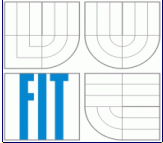




Methods for Quality Determination of Papillary Lines in Fingerprints

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Overview

- ➔ Technologies of fingerprint sensors
- ➔ Quality measures derived from the image histogram
- ➔ Information entropy in the fingerprint
- ➔ Quality estimation of a papillary line

1 – Technologies of Fingerprint Sensors

Optical Technology



Capacitive Technology



Ultrasound Technology



E-Field Technology



Electro-optical Technology



Pressure Technology

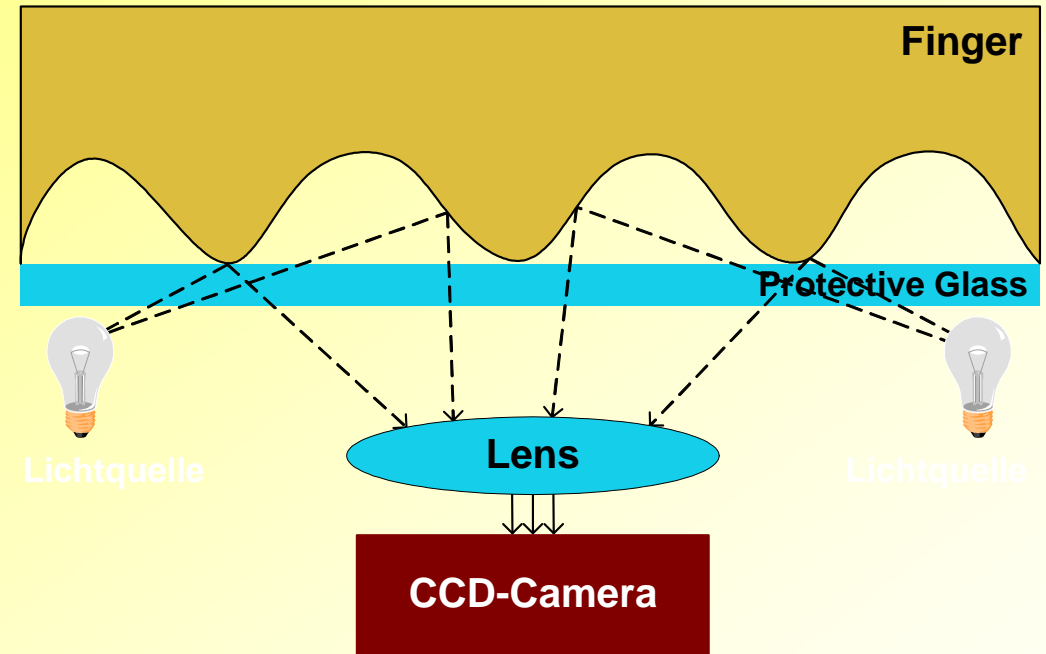


Thermal Technology

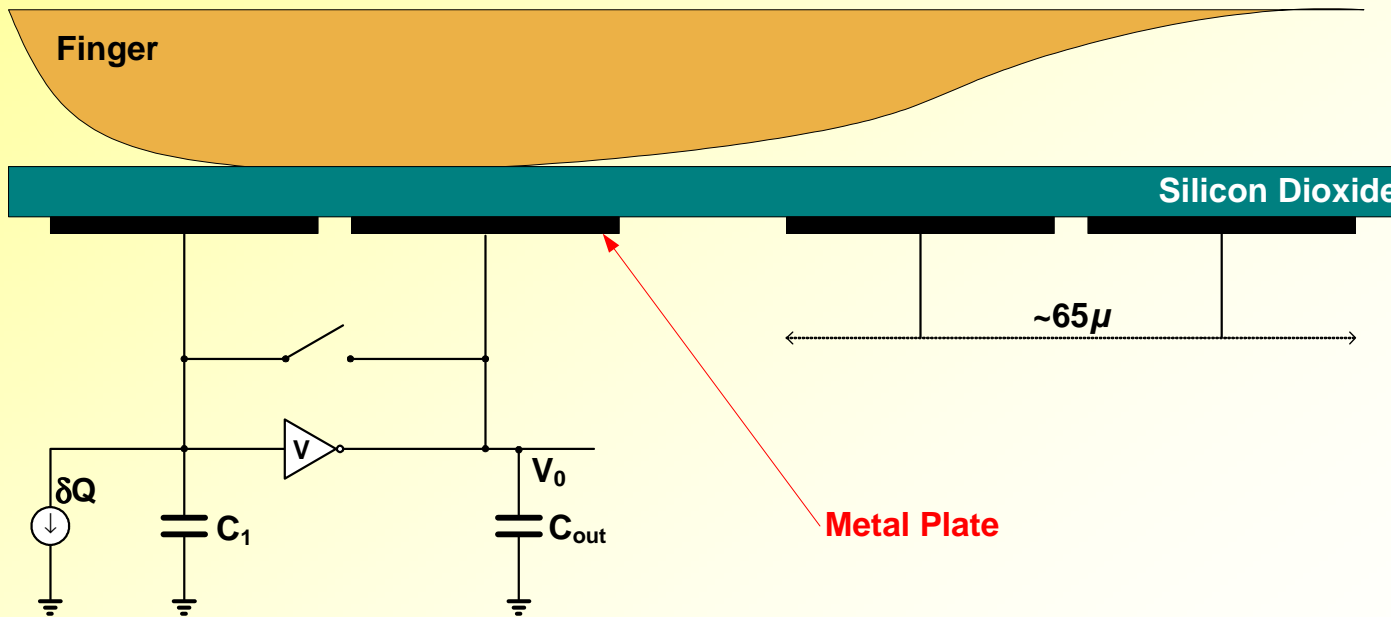


Fingerprint Sensor Technologies I.

