

指紋辨識技術

義守大學電機系

機器智慧與自動化技術(MIAT)實驗室

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2004年4月6日



大綱

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PART 2 : 指紋影像感測器

PART 3 : 指紋影像增強

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PART 5 : 指紋特徵點比對



PART 1

指紋與生物辨識

Fingerprint and Biometrics

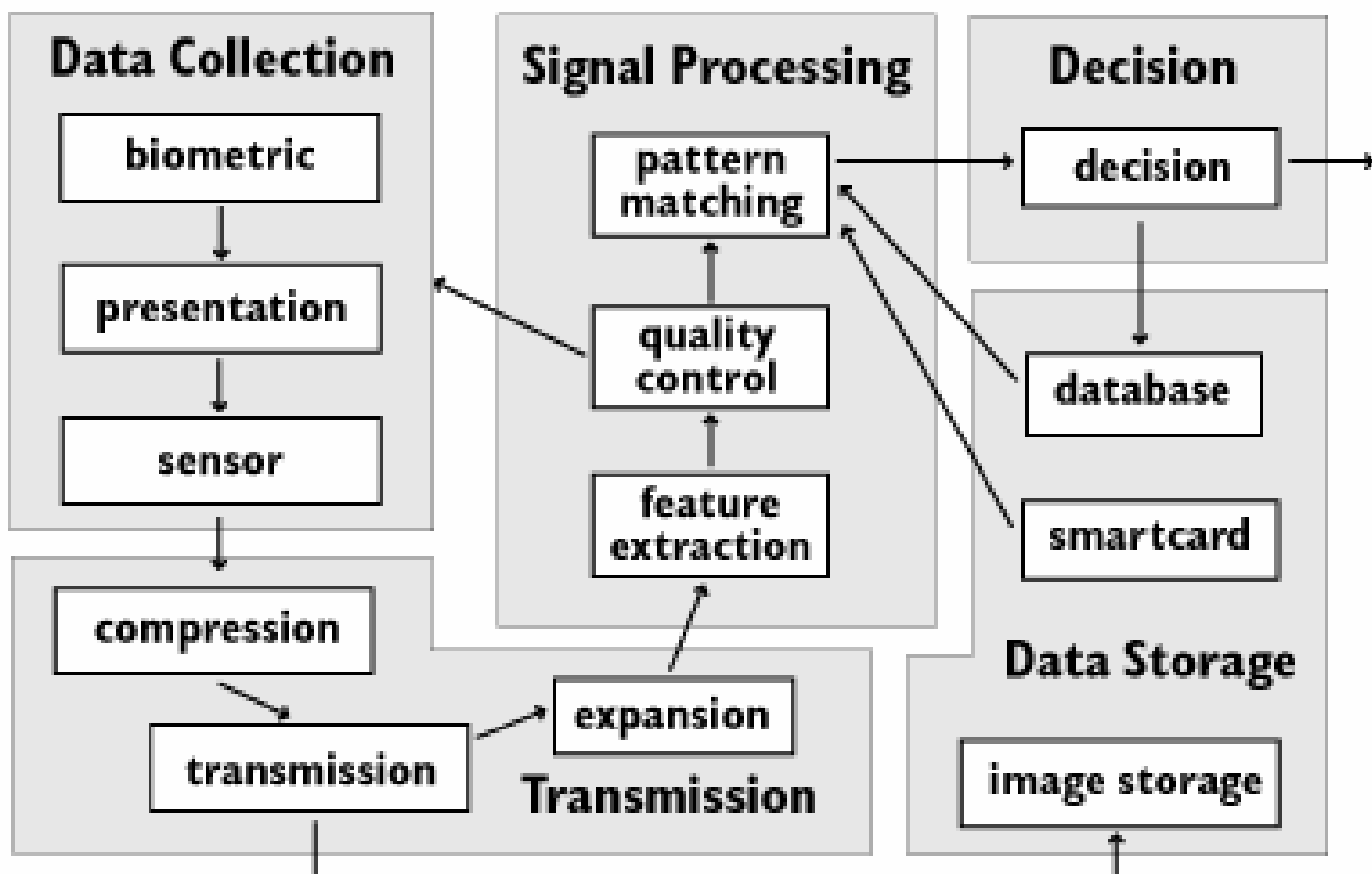


What is Biometrics?

- automated methods of recognizing a person based on a physiological or behavioral characteristics
- characteristics used by biometric security systems include
 - **Fingerprints**
 - Voiceprints
 - facial features
 - writing patterns
 - retinal patterns
 - hand geometry



Biometric Security





High/Low Contrast Fingerprint



High contrast print

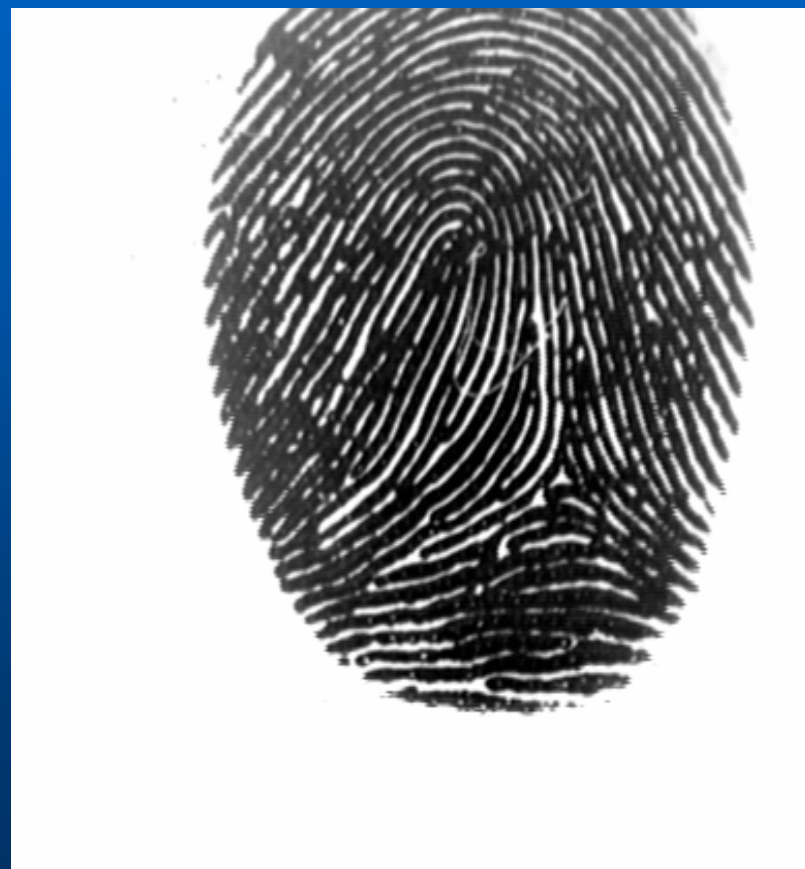
Low contrast print



Dry/Wet Fingerprint



Typical dry print



Typical Wet Print



PART 2

指紋影像感測器

fingerprint capture devices



Comparison of Fingerprint Capture Devices

Company	Technology	Type	Area (in)
Identicator	Optical	Touch	0.6×0.72
Digital Persona	Optical	Touch	0.7×0.7
SecuGen	Optical	Touch	0.53×0.64
Ethentica	Electro-optical	Touch	0.56×0.76
Veridicom	Capacitive	Touch	0.6×0.6
Authentec	<i>E</i> -field	Touch	0.51×0.51
Infineon	Capacitive	Touch	0.43×0.56
Atmel	Thermal	Swipe	0.55×0.06
Veridicom	Capacitive	Swipe	0.51×0.1

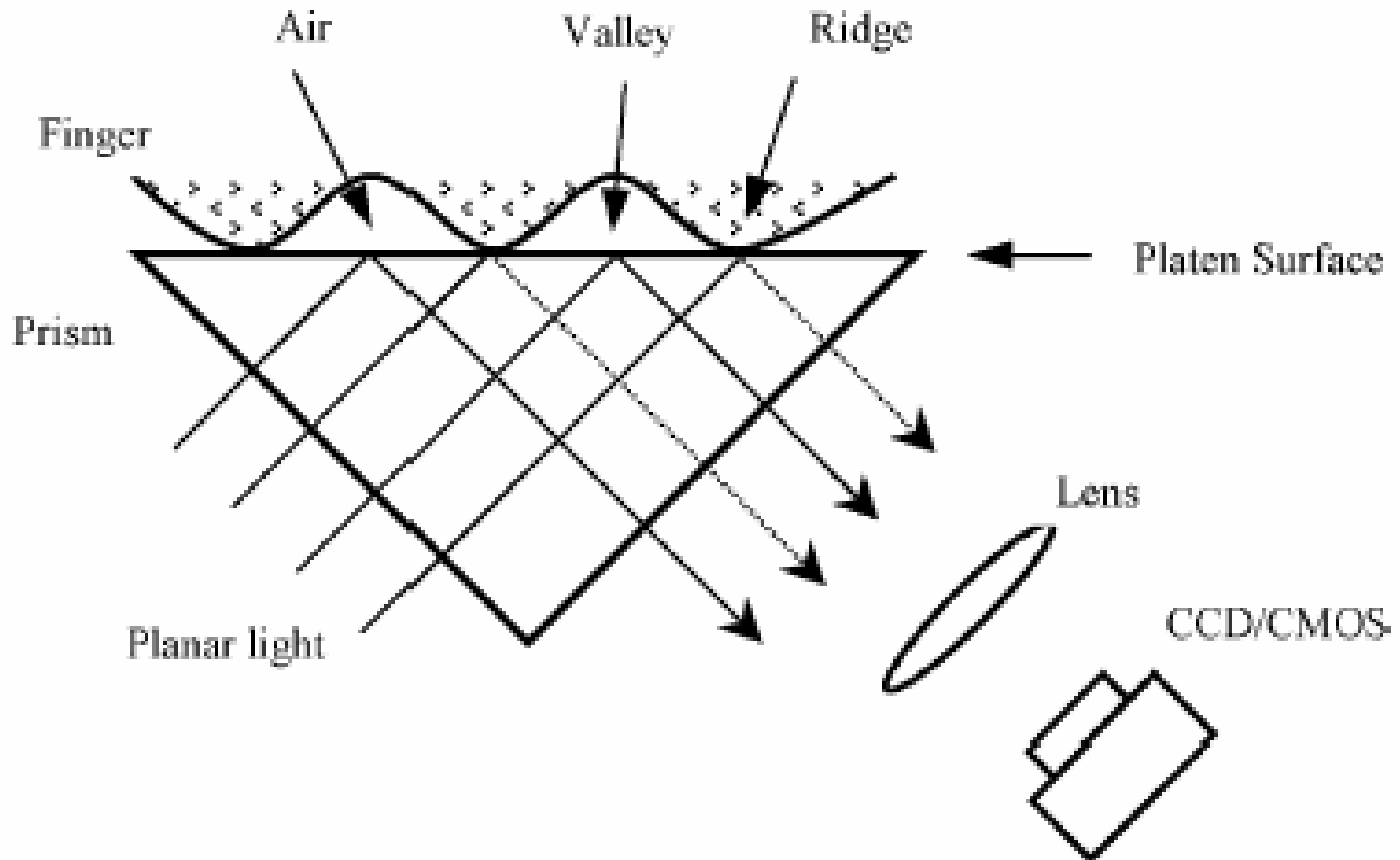


Comparison of Fingerprint Capture Devices(Cont.)

