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

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PART 1

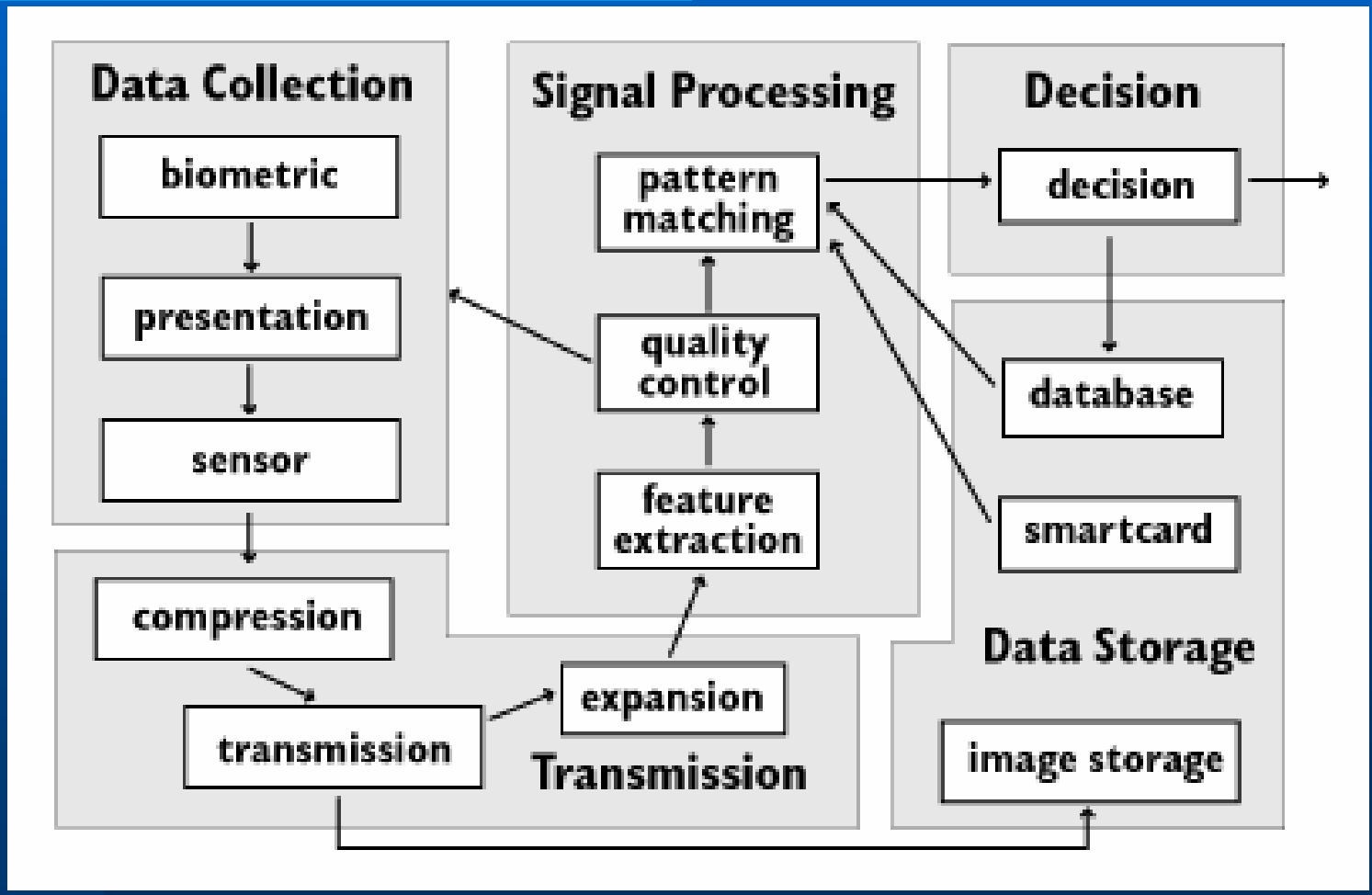
指紋與生物辨識

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



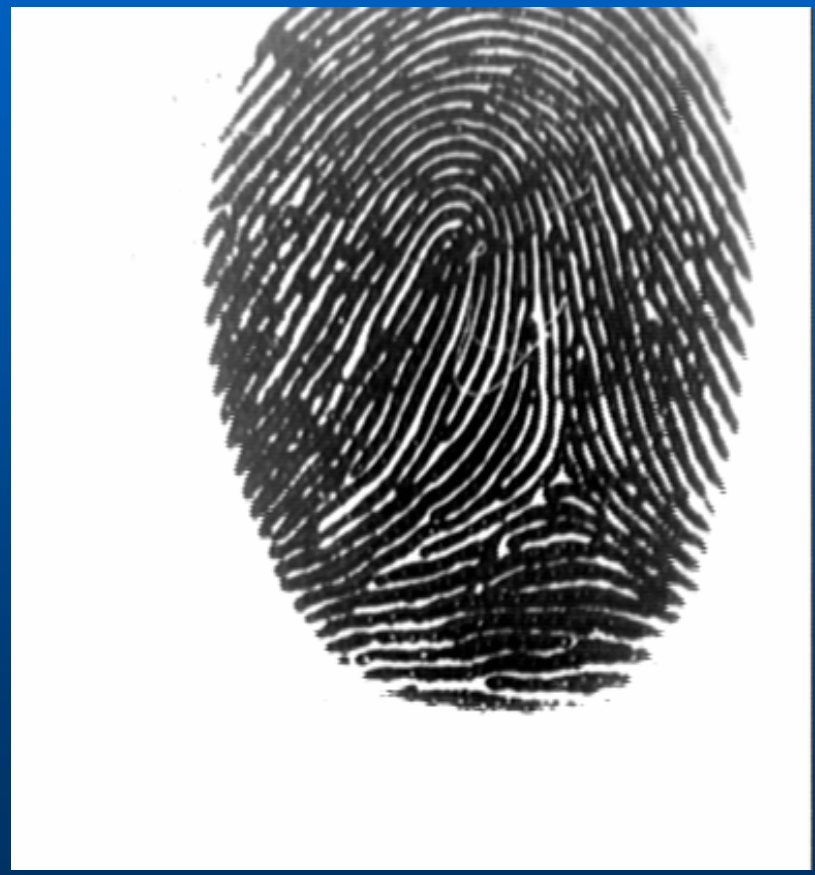
High/Low Contrast Fingerprint

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

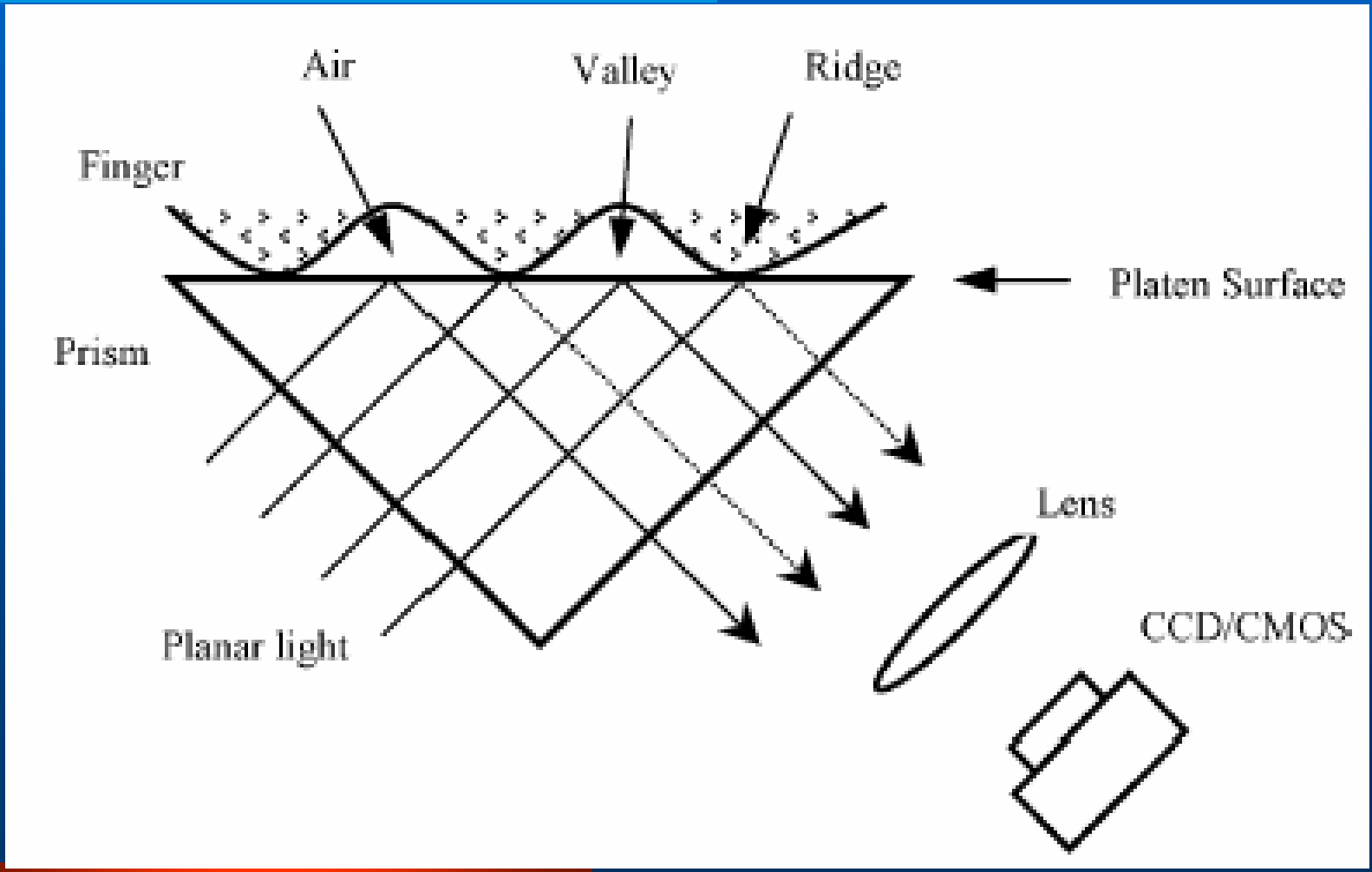
Comparison of Fingerprint Capture Devices