→ Optical Technology

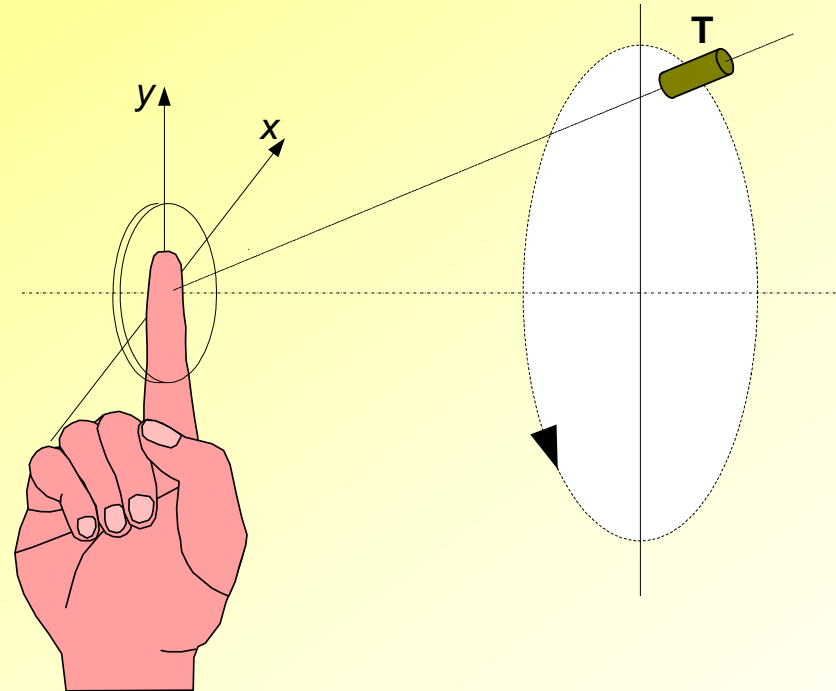


→ Capacitive Technology



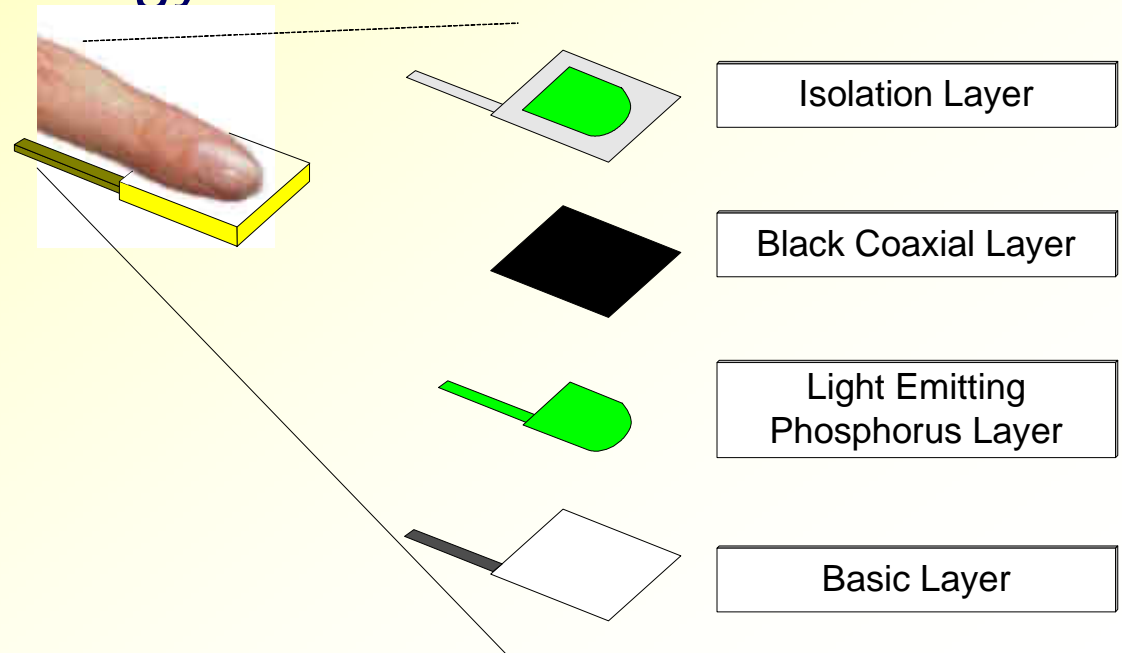
Fingerprint Sensor Technologies II.