Company	System size	Resolution [dpi]	Bits/Pixel	Cost
Identicator	small	331	8	Low
Digital Persona	small	300	8	Low
SecuGen	small	450	8	Low
Ethentica	small	400	8	Low
Veridicom	small	500	8	Low
Authentec	small	250	8	Low
Infineon	small	500	8	Low
Atmel	smaller	500	8	Lower
Veridicom	smaller	500	8	Lower

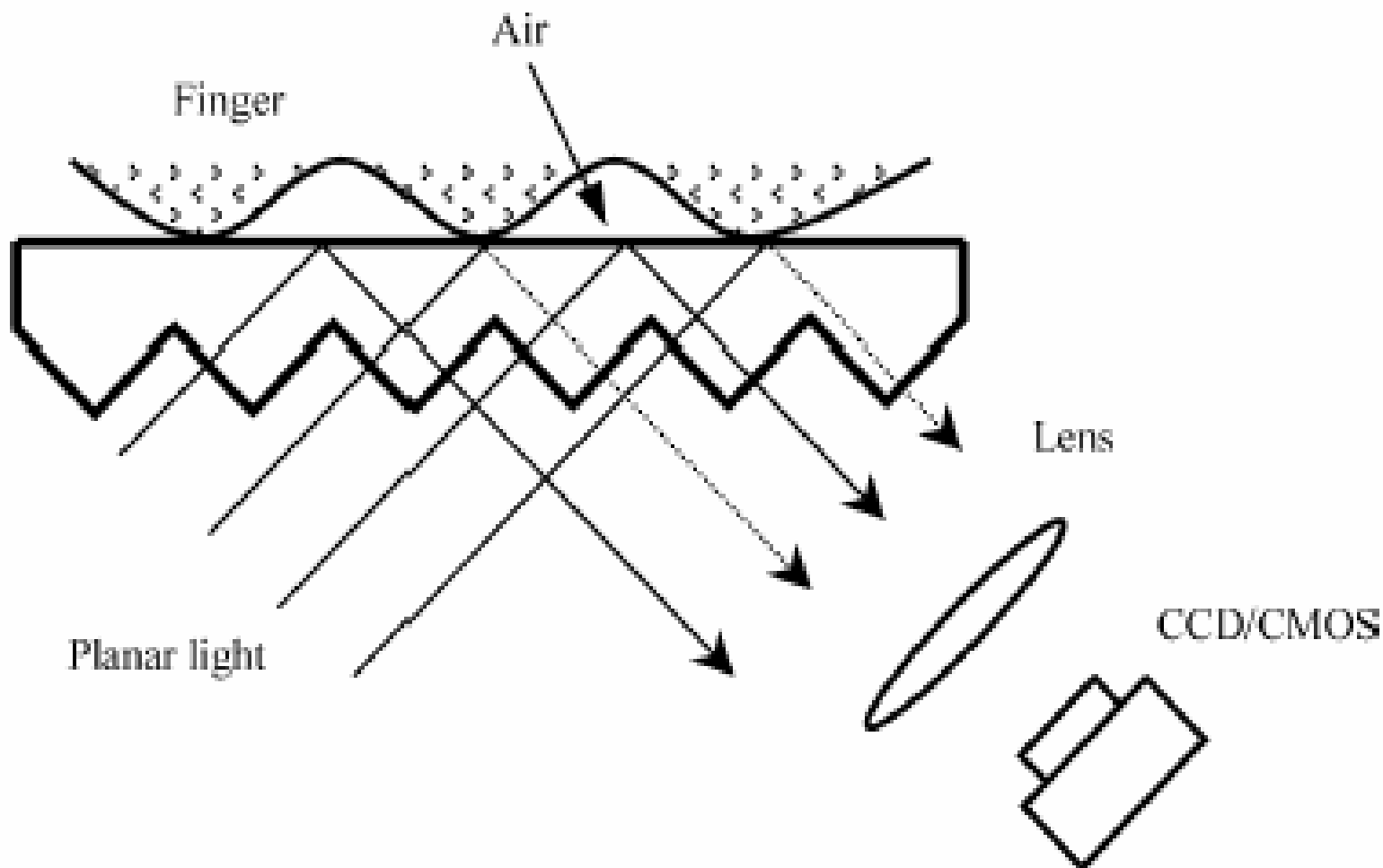


Optical Sensor



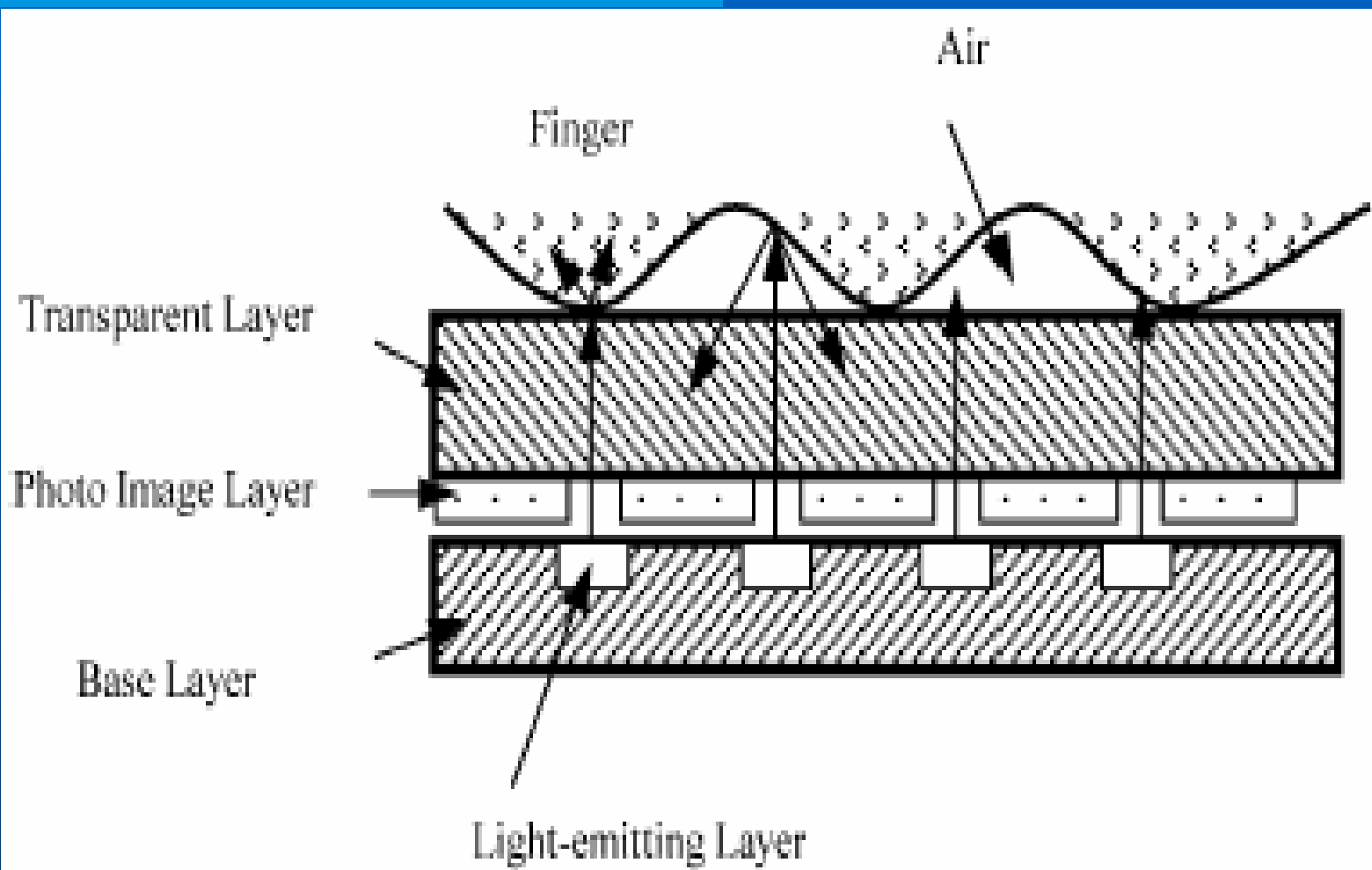


Small Size Optical Sensor