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	*E*-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

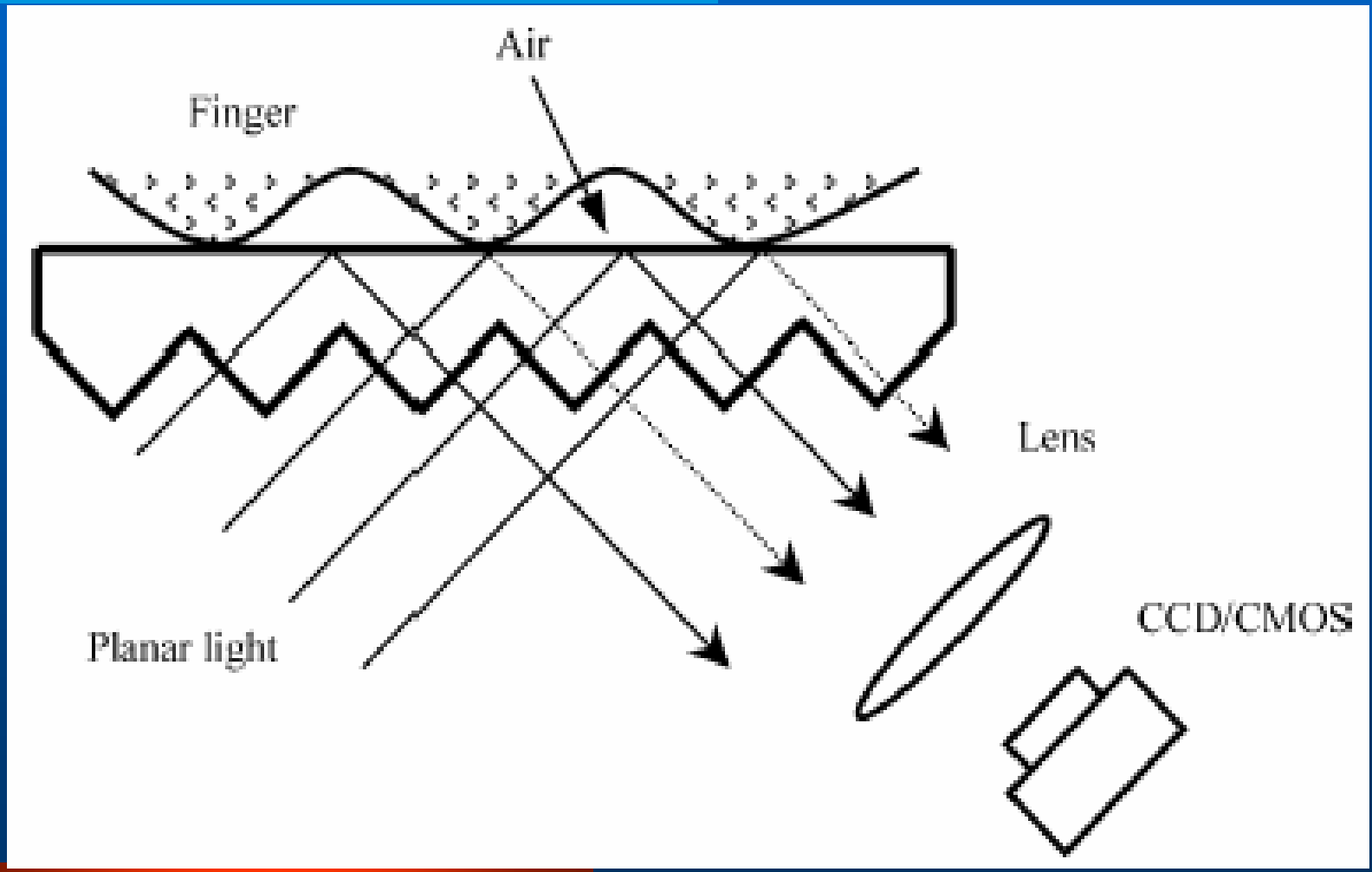
Comparison of Fingerprint Capture Devices(Cont.)

