EEE-6561 Fundamentals of Biometric Identification

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Lecture #11: Fingerprint Recognition (Part 2)

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Outline

1. Introduction
2. Friction Ridge Pattern
3. **Fingerprint Acquisition**
4. Feature Extraction
5. Matching
6. Fingerprint Indexing
7. Fingerprint Synthesis
8. Palmprint
9. Summary

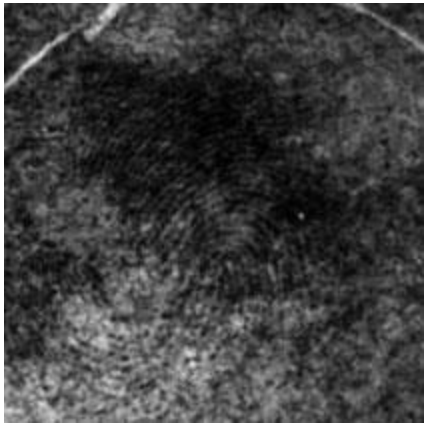
3. Fingerprint Acquisition

- The process of capturing and digitizing the fingerprint of an individual.
- Digital images of the fingerprints can be acquired using
  - off-line method (inked fingerprint, latent fingerprint);
  - on-line method (live-scan fingerprint).

3.1 Fingerprint Acquisition: Sensing techniques

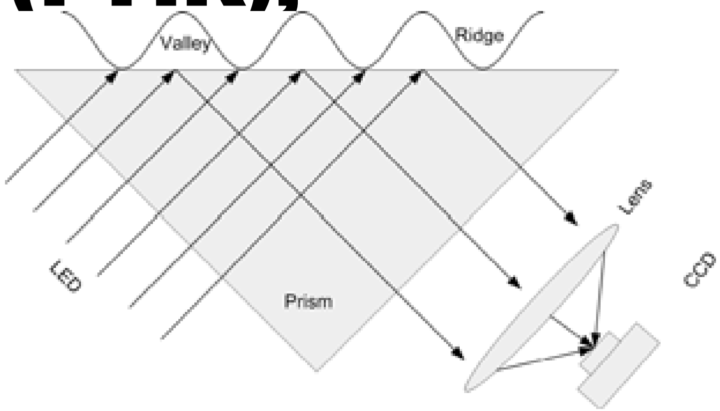
- An example of inked fingerprint, live-scan fingerprint and latent fingerprint.





3.1 Fingerprint Acquisition: Live-scan sensing techniques

- Optical Frustrated Total Internal Reflection (FTIR);



- Capacitance;
- Ultrasound Reflection;
- Piezoelectric Effect;
- Temperature Differential.

3.2 Fingerprint Acquisition: Image quality

- It is obvious that the fingerprint image quality is very important.
- Influence factor:
  - image resolution;
  - finger area;
  - clarity of ridge pattern.
- Live-scan or inked fingerprints are typically of better quality than latent fingerprints.

3.2 Fingerprint Acquisition: Image quality

- Examples of low quality fingerprint images (dry, wet, and creases).

