Some Recent Works in Fingerprint Recognition

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2013.10.25
New methods (after 2010):
- Extended fingerprint features
- 3D- fingerprint recognition
- Latent fingerprint recognition

Our works:
- Non-minutiae fingerprint matching
- Two-stage filtering enhancement
background

- Minutiae-based

Fig. 1. An example of two fingerprints with distortion from the same finger.
Gabor-filters fingercode

Extended fingerprint features

Fig. 1: Extended features defined by CDEFFS (http://fingerprint.nist.gov/standard/cdeffs/). (a) Pores, (b) Dots, (c) Incipient ridges, (d) Creases, (e) Ridge edge protrusions, (f) Ridge skeletons, and (g) Ridge path segments.

Fig. 2: Example pore extraction results.

- Level 1 (pattern), Level 2 (minutiae points) and Level 3 (pores and ridge shape).
Fingerprint Resolution

- **250 ~ 300 ppi**: the minimum resolution for Level 1 & 2 feature extraction
- **500 ppi**: (50 micra): FBI standard for AFIS
- **1000 ppi**: the minimum resolution for Level 3 feature extraction, e.g., pores (~60 micra)

Latent fingerprint recognition

Fig. 3. Proposed algorithm for separating overlapped fingerprints: 1) estimating the initial orientation field (OF); 2) separating overlapped orientation fields into component orientation fields; and 3) separating overlapped fingerprints into component fingerprints.


Fig. 3. Overview of the proposed approach.

Our works:

- Non-minutiae fingerprint matching
- Two-stage filtering enhancement
Non-minutiae based method

- motivation:
  - Input variation, non-linear deformation
  - Shortcomings of minutiae-based method
  - Non-minutiae, block invariant features

- Publications:
Gabor-filters fingercode

Wavelet based

DCT based

Fourier-Mellin invariant transform

Invariant moments

(a) Tessellated cells (local) or (b) tessellated cells (global) (Yang & Park, 2008a)

Hu moments + zernike moments

(a) s1  (b) s2  (c) s3  (d) s4

Four sub-images.
Our works:
- Non-minutiae fingerprint matching
- Two-stage filtering enhancement
Two-stage enhancement

motivation:

- Fuzzy, merged, poor quality
- Local Ridge Compensation
- Two-stage filtering enhancement

Publications:

Fig. 1. Diagram of the whole process of the proposed two-stage enhancement scheme (dire = ridge direction, freq = ridge frequency).
Spatial Ridge-Compensation Filtering

ftimg(i, j) = \frac{\sum_{m=-\lfloor\frac{w-1}{2}\rfloor}^{\lfloor\frac{w-1}{2}\rfloor} \sum_{n=-\lfloor\frac{h-1}{2}\rfloor}^{\lfloor\frac{h-1}{2}\rfloor} \text{norm}(i', j')} {((w-1) \times \beta + \alpha) \times h)}

(6)

i' = i + m \cos(O(i, j)) + n \sin(O(i, j))

(7)

j' = j - m \sin(O(i, j)) + n \cos(O(i, j))

(8)

mask = \begin{bmatrix}
\beta & \beta & \beta & \beta & \beta & \beta & \beta & \beta & \beta \\
\alpha & \alpha & \alpha & \alpha & \alpha & \alpha & \alpha & \alpha & \alpha \\
\beta & \beta & \beta & \beta & \beta & \beta & \beta & \beta & \beta
\end{bmatrix}
Frequency domain filtering

Using polar coordinates \((\rho, \phi)\) to express the filters as a separable function, the frequency bandpass filters \(H(\rho, \phi)\) used are separable in the radial and the angular domains, respectively and are given as follows:

\[
H(\rho, \phi) = H_\rho(\rho)H_\phi(\phi) \tag{10}
\]

\[
H_\rho(\rho) = \frac{1}{\sqrt{2\pi \rho_{BW}}} \exp \left( -\frac{(\rho - \rho_c)^2}{2\rho_{BW}} \right) \tag{11}
\]

\[
H_\phi(\phi) = \begin{cases} 
\cos^2 \frac{\pi}{2} \frac{(\phi - \phi_c)}{\phi_{BW}} , & \text{if } |\phi| < \phi_{BW}, \\
0, & \text{otherwise.}
\end{cases} \tag{12}
\]
Designed radial filter in the Fourier domain with $\rho_c = 5.0$. 
Frequency domain filtering

a) FFT domain: The FFT of each subimage is obtained by removing the dc component, $F = \text{FFT}(\text{block\_fltimg})$.

b) Angular filter: The angular filter $F_a$ is applied, which is centered on the local orientation image and with the bandwidth inversely proportional to the coherence image using (12).

c) Radial filter: The radial filter $F_r$ is applied, which is centered on the local frequency image using (11).

d) Filtered image: The block is filtered in the frequency domain, i.e., $F = F \times F_a \times F_r$.

e) Reconstructed image: The enhanced image is reconstructed by $\text{Enhimg} = \text{IFFT}(F)$. 
Examples of two-stage enhanced images. (a)(c) original image; (b)(d) enhanced image
(a) Original image (b) Gabor filter enhancement (c) STFT enhancement (d) Our proposed method
Conclusion

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  - 3D-fingerprint recognition
  - Latent fingerprint recognition

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Thanks!