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

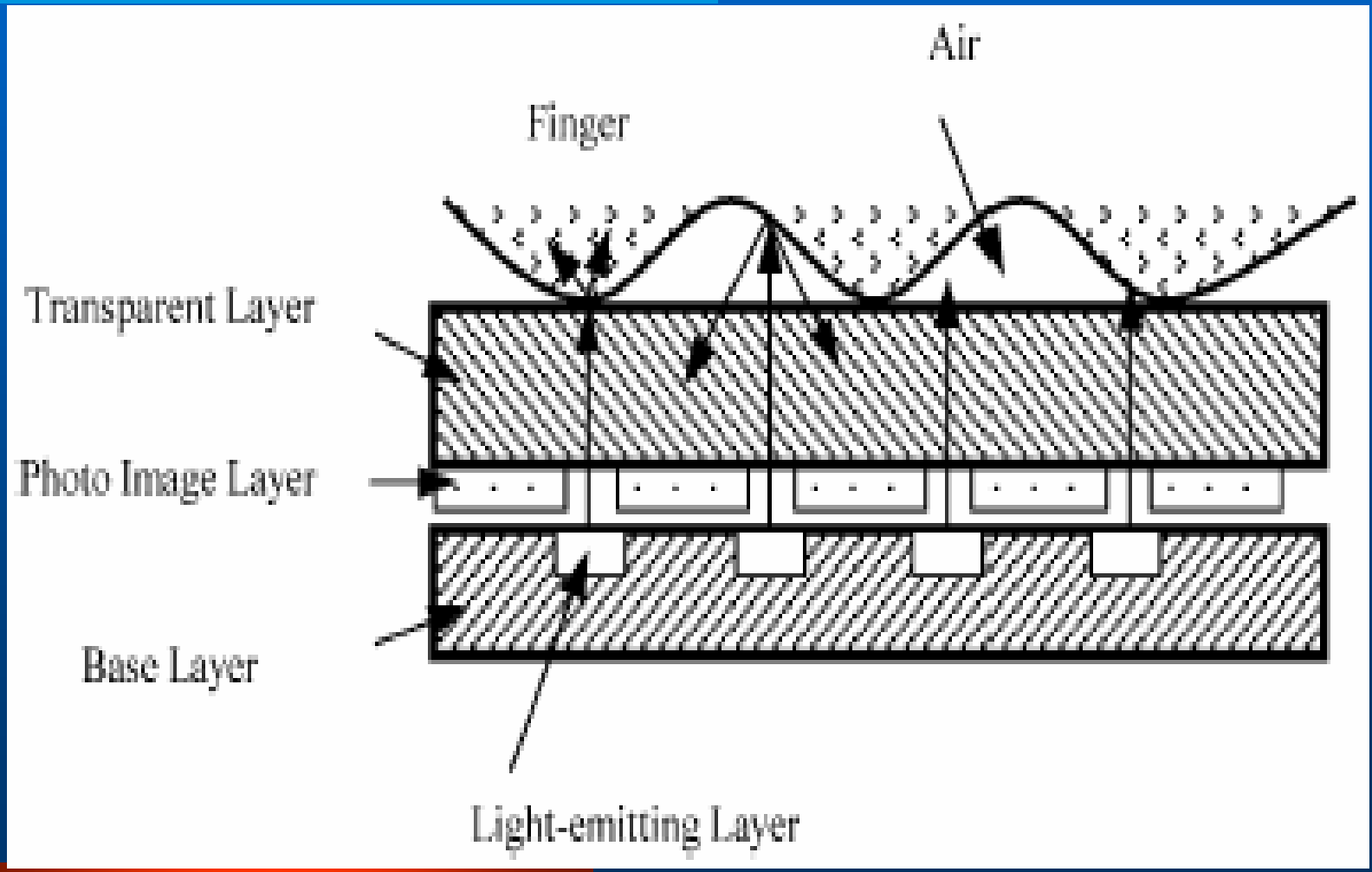
Optical Sensor



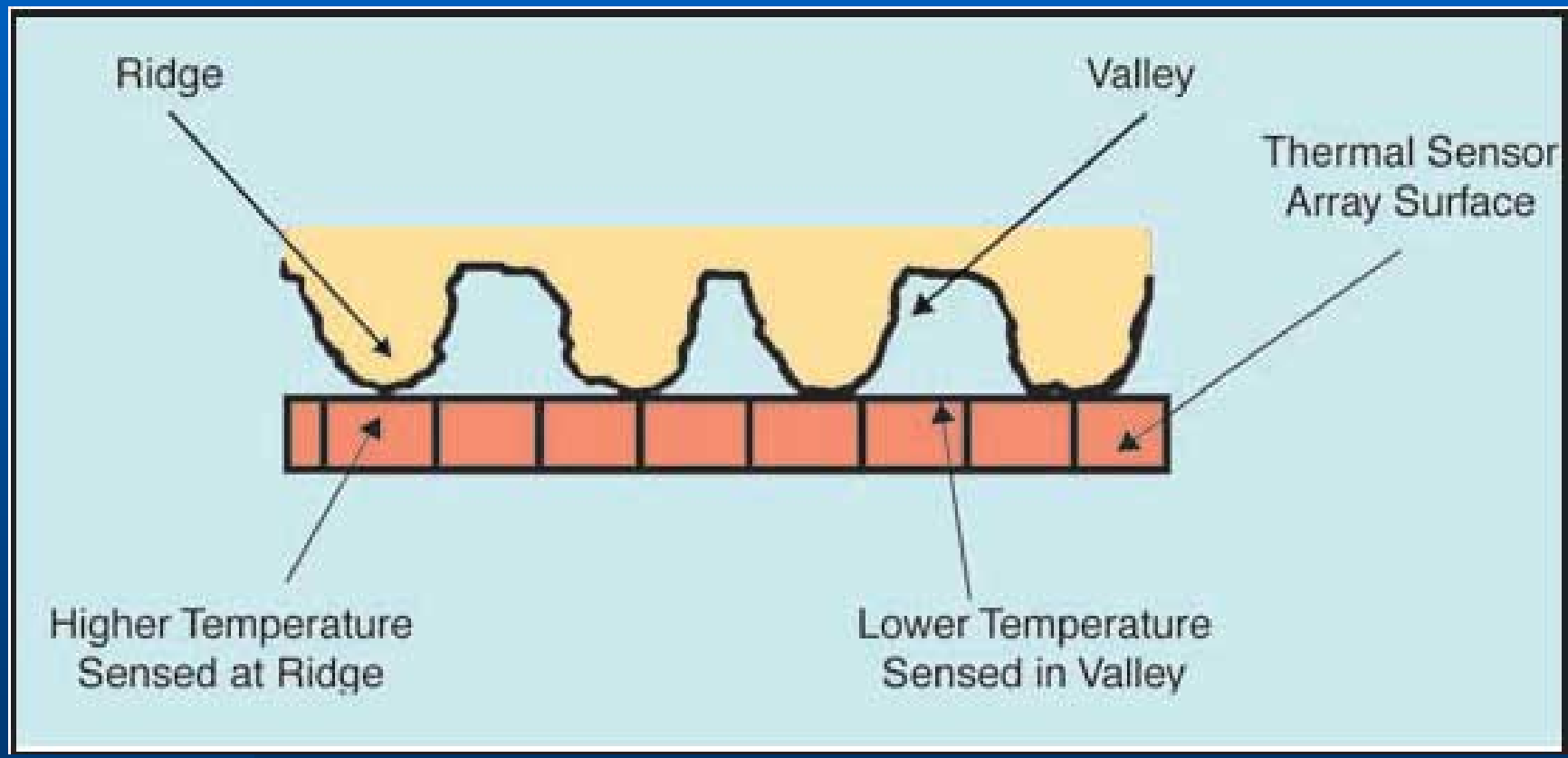
Small Size Optical Sensor



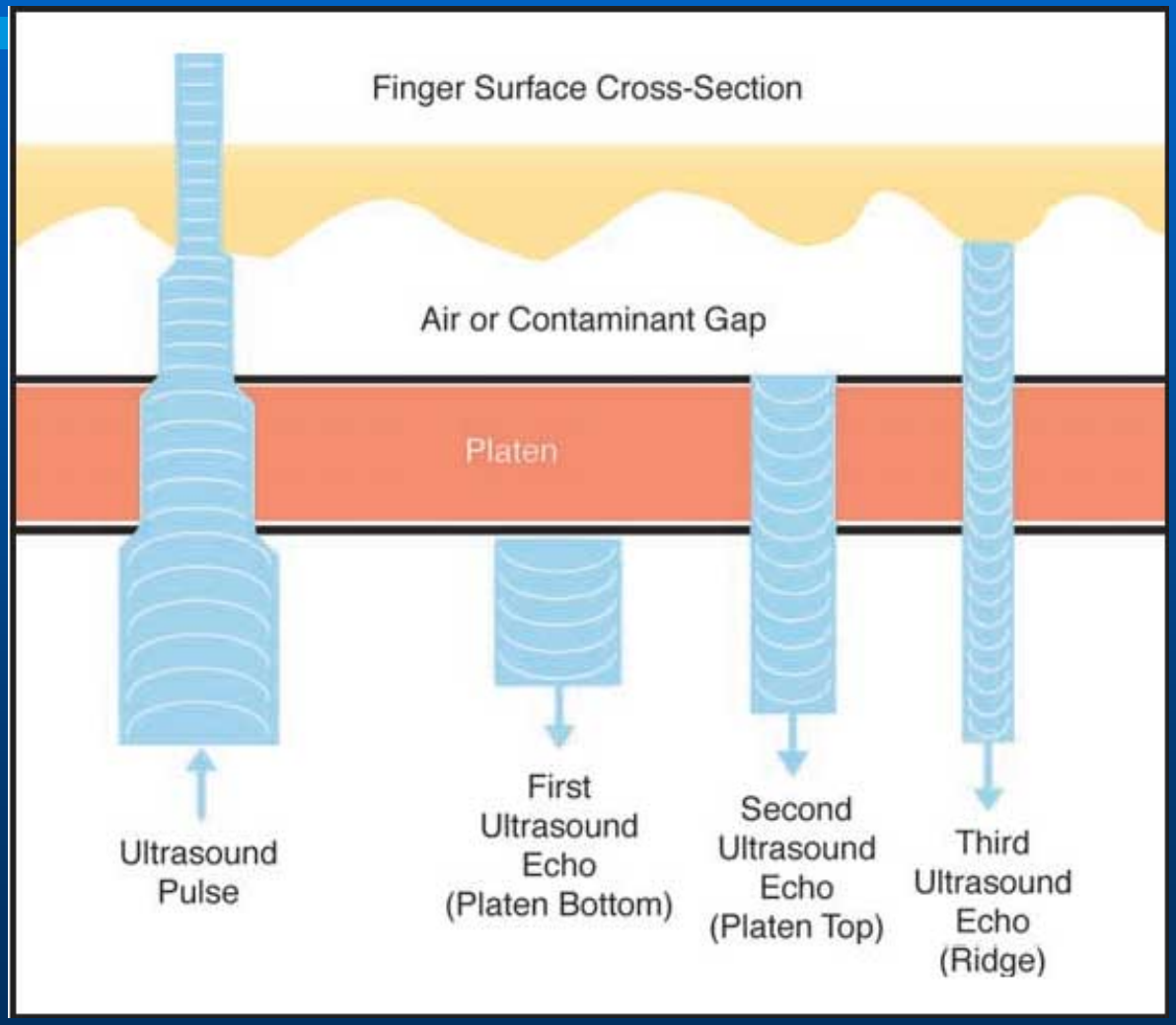
Electro-Optical Sensor



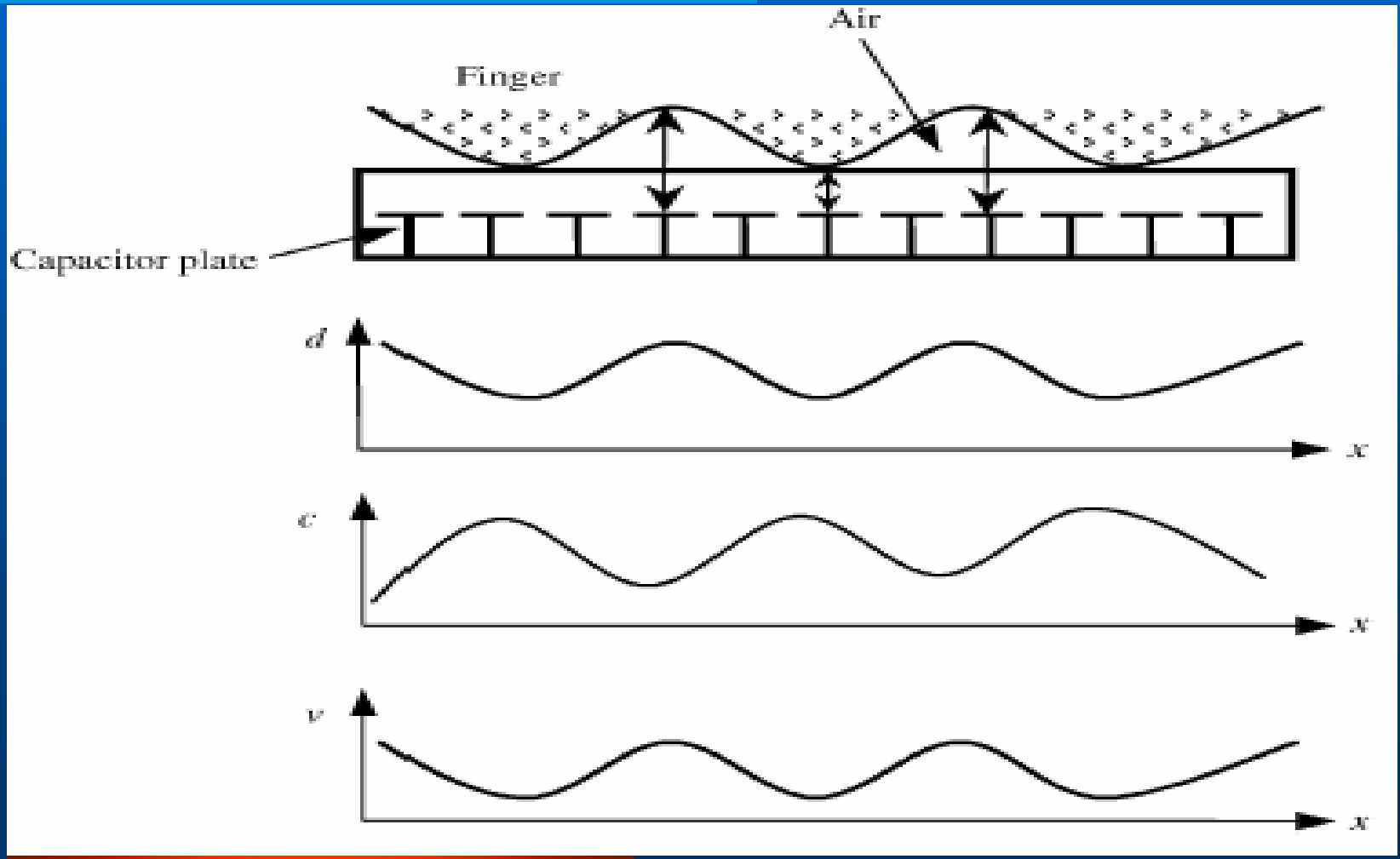
Thermal Sensor



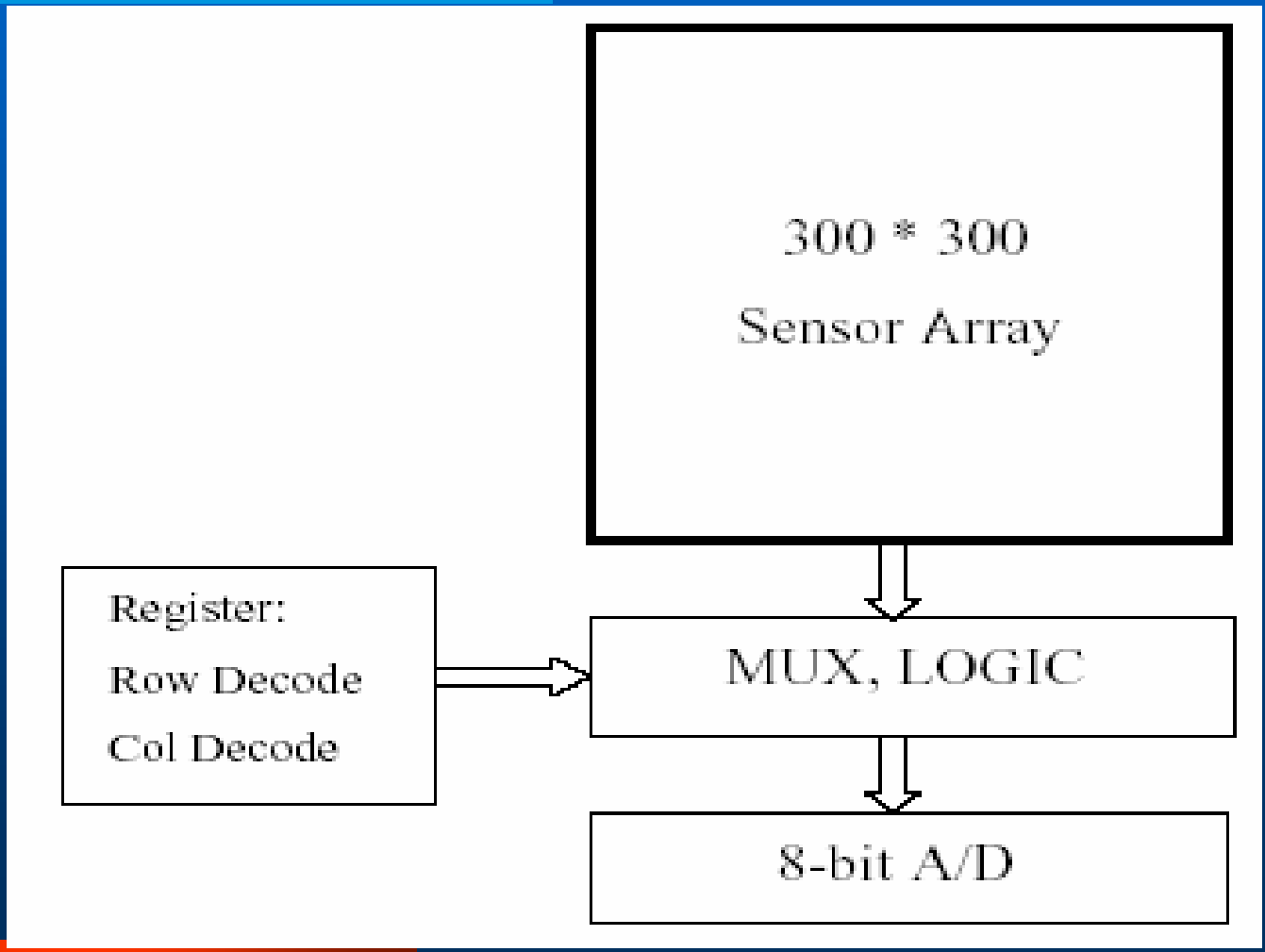
Ultrasonic Sensor



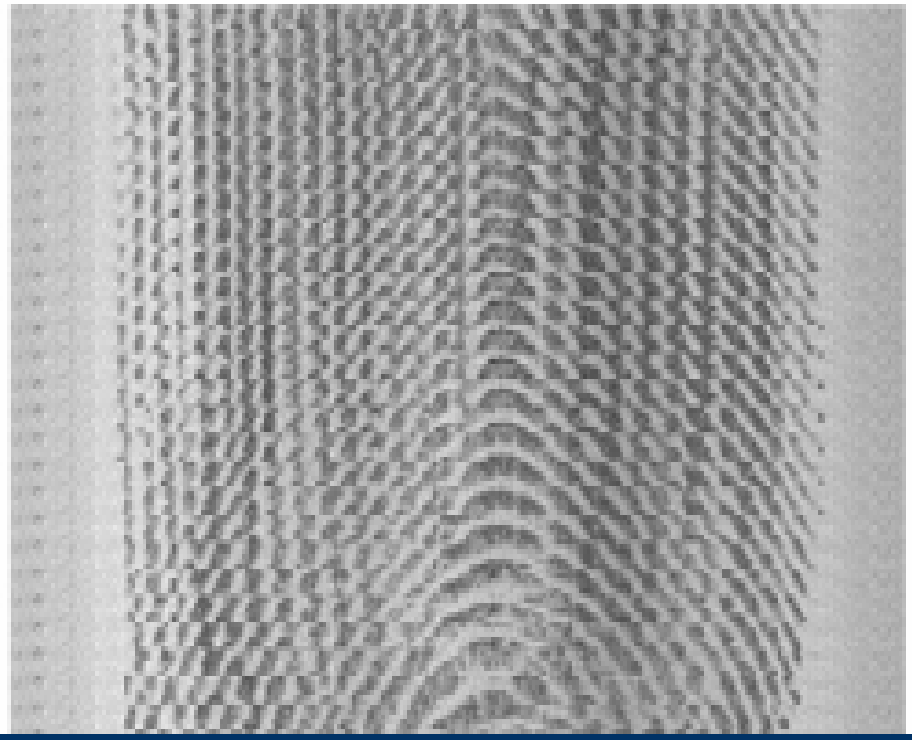
Capacitive Sensor



Capacitive Sensor



Swipe Sensor



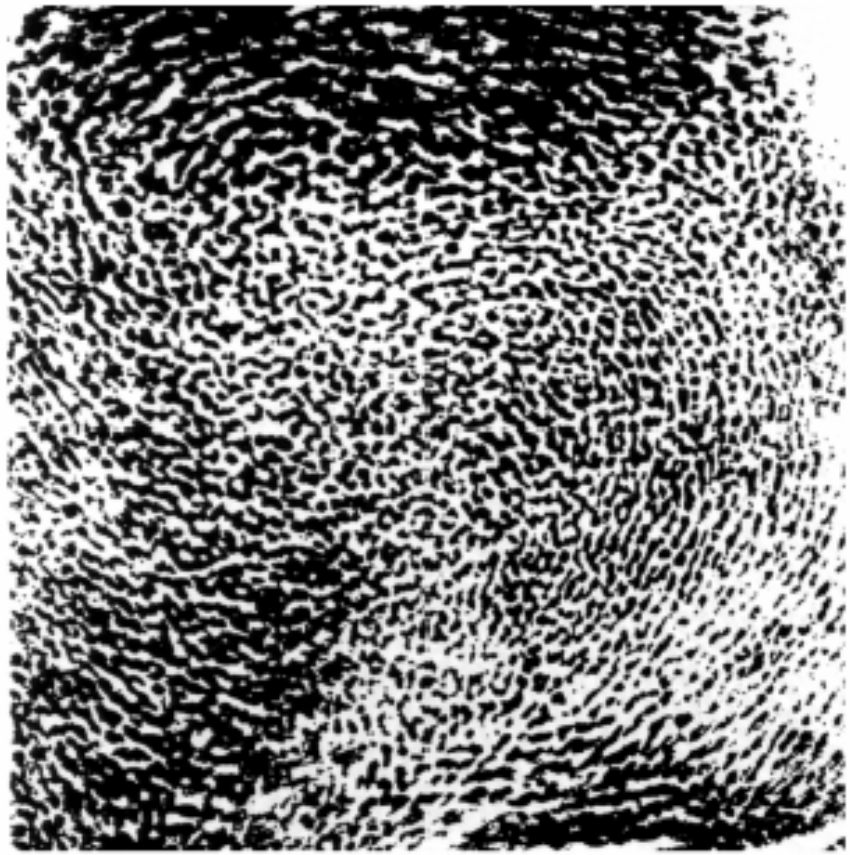