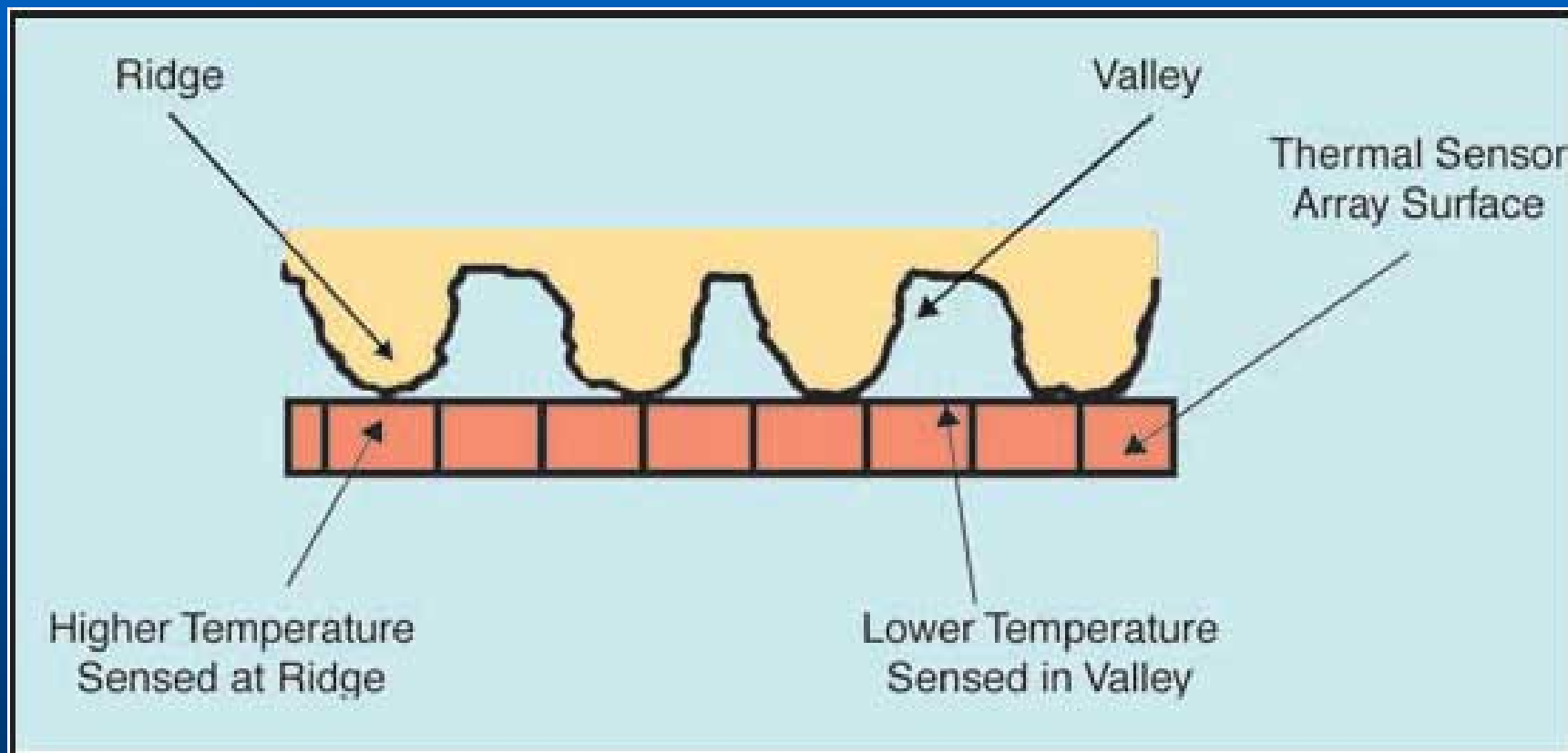


Electro-Optical Sensor



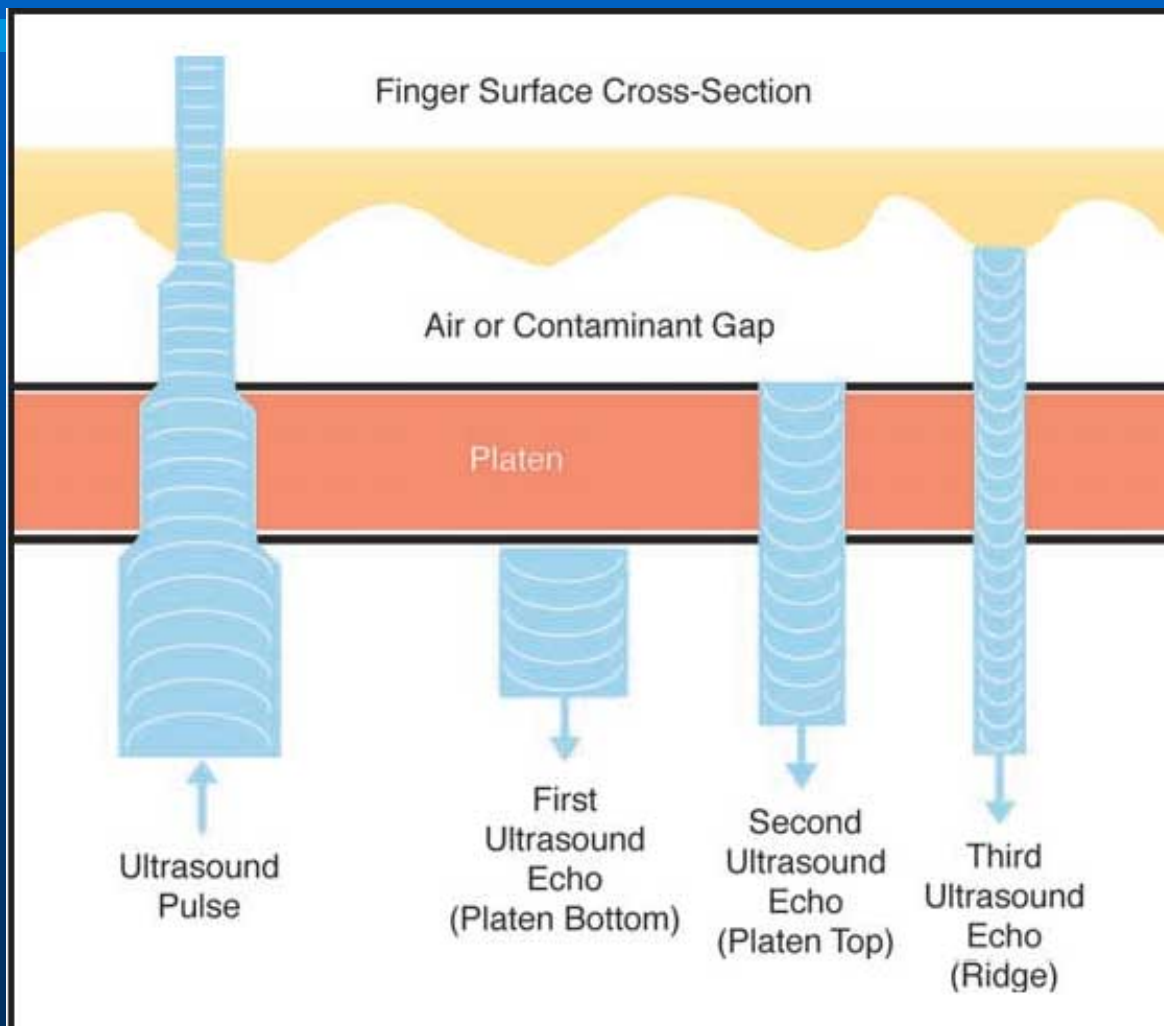


Thermal Sensor



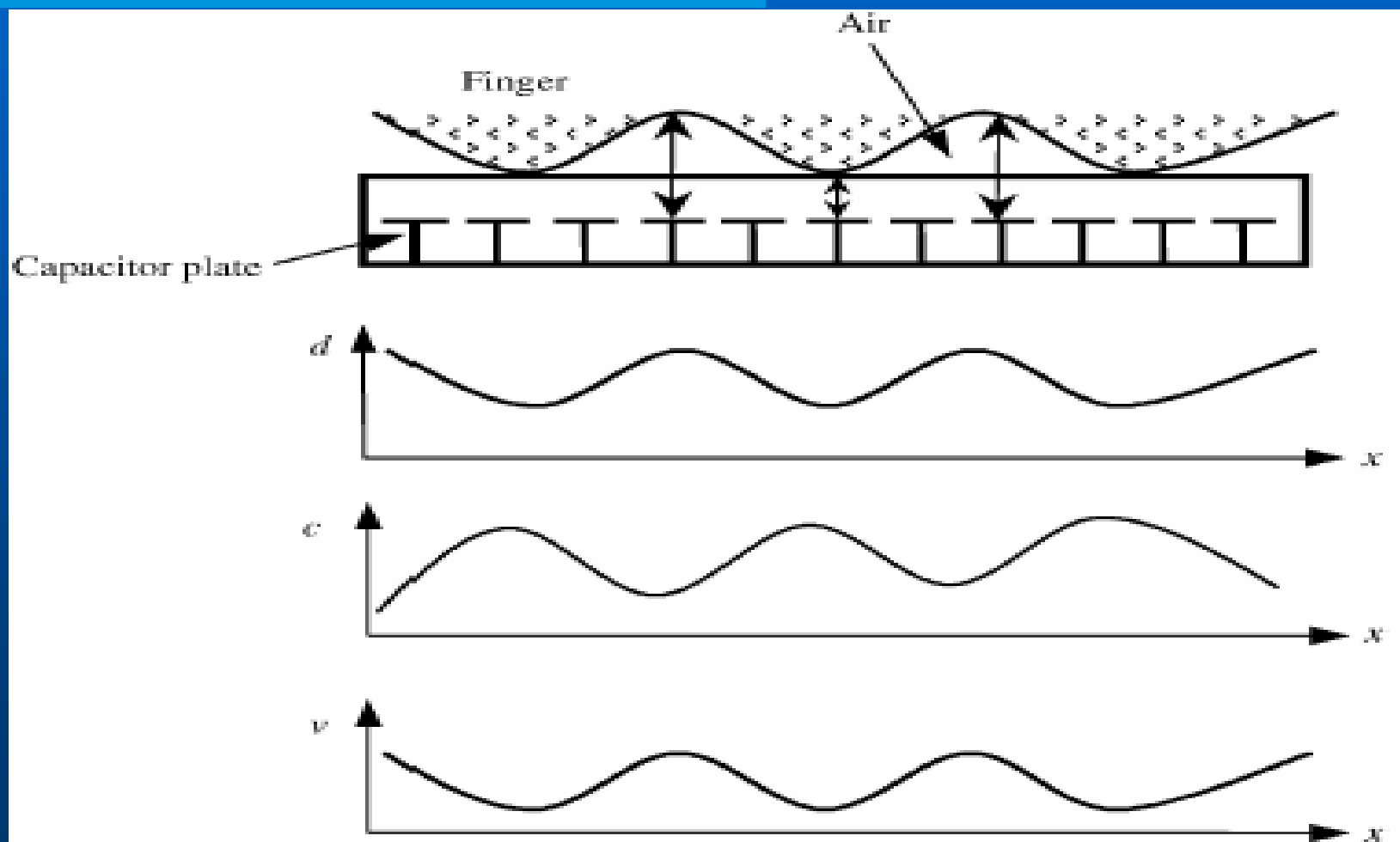


Ultrasonic Sensor



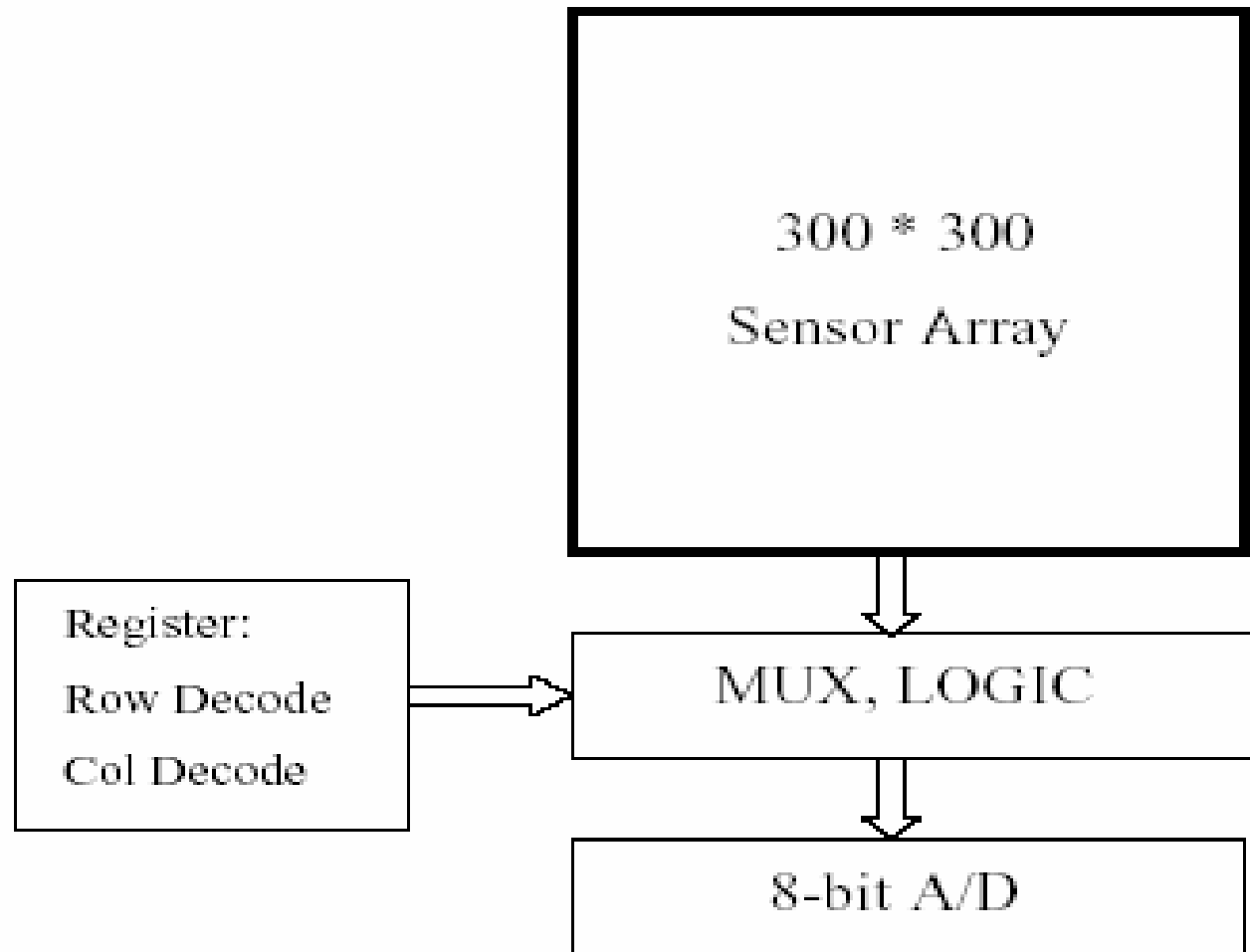


Capacitive Sensor



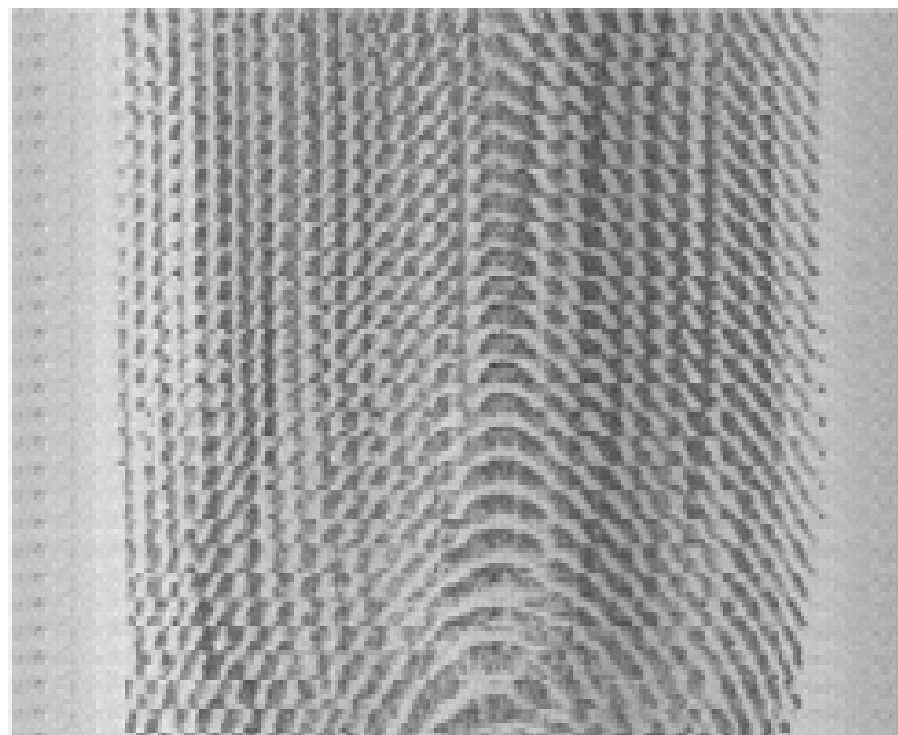


Capacitive Sensor





Swipe Sensor





Advantages of Swipe Sensor

- Much lower cost, 1/5 – 1/10 of a touch sensor
- Very small size
- Lower power consumption