→ Ultrasonic Technology



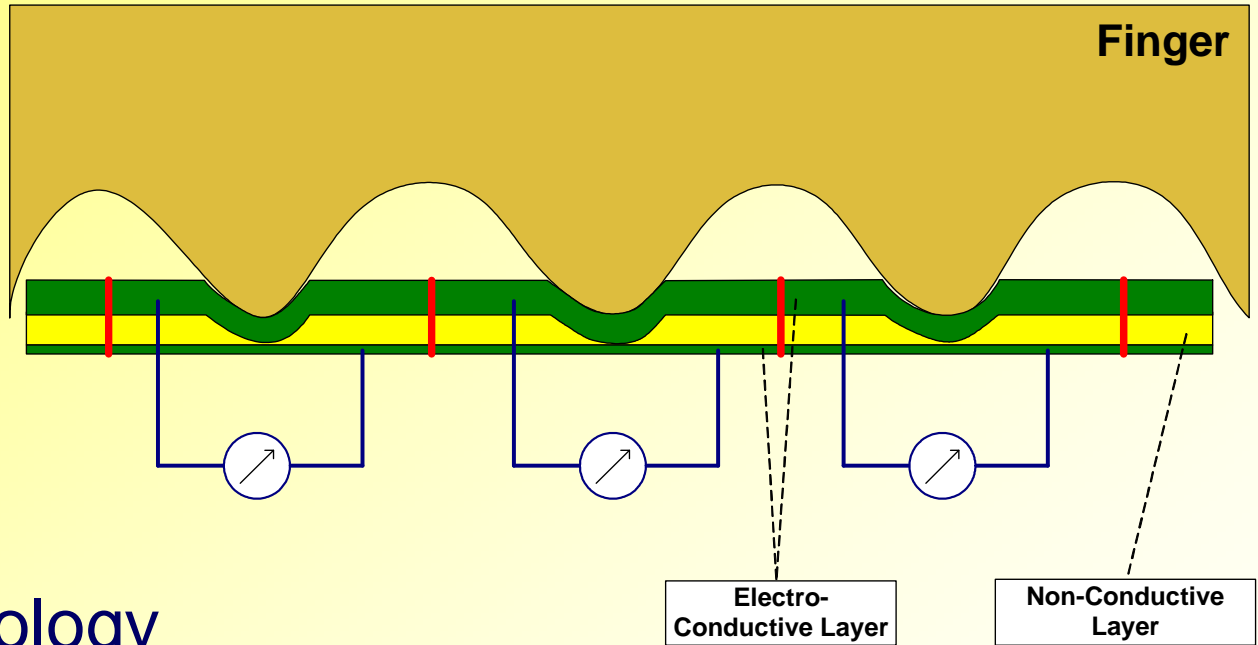
→ Electro-optical Technology

AuthentTec

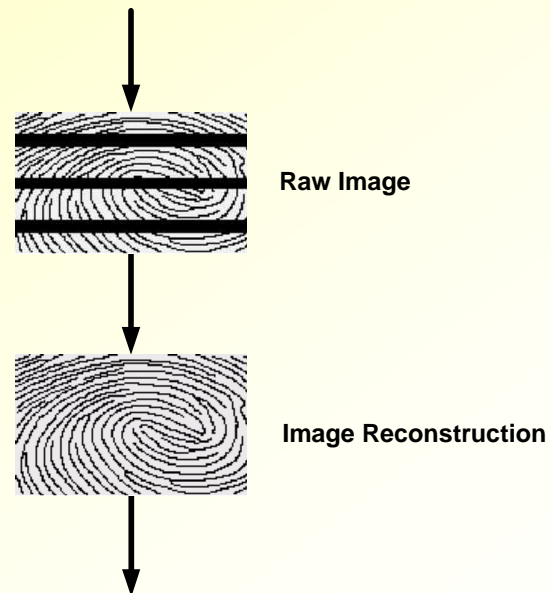
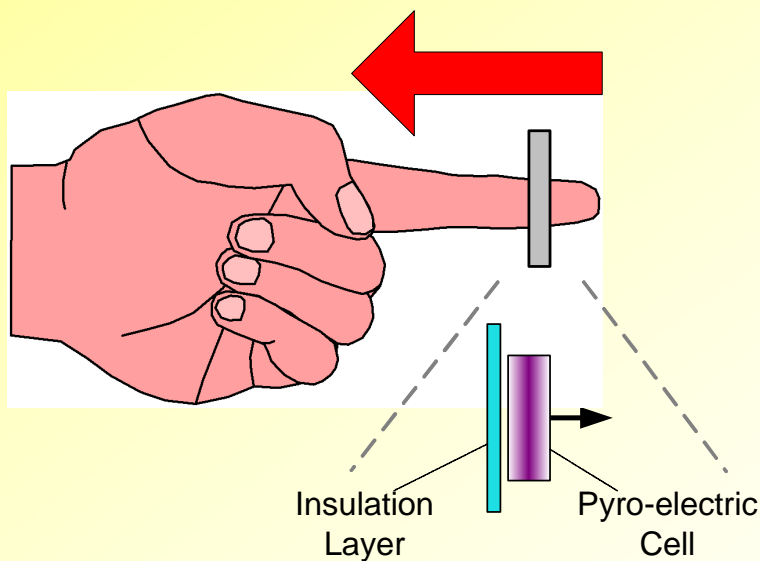


Fingerprint Sensor Technologies III.