Advantages of Swipe Sensor

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

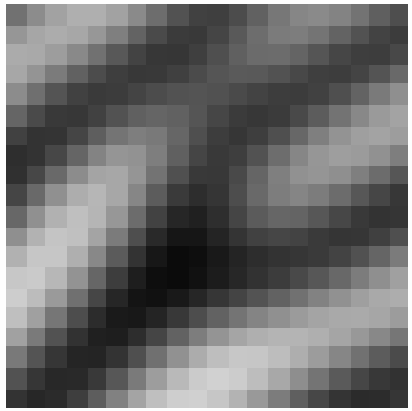
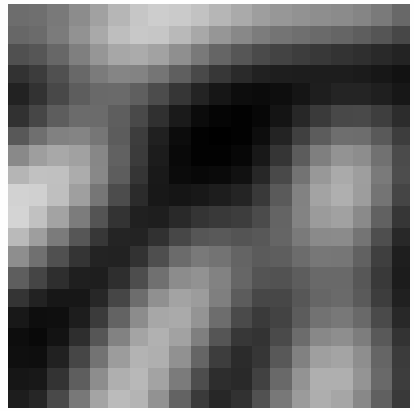
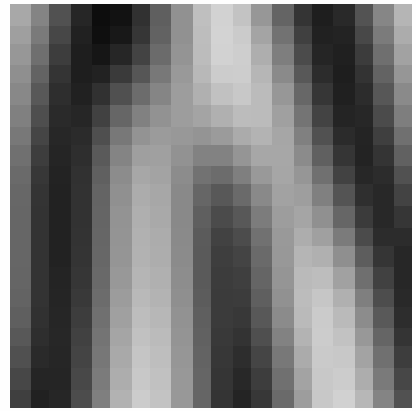
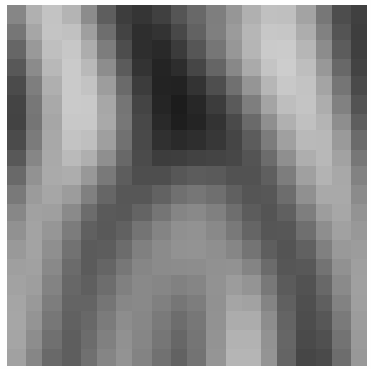
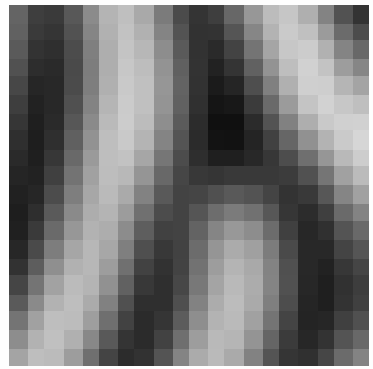
PART 3

指紋影像增強
Fingerprint Image Enhancement

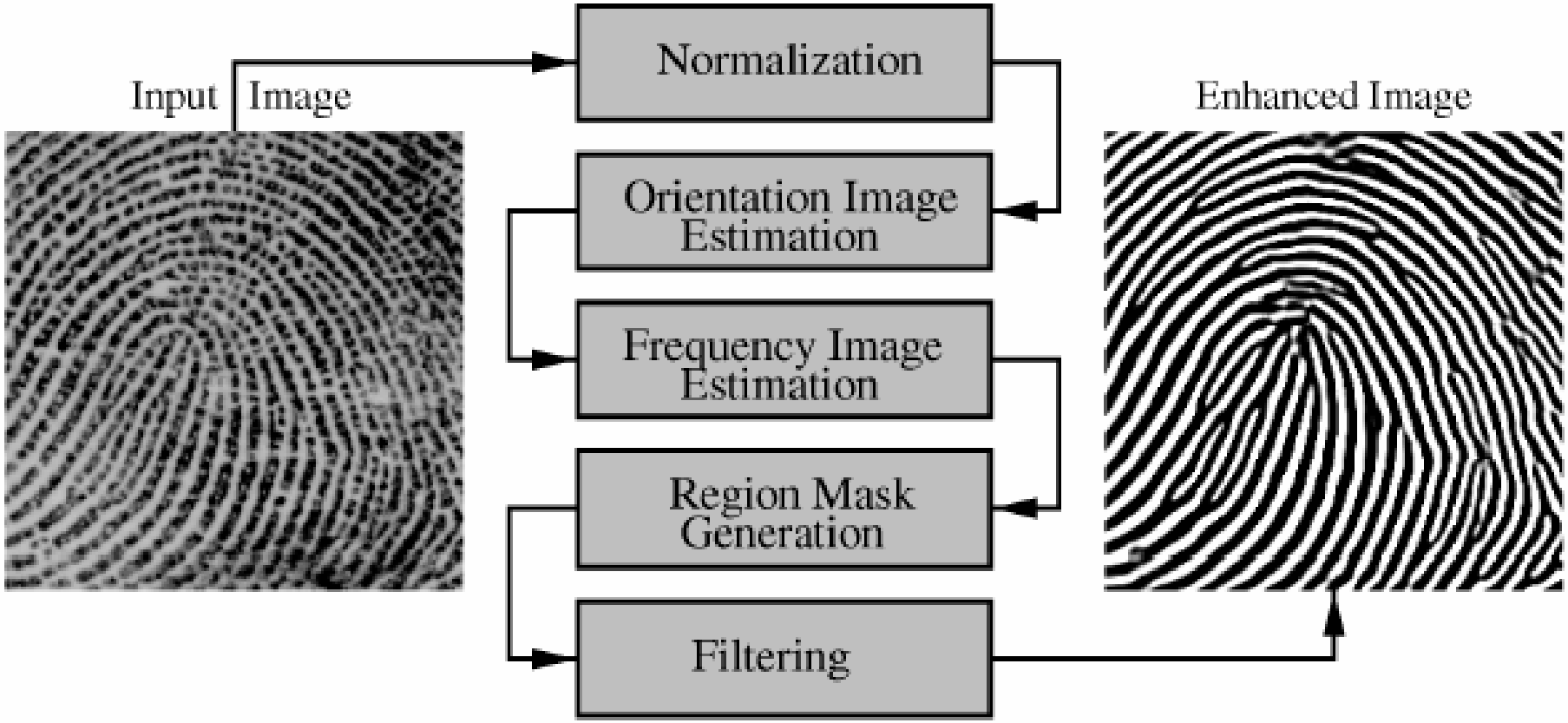
FP images of poor quality



Ridge and Valley in FP Image

Fingerprint image enhancement



Normalization

$$G(i,j) = \begin{cases} M_0 + \sqrt{\dfrac{VAR_0\left(I(i,j)-M\right)^2}{VAR}} & \text{if } I(i,j) > M \\ M_0 - \sqrt{\dfrac{VAR_0\left(I(i,j)-M\right)^2}{VAR}} & \text{otherwise} \end{cases}$$

Orientation Image

$$V_x(i,j) = \sum_{u=i-\frac{W}{2}}^{i+\frac{W}{2}} \sum_{v=j-\frac{W}{2}}^{j+\frac{W}{2}} 2\partial_x(u,v)\partial_y(u,v),$$

$$V_y(i,j) = \sum_{u=i-\frac{W}{2}}^{i+\frac{W}{2}} \sum_{v=j-\frac{W}{2}}^{j+\frac{W}{2}} \left(\partial_x^2(u,v)\partial_y^2(u,v)\right),$$