- Permit longer length image is captured
- More durable due to smaller sensor area
- Self-cleaning via the swiping action
- No latent image.

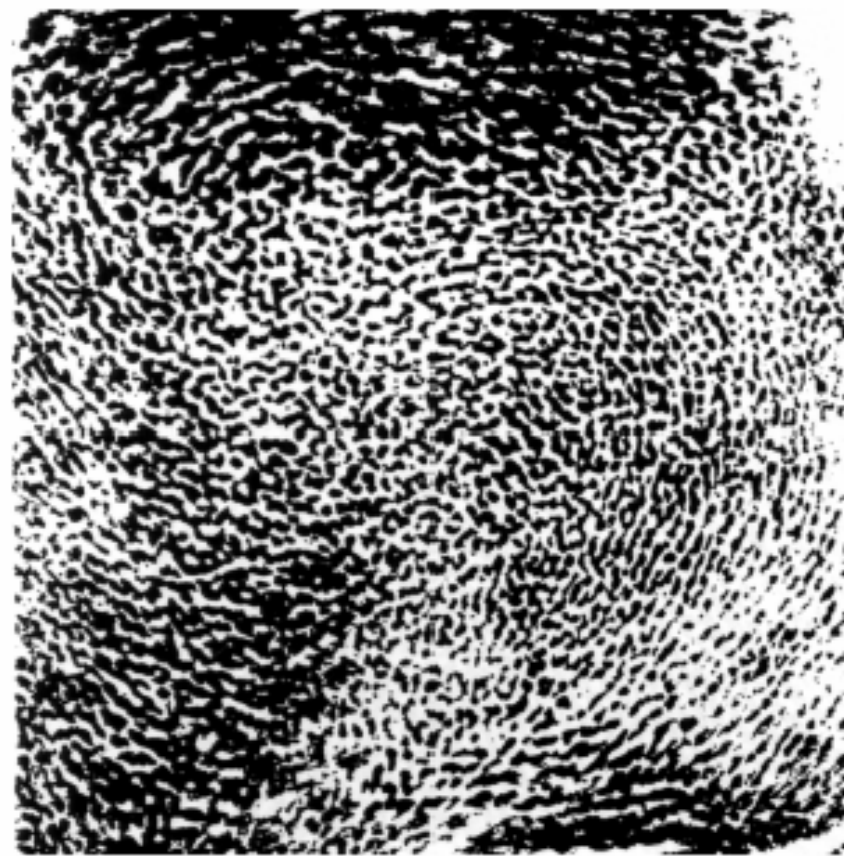


PART 3

指紋影像增強 Fingerprint Image Enhancement

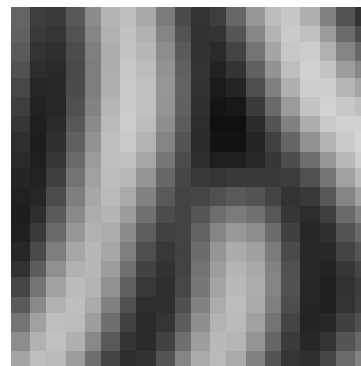
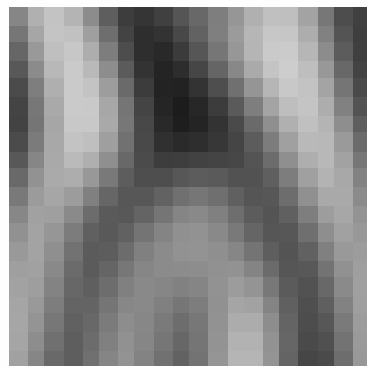
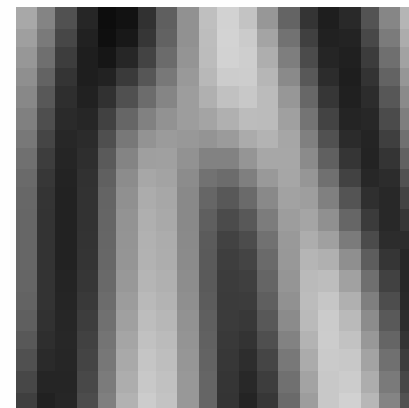
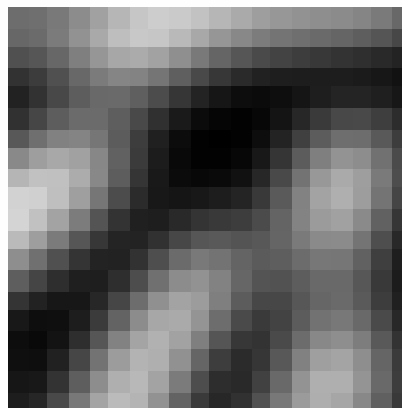
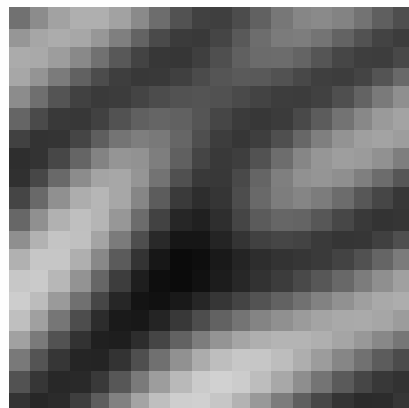


