Value is normalized between 0 and 1

Algorithm is not rotation and scale invariant – we have used the palm fixing stand for accurate image acquisition without shifts.
Construction of the Database

• Database of 400 images from 50 persons
• Result of comparison for 2 cases
Comparison with Database

Because of the time critical recognition stage we evaluate performance with several number of vectors - 64 / 51 / 26
Results of database evaluation

Each image is compared with each other image in database

Each black square represents the 8 images of each person

Black dots represent the FA
White dots represent the FR

Thresholded similarity indexes matrix, using 64 of 64 vectors, EER=0.17%
Experimental results

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<thead>
<tr>
<th></th>
<th>P2PM</th>
<th>ICPM</th>
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</thead>
<tbody>
<tr>
<td>EER</td>
<td>2.679%</td>
<td>0.557%</td>
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These methods* use binary image comparison and the database of 500 persons

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Our method uses vector set comparison, but database of 50 persons

Conclusions

- **Imaging**
  - Reflection method is more suitable for real system
  - Power efficiency can be achieved using IR LEDs

- **Processing**
  - CMF is suitable for embedded solutions
  - Complexity of CMF can be reduced ~ 200 times

- **Recognition**
  - Rotation and scale invariance must be considered
  - Further study on efficient vector comparison needed
Thank you!