$$\theta(i,j) = \frac{1}{2}\tan^{-1}\left(\frac{V_y(i,j)}{V_x(i,j)}\right),$$

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

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

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

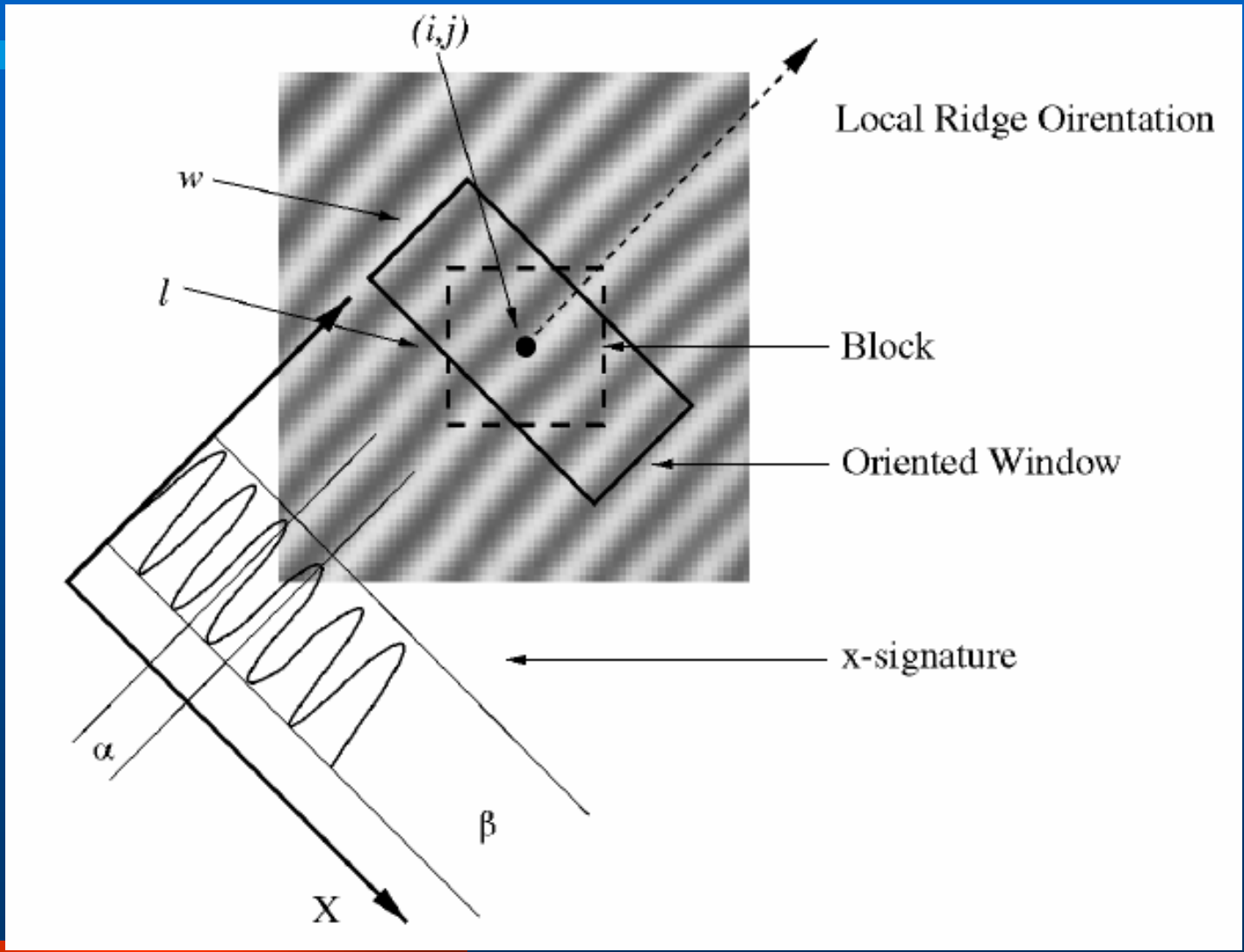
and

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

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

Orientation Image

Mask Generation



Gabor Filtering

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

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

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

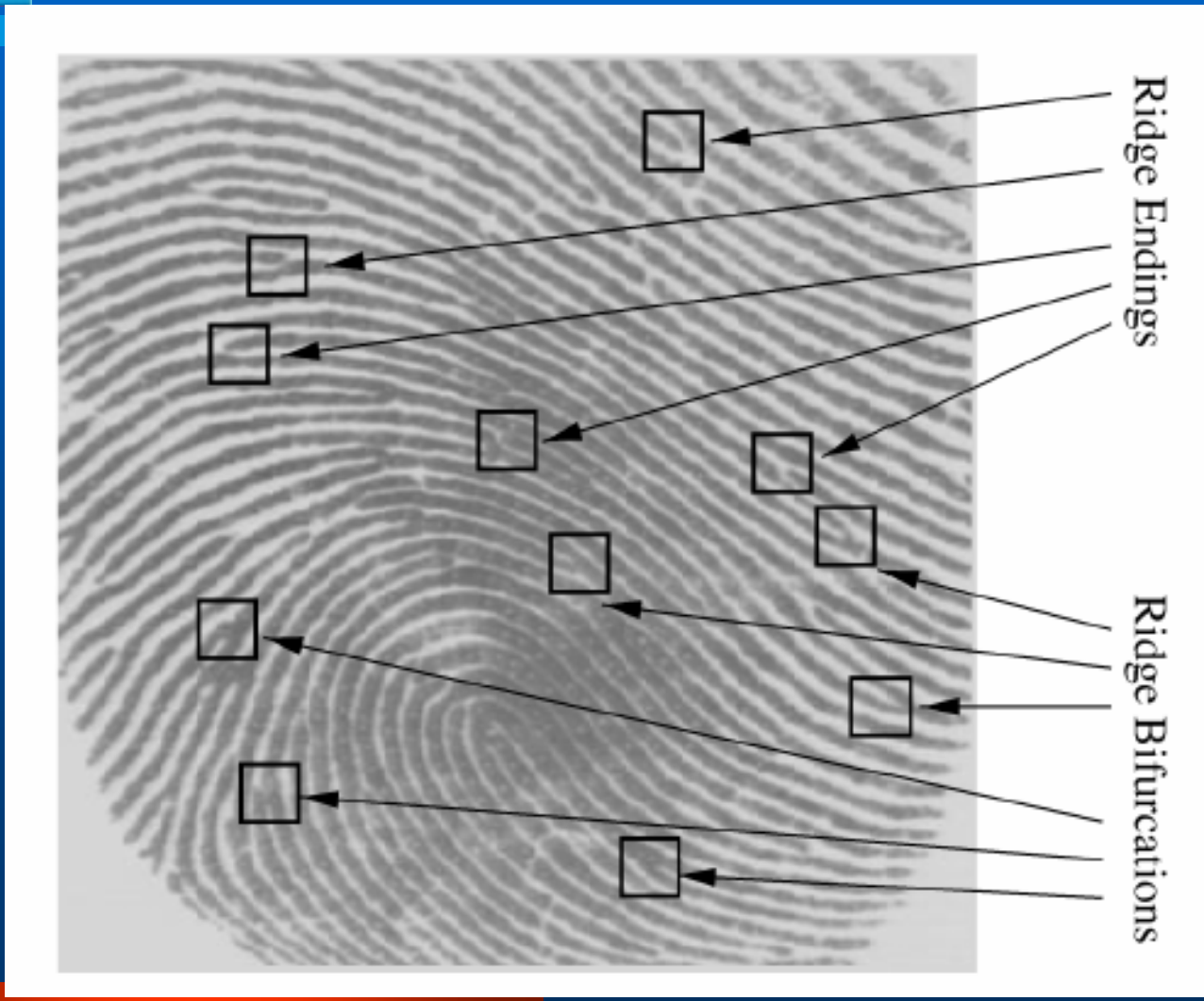
Result of Enhancement

MIAT's Approach

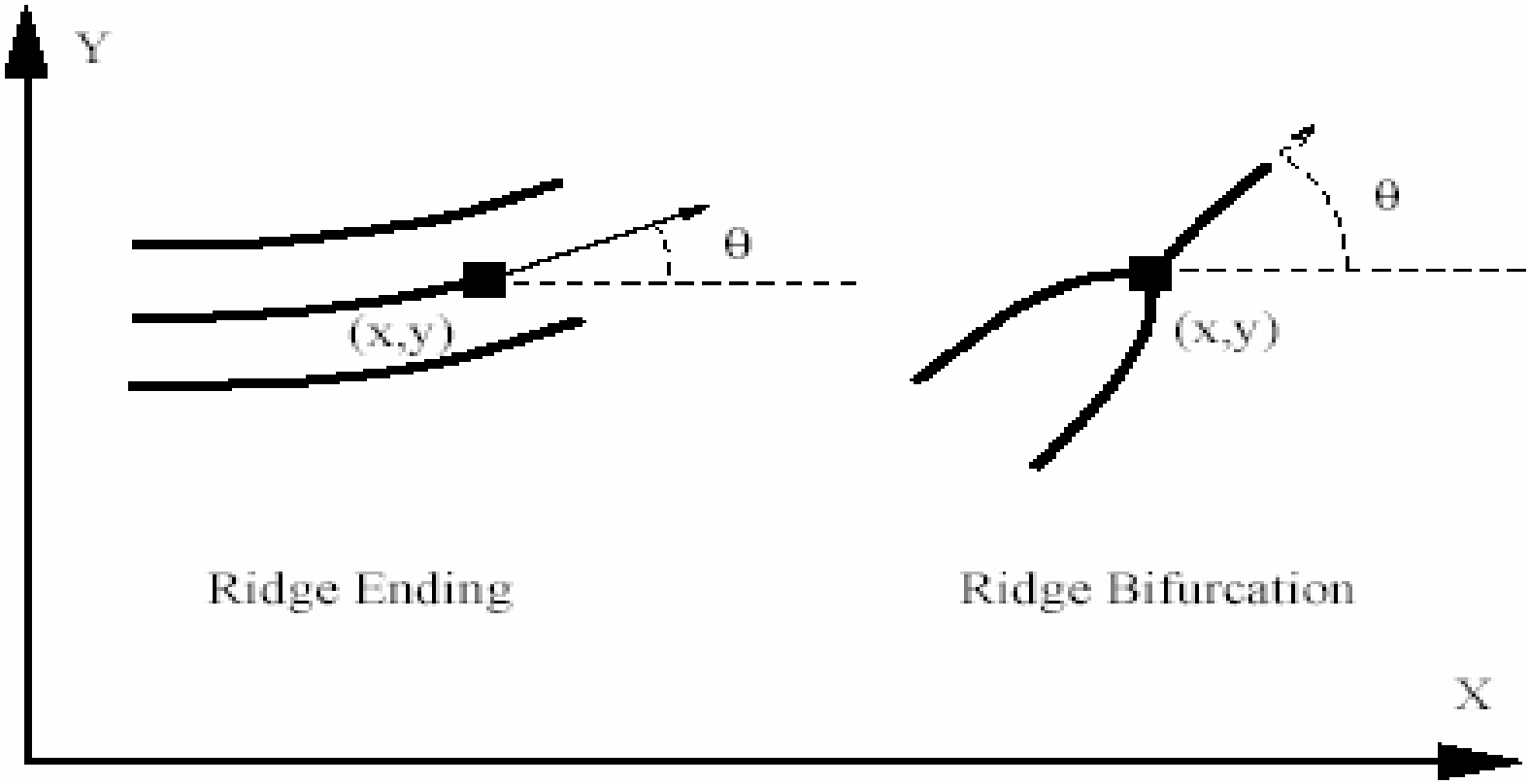
PART 4

指紋影像特徵點偵測
Fingerprint Minutia Detection

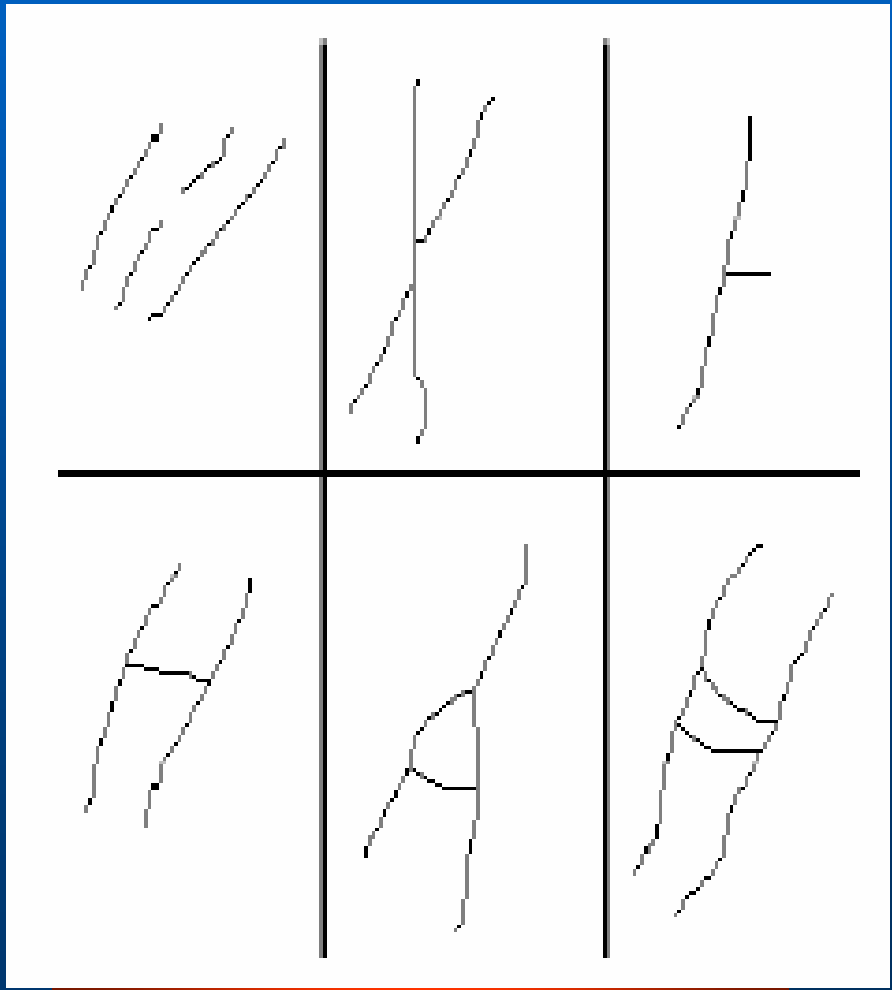
Minutiae in Fingerprint



Fingerprint Minutiae



False Minutiae



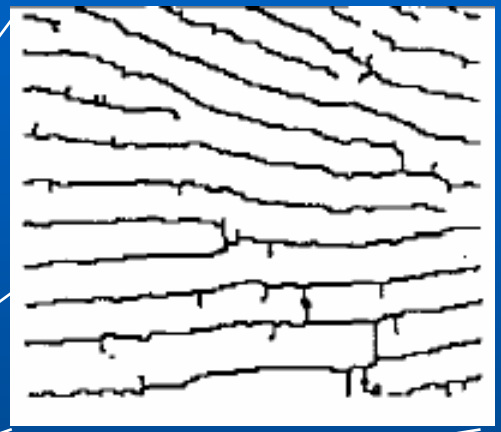
- Close Endpoints
- Cross
- Spurs
- Bridges
- Triangles and ladders