FP images of poor quality



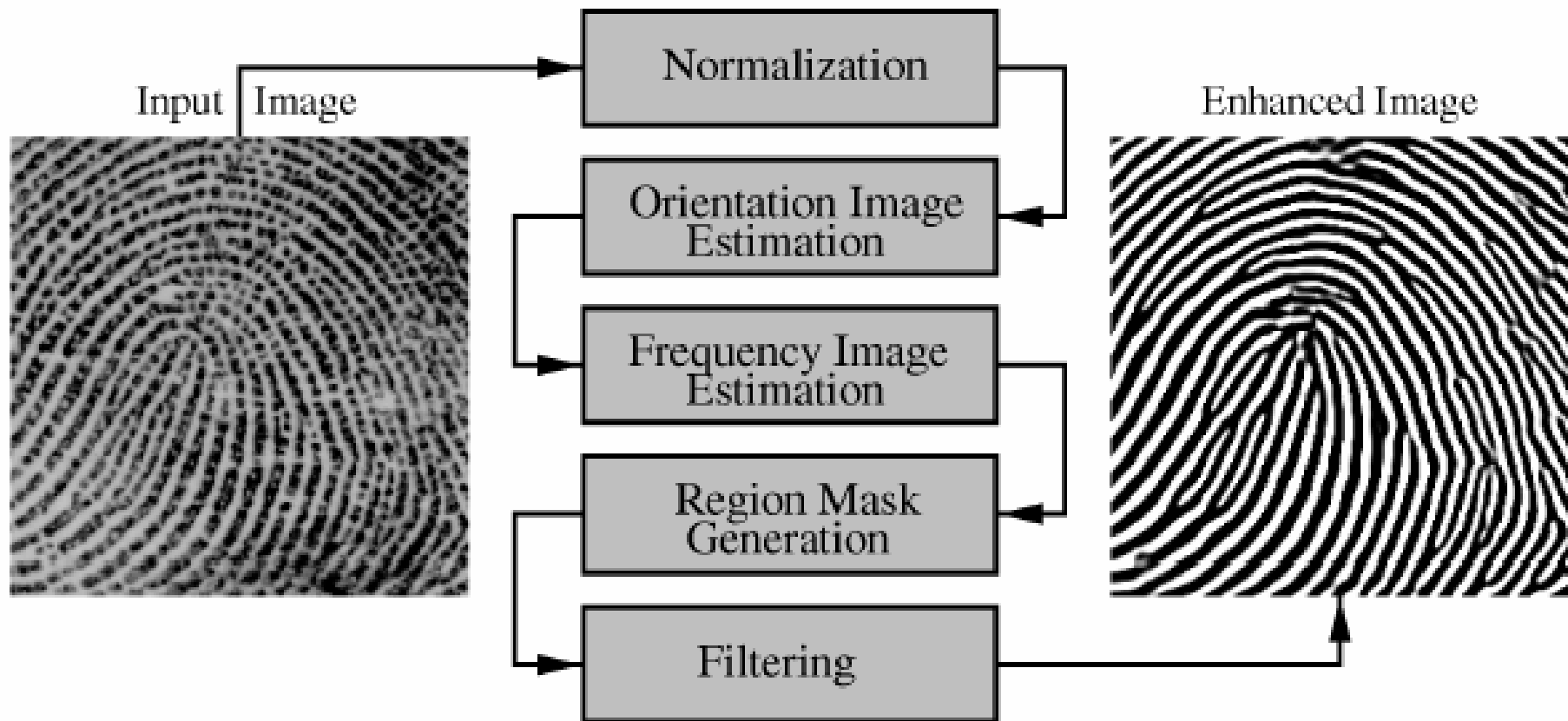


Ridge and Valley in FP Image





Fingerprint image enhancement





Normalization

$$G(i, j) = \begin{cases} M_0 + \sqrt{\frac{\text{VAR}_0(I(i, j) - M)^2}{\text{VAR}}} & \text{if } I(i, j) > M \\ M_0 - \sqrt{\frac{\text{VAR}_0(I(i, j) - M)^2}{\text{VAR}}} & \text{otherwise} \end{cases}$$





Orientation Image

$$\mathcal{V}_x(i, j) = \sum_{u=i-\frac{w}{2}}^{i+\frac{w}{2}} \sum_{v=j-\frac{w}{2}}^{j+\frac{w}{2}} 2\partial_x(u, v)\partial_y(u, v),$$

$$\mathcal{V}_y(i, j) = \sum_{u=i-\frac{w}{2}}^{i+\frac{w}{2}} \sum_{v=j-\frac{w}{2}}^{j+\frac{w}{2}} (\partial_x^2(u, v)\partial_y^2(u, v)),$$

$$\theta(i, j) = \frac{1}{2} \tan^{-1} \left(\frac{\mathcal{V}_y(i, j)}{\mathcal{V}_x(i, j)} \right),$$

$$\Phi_x(i, j) = \cos(2\theta(i, j)),$$

$$\Phi_y(i, j) = \sin(2\theta(i, j)),$$

$$\Phi'_x(i, j) = \sum_{u=-w_\Phi/2}^{w_\Phi/2} \sum_{v=-w_\Phi/2}^{w_\Phi/2} W(u, v)\Phi_x(i - uw, j - vw)$$

and

$$\Phi'_y(i, j) = \sum_{u=-w_\Phi/2}^{w_\Phi/2} \sum_{v=-w_\Phi/2}^{w_\Phi/2} W(u, v)\Phi_y(i - uw, j - vw),$$

$$O(i, j) = \frac{1}{2} \tan^{-1} \left(\frac{\Phi'_y(i, j)}{\Phi'_x(i, j)} \right)$$

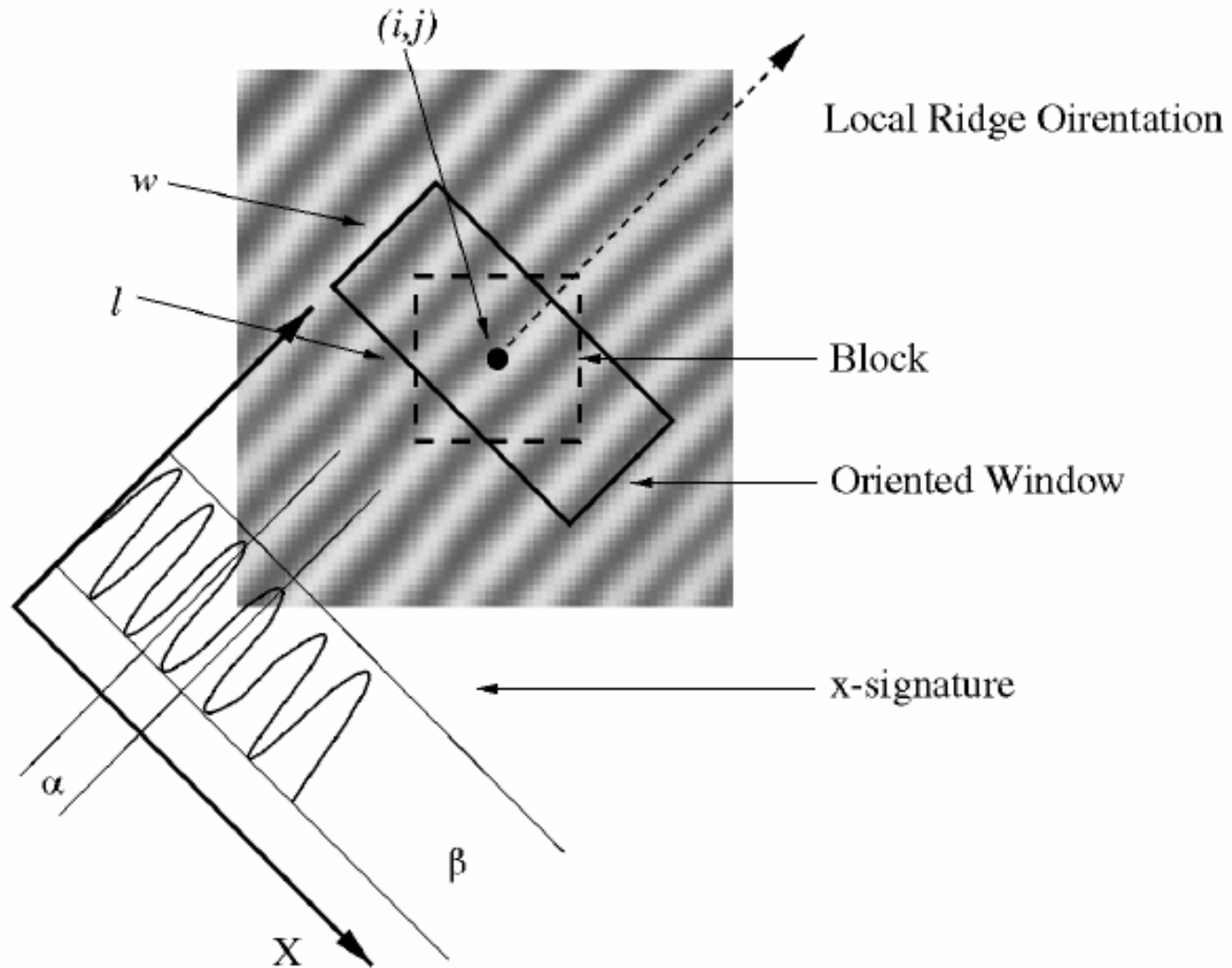


Orientation Image





Mask Generation





Gabor Filtering

$$h(x, y; \phi, f) = \exp\left\{-\frac{1}{2}\left[\frac{x_\phi^2}{\delta_x^2} + \frac{y_\phi^2}{\delta_y^2}\right]\right\} \cos(2\pi f x_\phi),$$