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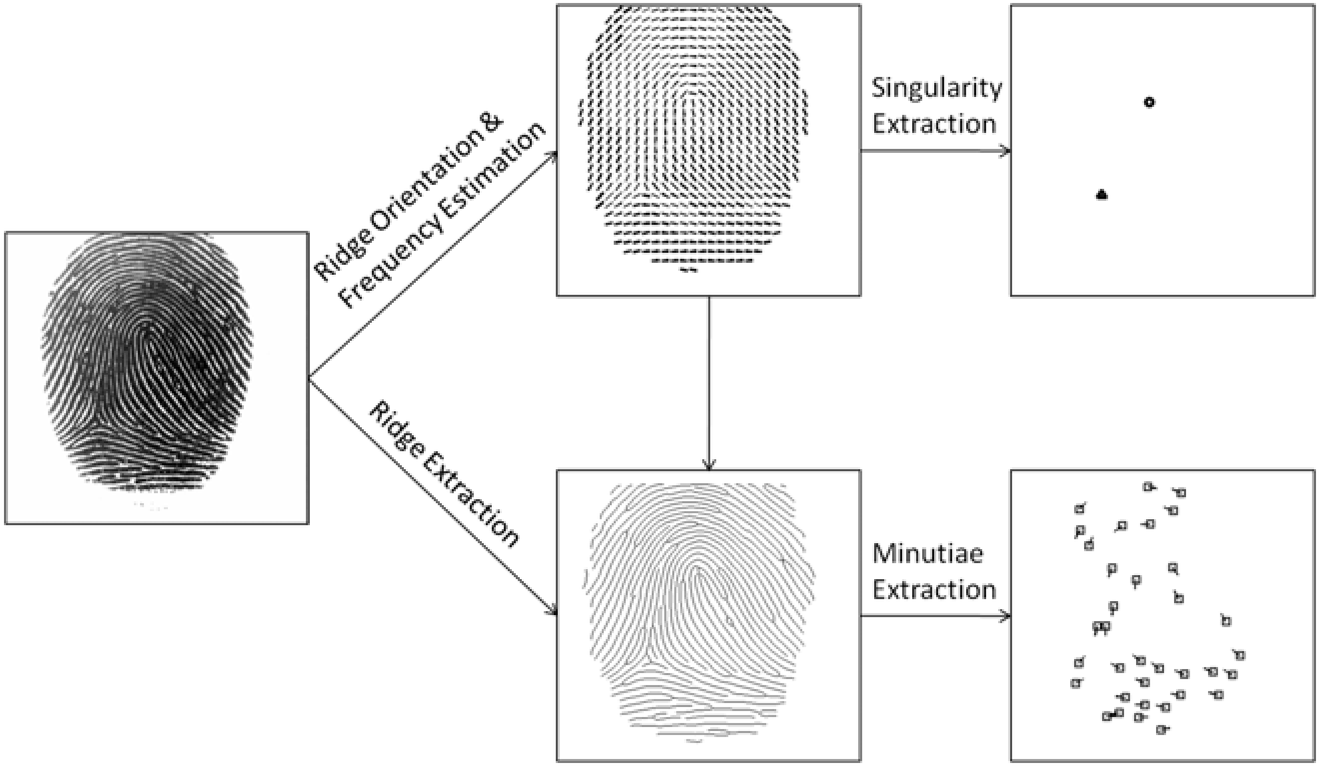
4. Feature Extraction

- **A typical feature extraction algorithm includes four main steps:**
  - **ridge orientation and frequency estimation;**
  - **ridge extraction;**
  - **singularity extraction;**
  - **minutiae extraction.**

4. Feature Extraction

- **Schematic diagram for the extraction of level 1 and level 2 features from a fingerprint image.**



4.1 Feature Extraction: Ridge parameters estimation

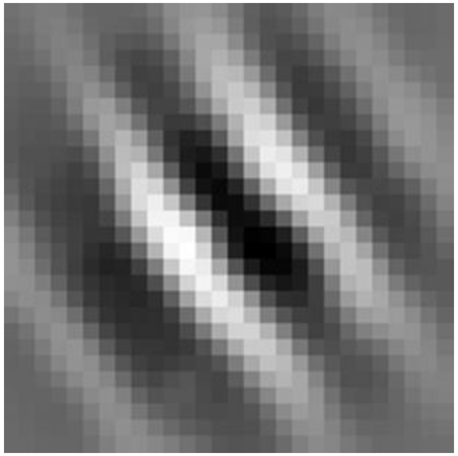
- **Ridge pattern in a local area of a fingerprint can be approximated by a cosine wave**

$$w(x,y) = A\cos(2\pi f_0(x\cos\theta + y\sin\theta))$$

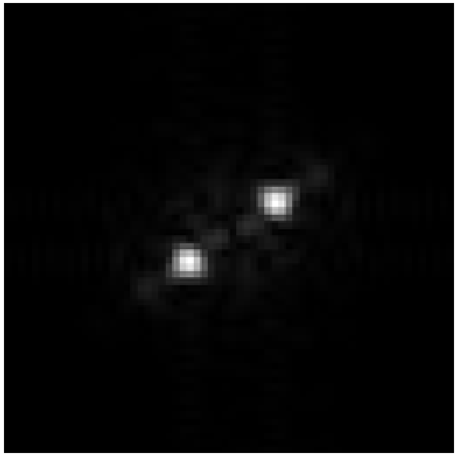
- **2D Fourier transform of cosine wave**

$$W(u,v) = \frac{A}{2}[\delta(u - f_0\cos\theta, v - f_0\sin\theta) + \delta(u + f_0\cos\theta, v + f_0\sin\theta)]$$

