Processing of Palm Print and Blood Vessel Images for Multimodal Biometrics

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Motivation

Multimodal Biometrics

- Provides:
  - Easy enrolment
  - Unique parameters
  - Hard to falsify
Outline

Image acquisition  Image processing  Feature comparison  Data fusion & Recognition  Results

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Outline

- Image acquisition
- Image processing
- Feature comparison
- Data fusion & Recognition
- Results

Image showing false acceptance rate (FAR) and false rejection rate (FRR) as functions of a threshold, with equal error rate (EER) as a point of intersection.

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Image Acquisition (I)

In visible light spectrum using white LEDs
Image Acquisition (II)

In infrared light spectrum using IR LEDs
Image processing (I)

Cross section of the ridge

Cross section of the vessels
Complex 2D Matched Filtering:

- Based on the matched filtering
- Improved processing speed (angle invariant)
- Obtains vectors and their angular orientation in the image

\[
CMF(x, y) = \sum_{l} e^{jk\phi_l} G(x, y, \phi_l)
\]

For further information:
Most significant vectors are extracted to describe the object. The result is a data set of 64 vectors (256 bytes).
Feature comparison (I)

Vector set A
Vector set from the database

Vector set B
Acquired vector set
Feature comparison (II)

\[ \vec{v}_p(A) \quad \vec{v}_q(B) \]

Magnitudes:

\[ \left| \vec{v}_p(A) \right| \cdot \left| \vec{v}_q(B) \right| \]
Feature comparison (II)

Magnitudes: \[ |\vec{v}_p(A)| \cdot |\vec{v}_q(B)| \]

Angles: \[ \cos \angle (\vec{v}_p(A); \vec{v}_q(B)) \]
Feature comparison (II)

Magnitudes: \[ |\vec{v}_p(A)| \cdot |\vec{v}_q(B)| \]

Angles: \[ \cos \angle(\vec{v}_p(A); \vec{v}_q(B)) \]

Distance: \[ \exp \left( - \frac{d_{||}^2}{\sigma_{||}^2} \right) \cdot \exp \left( - \frac{d_{\perp}^2}{\sigma_{\perp}^2} \right) \]
Feature comparison (II)

Magnitudes: \[ |\vec{v}_p (A)| \cdot |\vec{v}_q (B)| \]

Angles: \[ \cos \angle(\vec{v}_p (A); \vec{v}_q (B)) \]

Distance: \[ \exp \left( -\frac{d^2_{\parallel}}{\sigma^2_{\parallel}} \right) \cdot \exp \left( -\frac{d^2_{\perp}}{\sigma^2_{\perp}} \right) \]

Similarity of particular pair of vectors: \[ S_{p,q} \]
Feature comparison (II)

Similarity of two vector sets:

$$s(A, B) = \sum \sum S_{p,q}$$

Similarity index is normalized so that $S(A, B)$ is in the [0;1]
Database evaluation (I)

• Two databases; 500 images from 50 persons
• 5 images in IR and 5 in visible light spectrum

Palm prints EER = 2.82%
Palm vessels EER = 0.32%
Database evaluation (II)

We evaluate two parameters to estimate the system’s overall performance:

EER and FRR at FAR ≤ 0.01%

Because minimal FAR is more important in practical systems than FRR.
Fusion (I)

A pair of similarity indexes $S_1$ and $S_2$

Vessel comparison

Database

Ridge comparison

Database
A pair of similarity indexes can be plotted as a dot in \((S_1; S_2)\) plane.
For positive comparison of two data sets, similarity values are expected to be high, so the dot appears in the upper right corner of the plane.
For negative comparison of two data sets, similarity values are expected to be low, so the dot appears in the lower left corner of the plane.
By analyzing both databases we can construct two sets that represent the positive and negative comparisons of evaluated database. The main task is to find an optimal separation threshold.
Fusion (I)

Using only one parameter (palm prints or palm blood vessels), separating line is either horizontal or vertical and the performance is poor.
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Using only one parameter (palm prints or palm blood vessels), separating line is either horizontal or vertical and the performance is poor.
By using both parameters we can choose an arbitrary separating function which improves the performance of biometric system

\[ T = f(S_1; S_2) \]

For simplicity we use a separating line

\[ T = k \cdot S_1 + (1 - k) \cdot S_2 \]
Fusion (II)

• Linear separation of two data sets

\[ T = k \cdot S_1 + (1 - k) \cdot S_2 \]

• Using this approach, FAR and FRR are functions of two parameters that can be plotted as surfaces:

We search for the optimal threshold and k value so that:
- EER(k) is minimized and
- \( FRR_{FAR\leq0.01\%} (k) \) is minimized
Results

EER

Palm prints: 2.82%
Palm veins: 0.32%
Fusion: 0.1%

FRR (FAR ≤ 0.01%)

Palm prints: 16.3%
Palm veins: 4.1%
Fusion: 0.3%
Conclusions

• Using the palm print and palm blood vessel images eases the enrolment procedure.
• Two parameters increase the overall system’s precision.
• Complex 2D Matched Filtering approach speeds up the feature extraction procedure.
• Further research with larger database is needed.

• Future work: embedded system development
Questions?!