$$x_\phi = x \cos \phi + y \sin \phi,$$

$$y_\phi = -x \sin \phi + y \cos \phi,$$

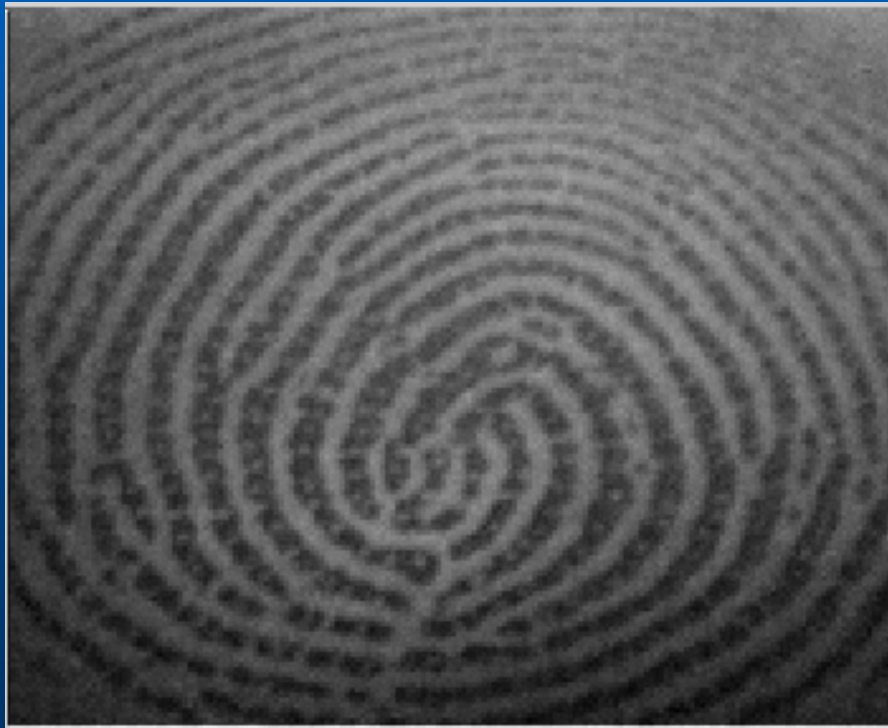


Result of Enhancement





MIAT's Approach



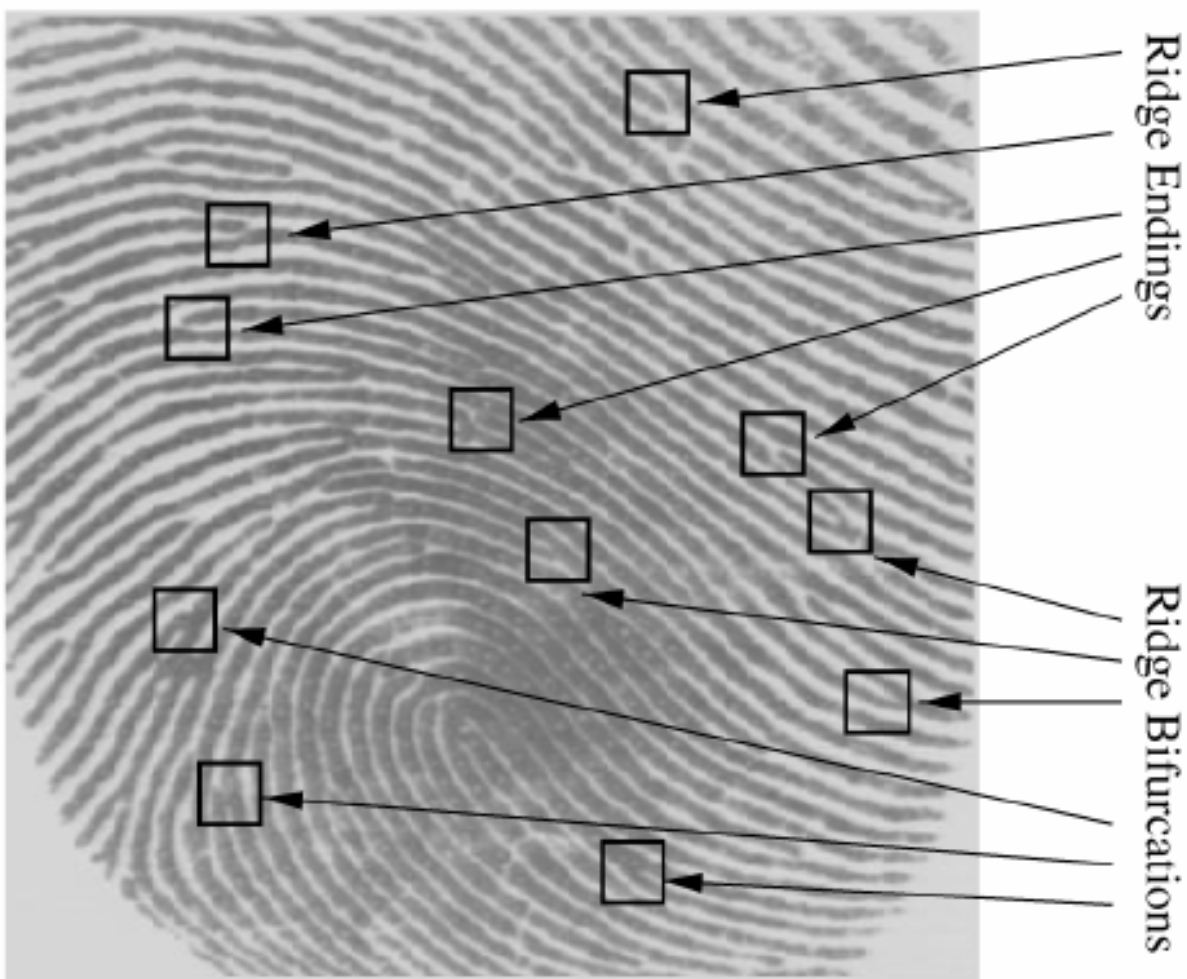


PART 4

指紋影像特徵點偵測 Fingerprint Minutia Detection

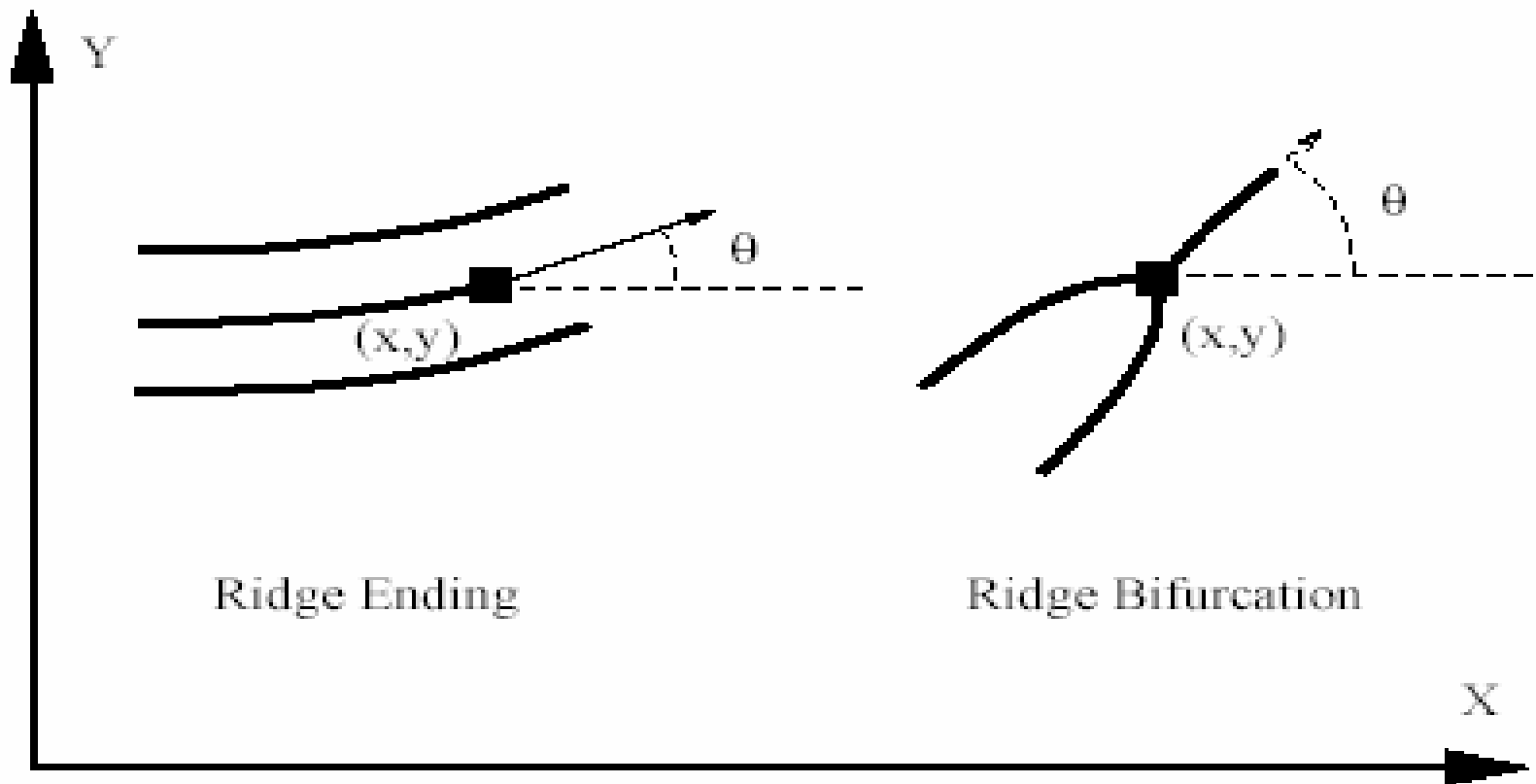


Minutiae in Fingerprint



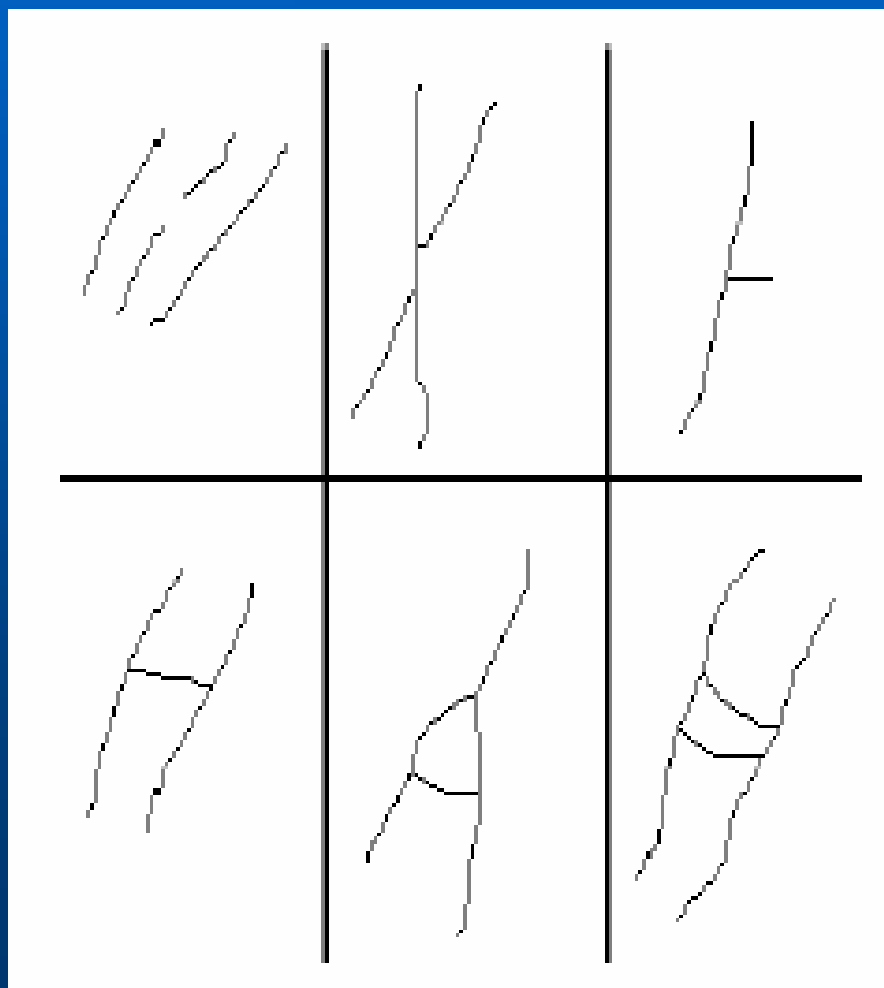


Fingerprint Minutiae





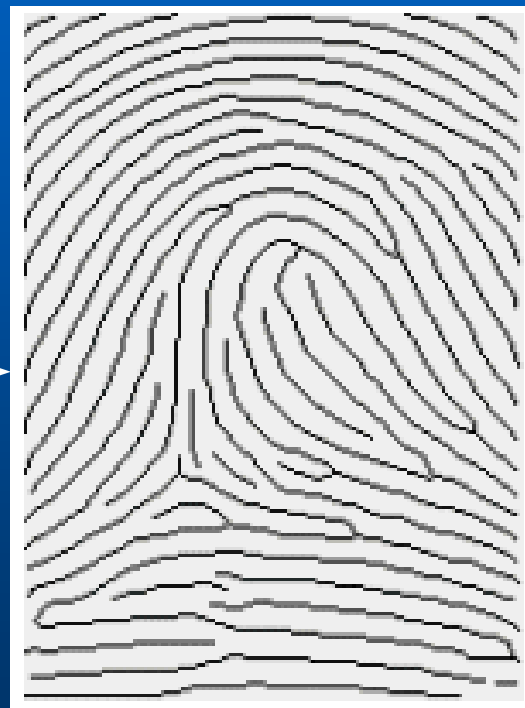