4.1 Feature Extraction: Ridge parameters estimation



local ridge pattern



magnitude spectrum

- **Let $(\widehat{u}, \widehat{v})$ denote the location of the maximum magnitude, then**

$$\widehat{A} = |W(\widehat{u}, \widehat{v})|,$$

$$\widehat{\theta} = \arctan\left(\frac{\widehat{u}}{\widehat{v}}\right),$$

$$\widehat{f}_0 = \sqrt{\widehat{u}^2 + \widehat{v}^2}.$$

4.1 Feature Extraction: Ridge parameters estimation

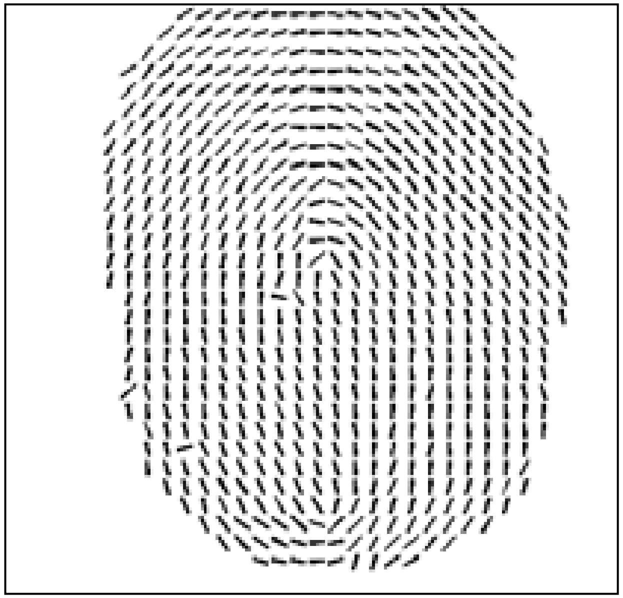
- To deal with noise, we should **smooth** the orientation field.
- Special consideration on ridge orientation:
  - in the range $[0, \pi)$.
  - θ and $(\theta + \pi)$ is the **same** orientation.
  - the average value between 1° and 179° should be **0° rather than 90°**!

4.1 Feature Extraction：Ridge parameters estimation

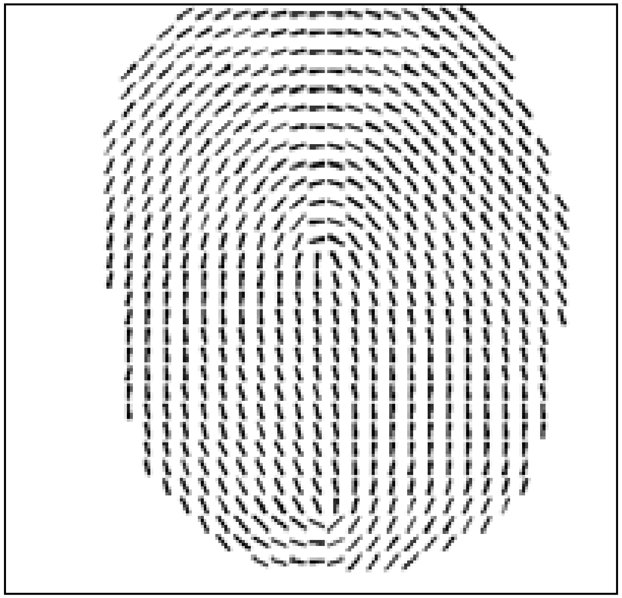
- **3 steps to smooth orientation field:**
  - **Construct a vector field** $V = \left(V_x, V_y\right) = (\cos 2\theta, \sin 2\theta)$**;**
  - **Perform low pass filtering on the two components of the vector field separately to obtain the smoothened vector field** $V' = ({V_x}', {V_y}')$**;**
  - **The smoothened orientation field is given by** $\frac{1}{2}\arctan(\frac{{V_x}'}{{V_y}'})$**.**

4.1 Feature Extraction：Ridge parameters estimation

Fingerprint image



Initial (noisy) orientation field



Smoothed orientation field

Questions