Preprocessing

Minutiae Detection

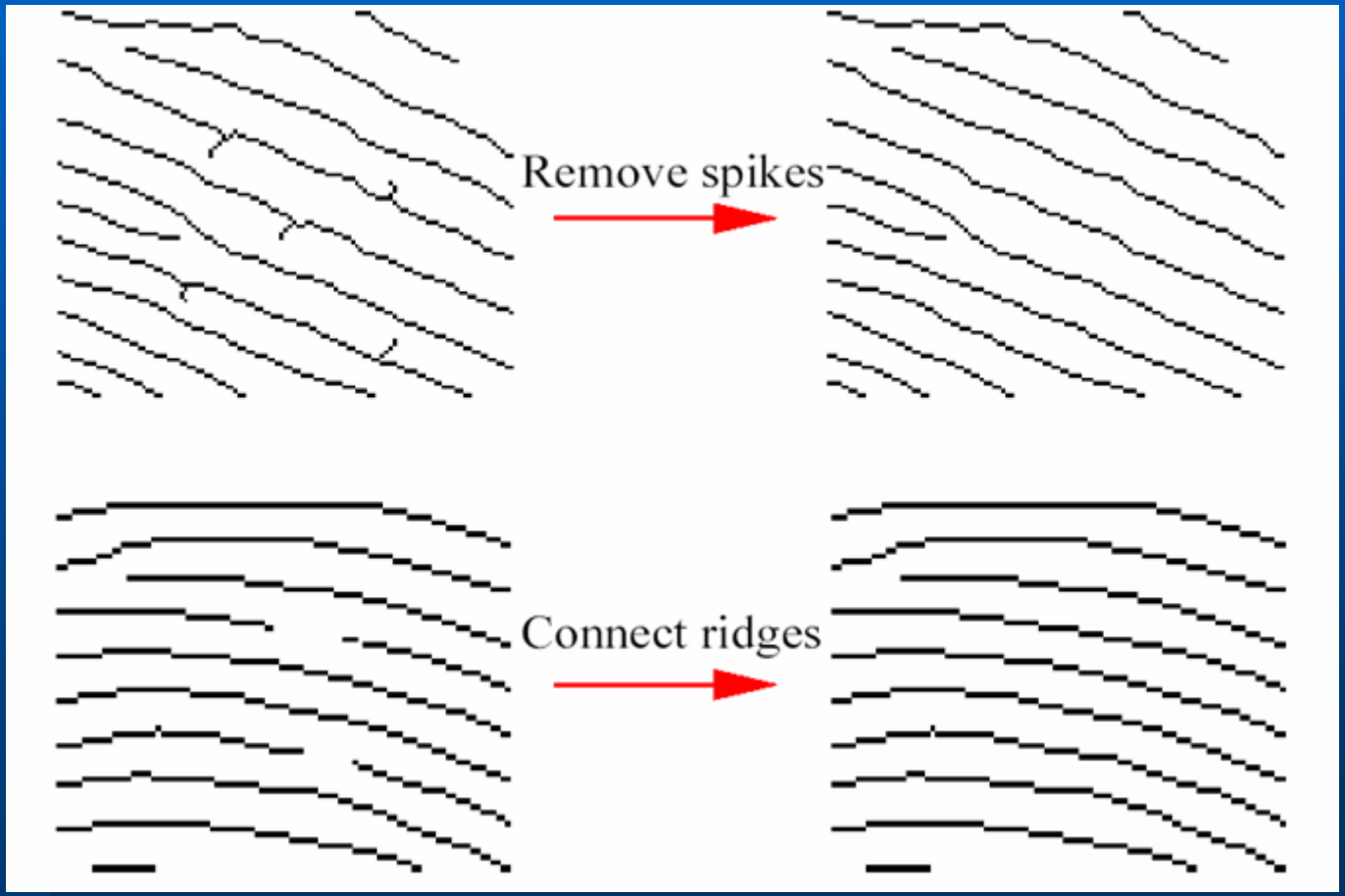
Enhancement

Thinning



Ridge Extraction

Ridge Extraction

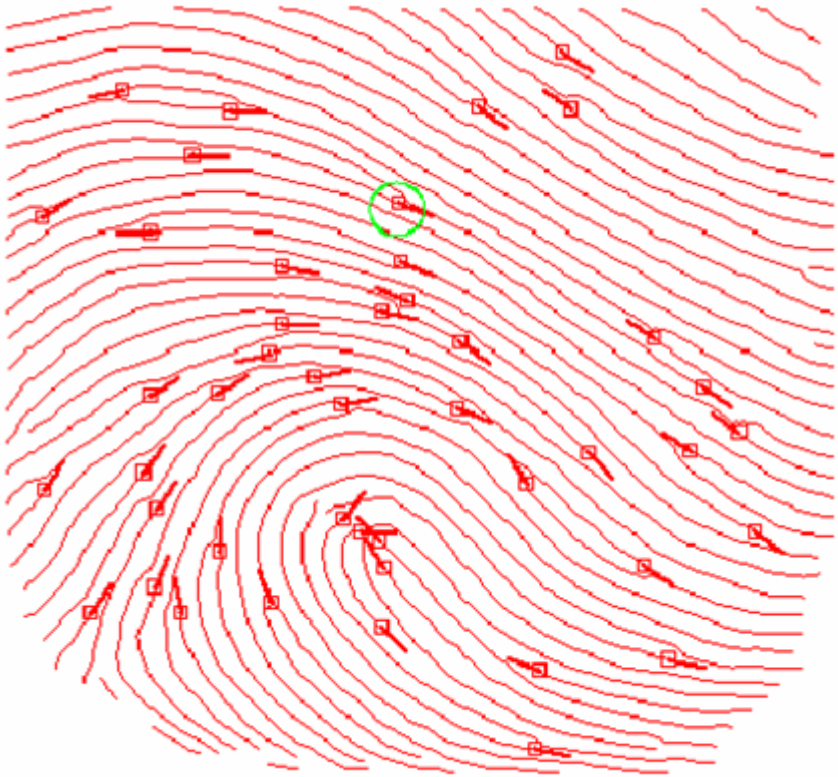


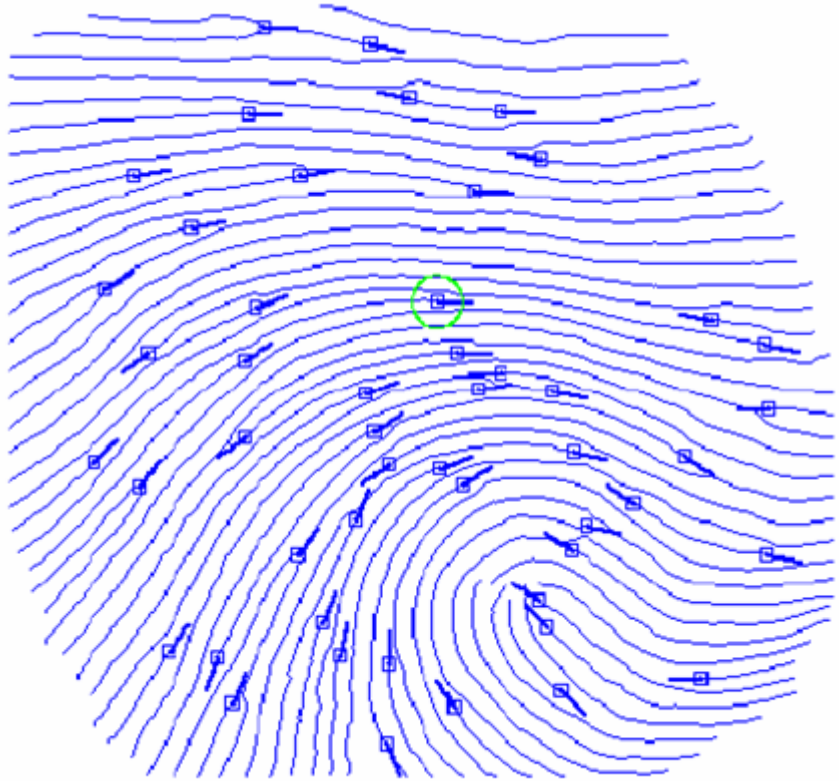
Minutiae Extraction

PART 5

指紋特徵點比對
Fingerprint Minutia Matching

Enroll and Verify Fingerprint





Minutiae Matching

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

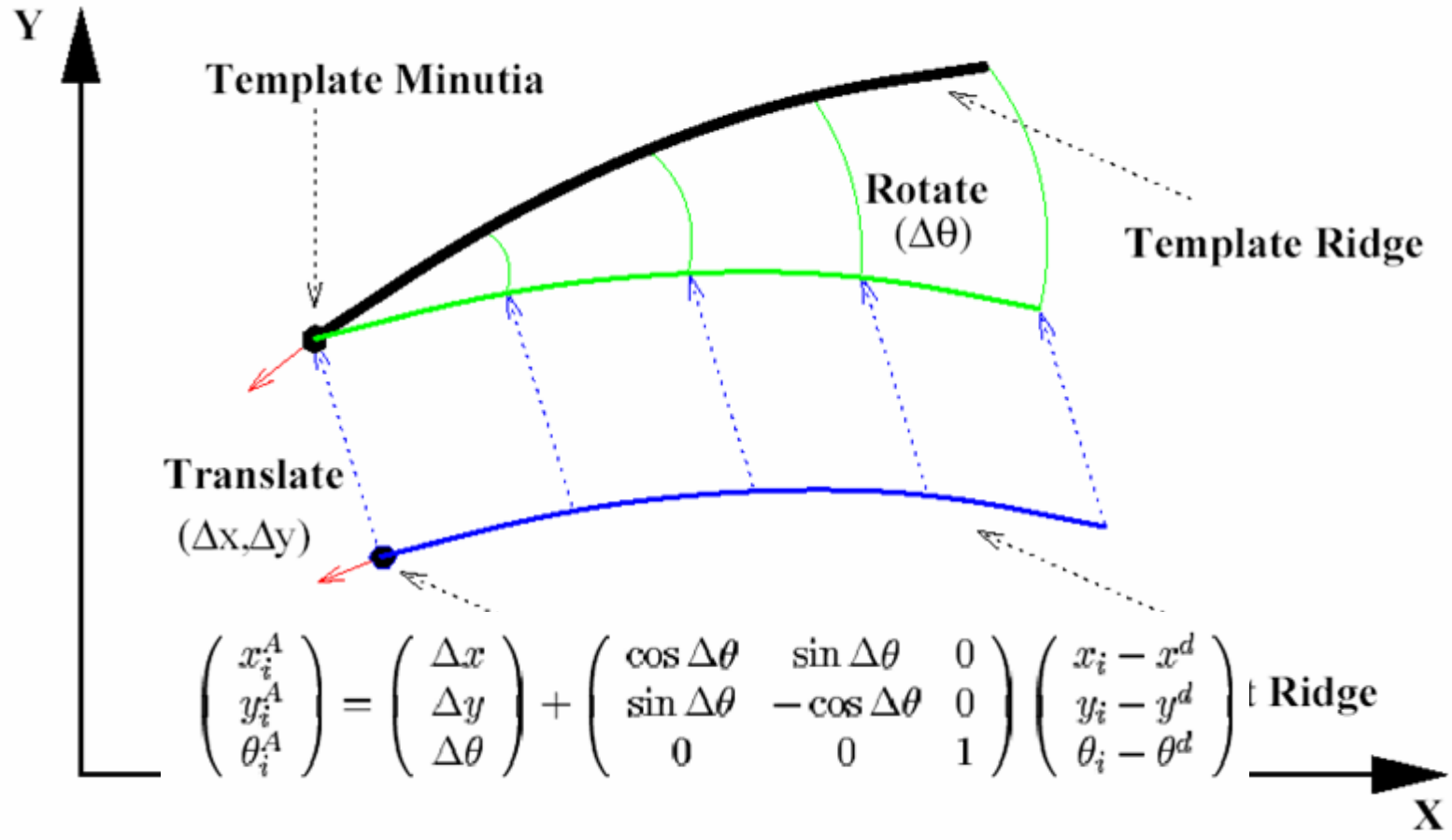
Matching

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

Minutiae Matching

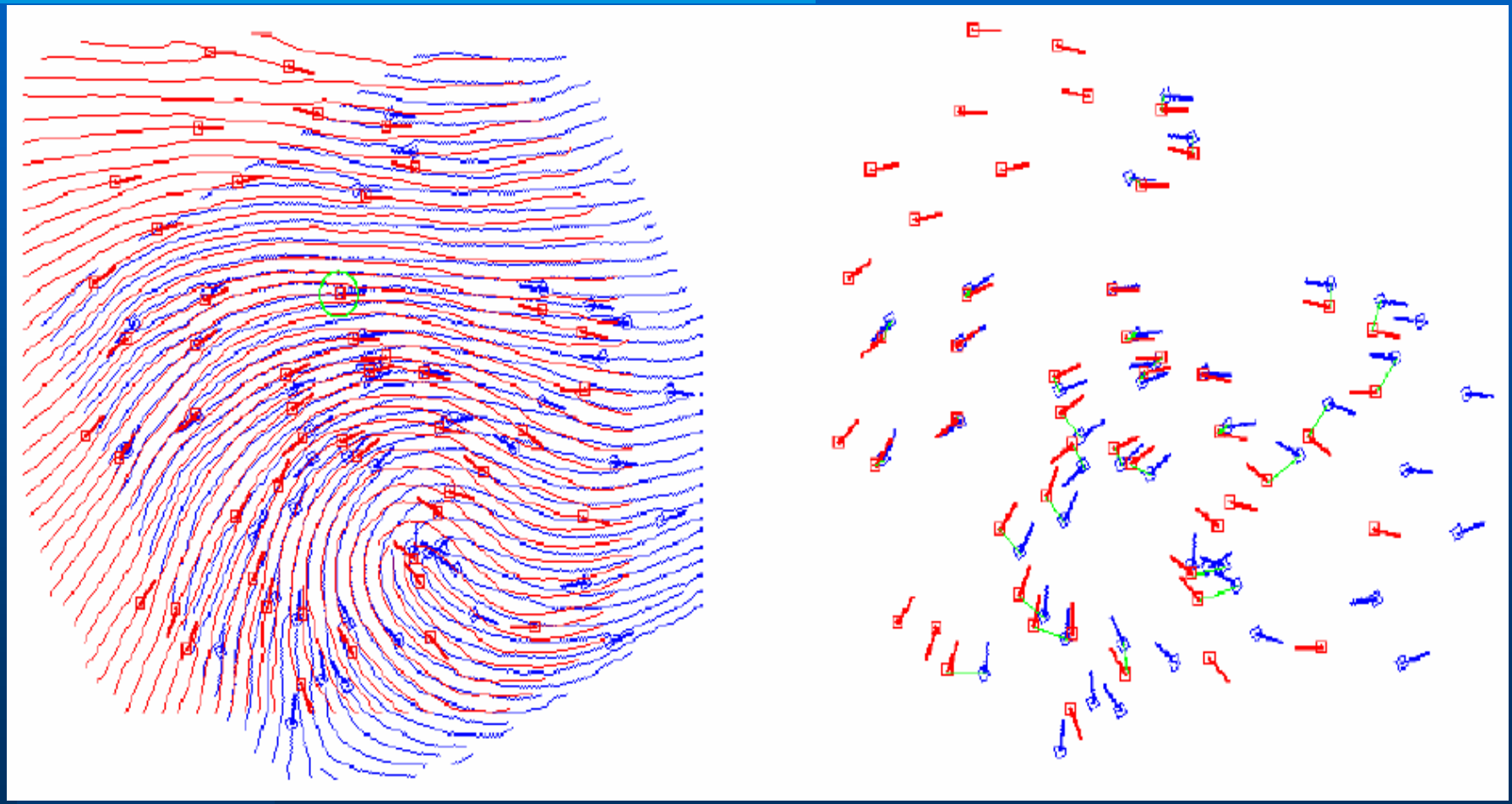
- Alignment stage
  - Estimate rotation, translation, and distortion
  - Input minutiae are aligned with the template minutiae
- Matching stage
  - Input and template minutiae are converted into polygons in the polar coordinate system
  - Polygons are matched using elastic string matching algorithm

Minutiae Matching



$$\begin{pmatrix} x_i^A \\ y_i^A \\ \theta_i^A \end{pmatrix} = \begin{pmatrix} \Delta x \\ \Delta y \\ \Delta\theta \end{pmatrix} + \begin{pmatrix} \cos\Delta\theta & \sin\Delta\theta & 0 \\ \sin\Delta\theta & -\cos\Delta\theta & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_i - x^d \\ y_i - y^d \\ \theta_i - \theta^d \end{pmatrix}$$

Minutiae Matching



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