False Minutiae



- Close Endpoints
- Cross
- Spurs
- Bridges
- Triangles and ladders



Preprocessing



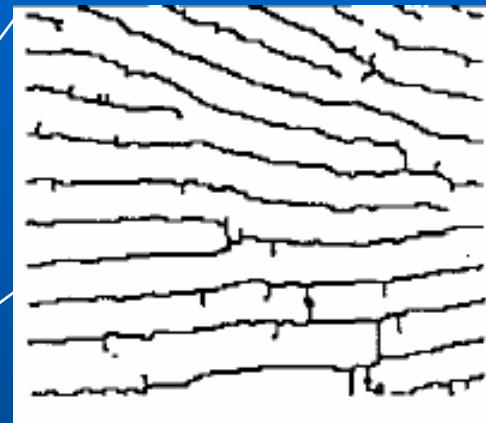


Minutiae Detection

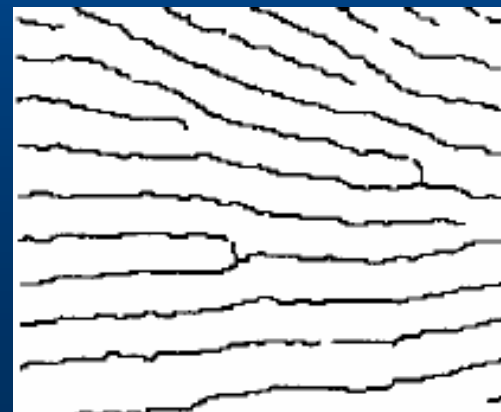
Enhancement



Thinning

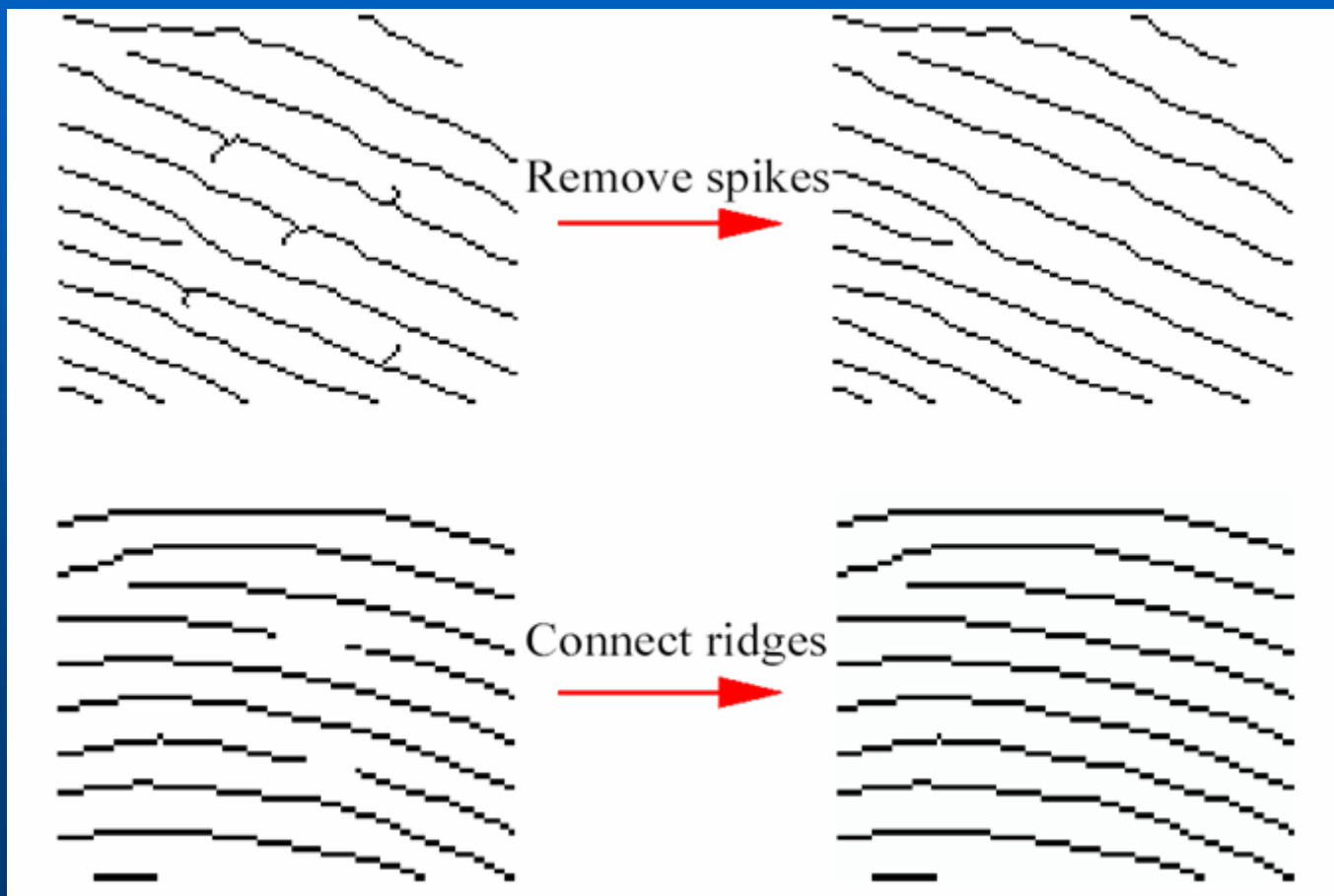


Ridge
Extraction





Ridge Extraction





Minutiae Extraction

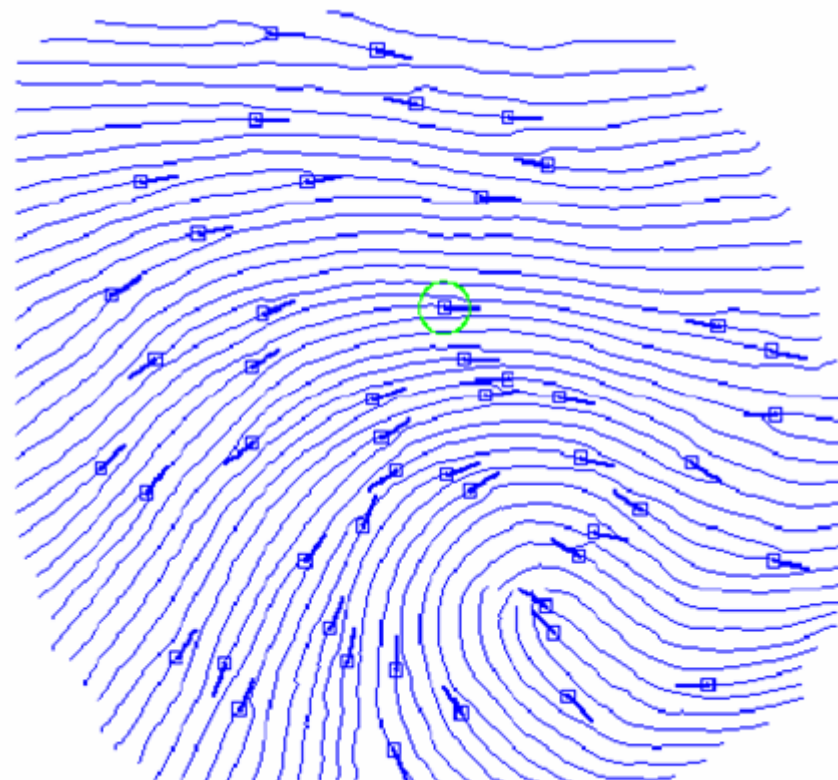
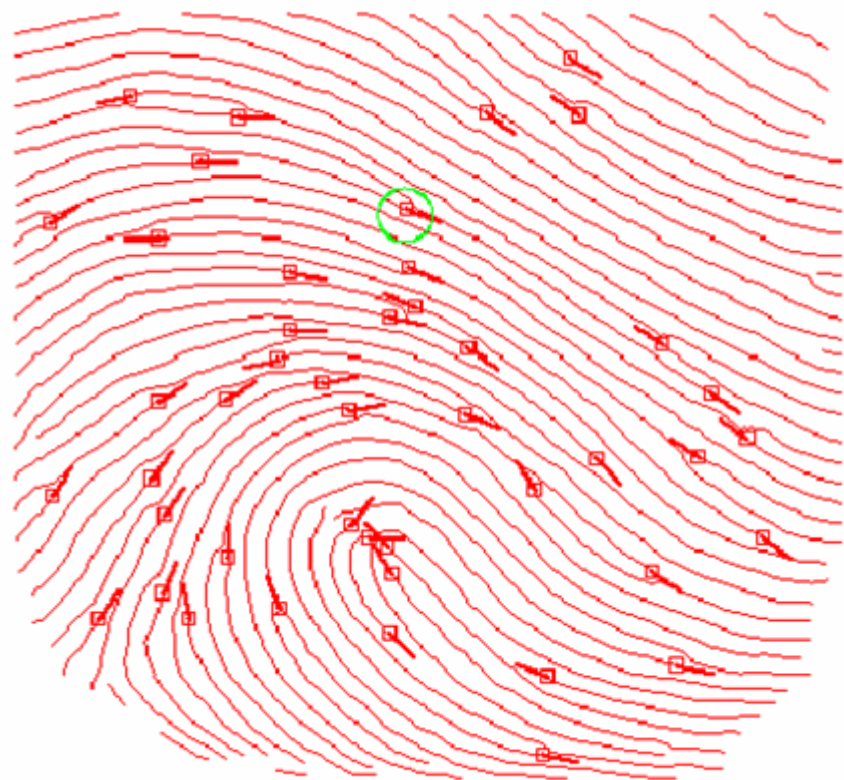


PART 5

指紋特徵點比對 Fingerprint Minutia Matching



Enroll and Verify Fingerprint





Minutiae Matching

$$P = \left\{ \left(x_1^P, y_1^P, \theta_1^P \right), \dots, \left(x_M^P, y_M^P, \theta_M^P \right) \right\}$$



Matching

$$Q = \left\{ \left(x_1^Q, y_1^Q, \theta_1^Q \right), \dots, \left(x_N^Q, y_N^Q, \theta_N^Q \right) \right\}$$

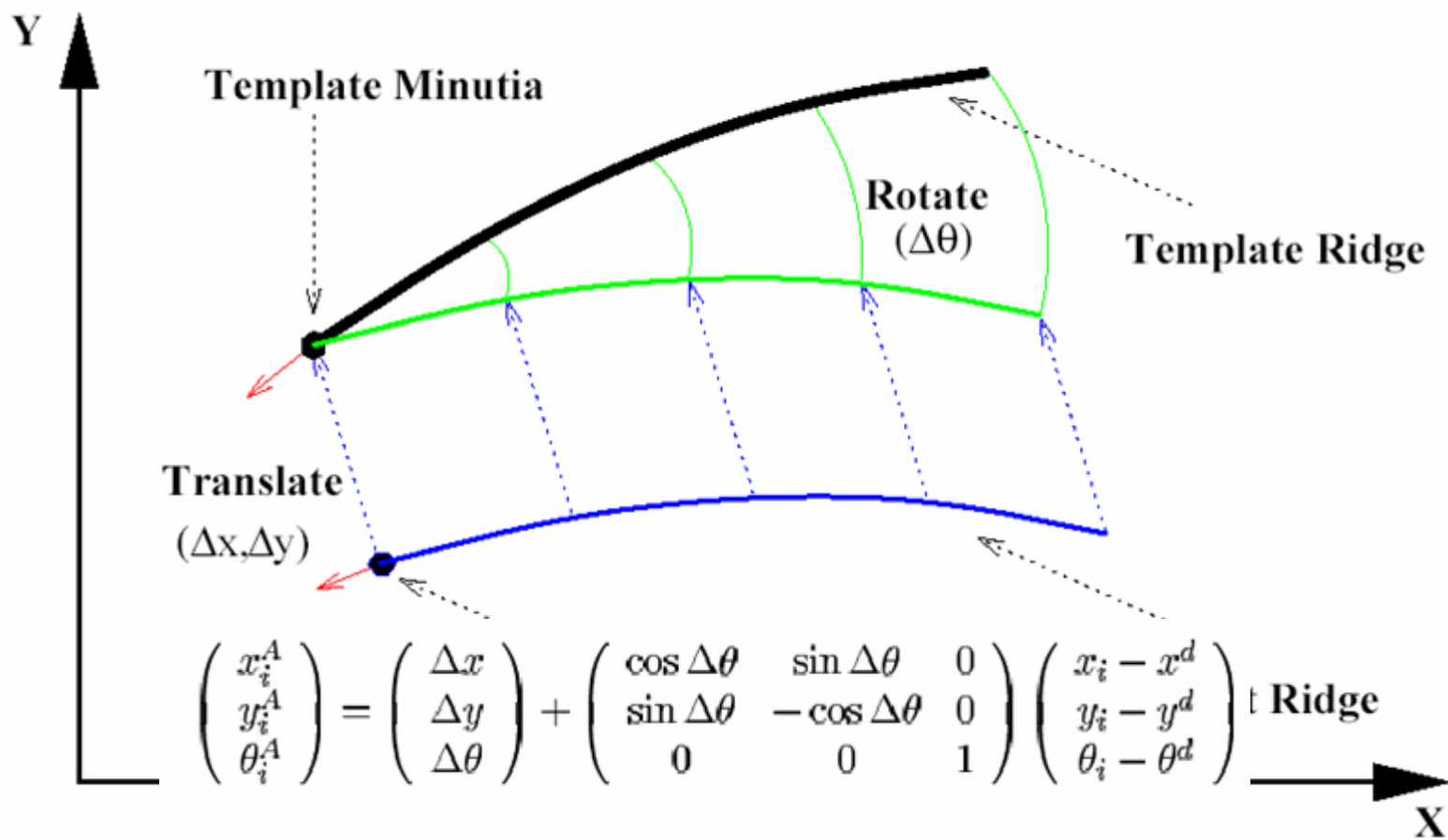


Minutiae Matching

- **Alignment stage**
 - Estimate rotation, translation, and distortion
 - Input minutiae are aligned with the template minutiae
- **Matching stage**
 - Input and template minutiae are converted into polygons in the polar coordinate system
 - Polygons are matched using elastic string matching algorithm

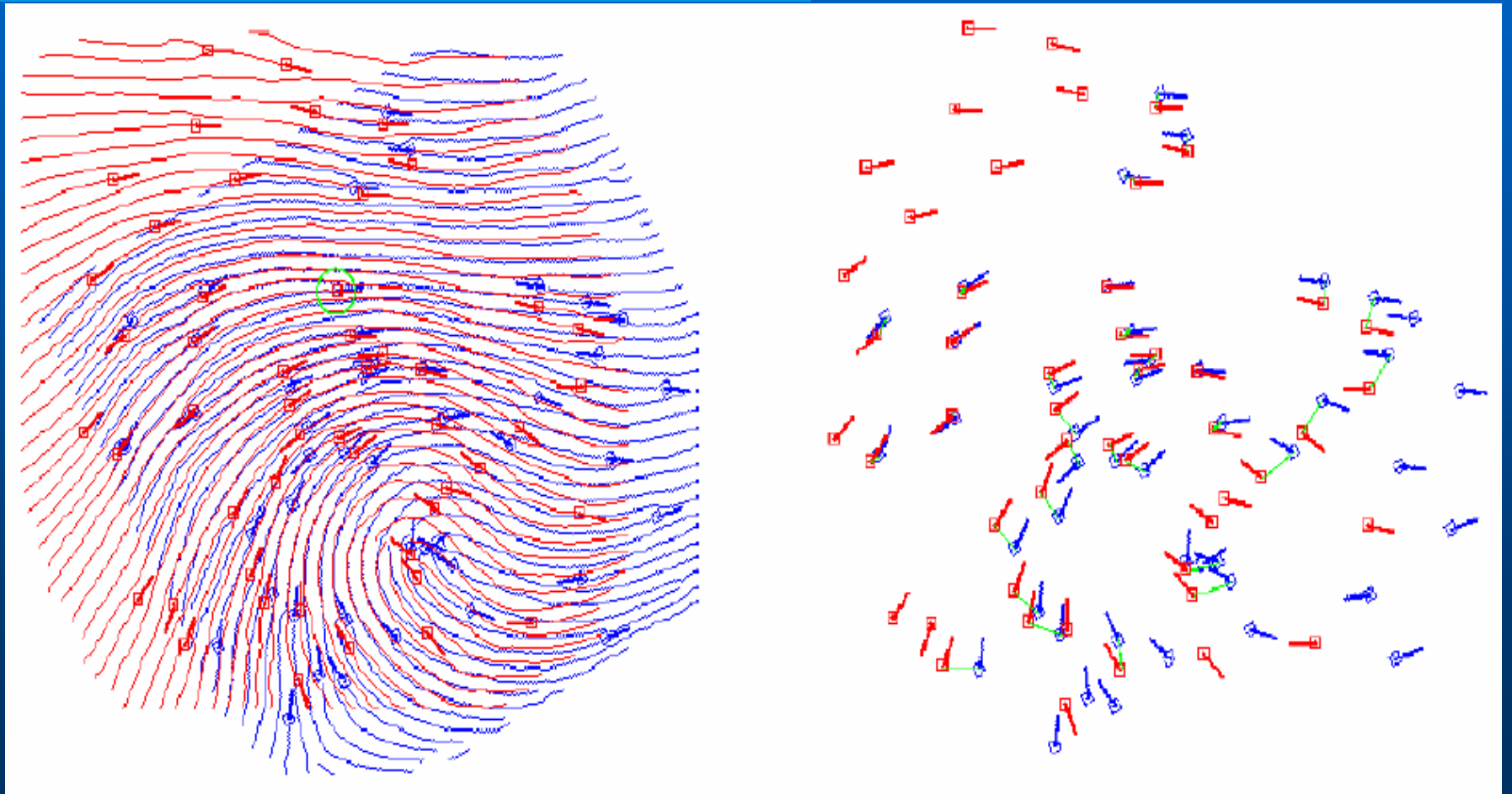


Minutiae Matching





Minutiae Matching





結語