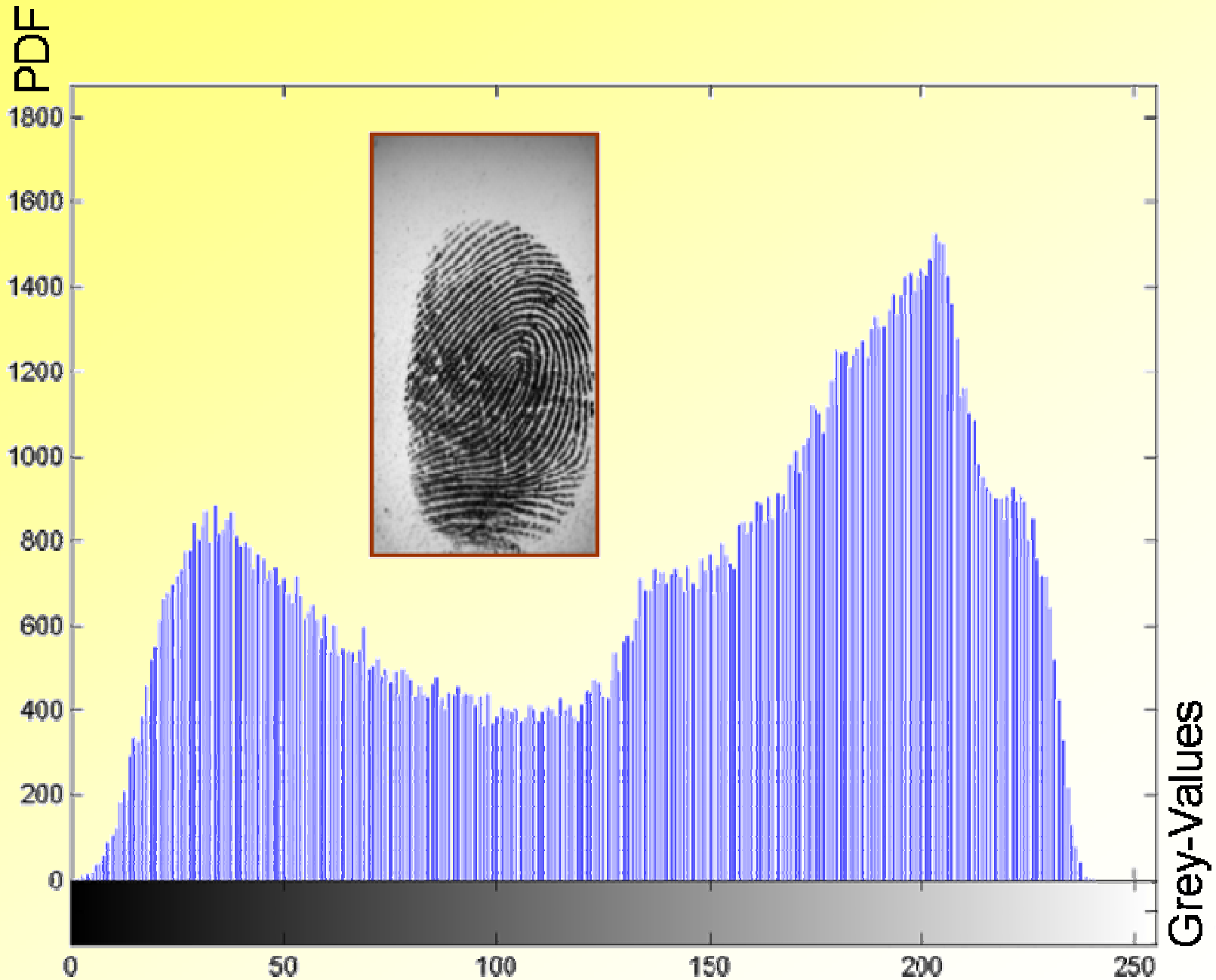
→ Pressure-Sensitive Technology



→ Thermal Technology

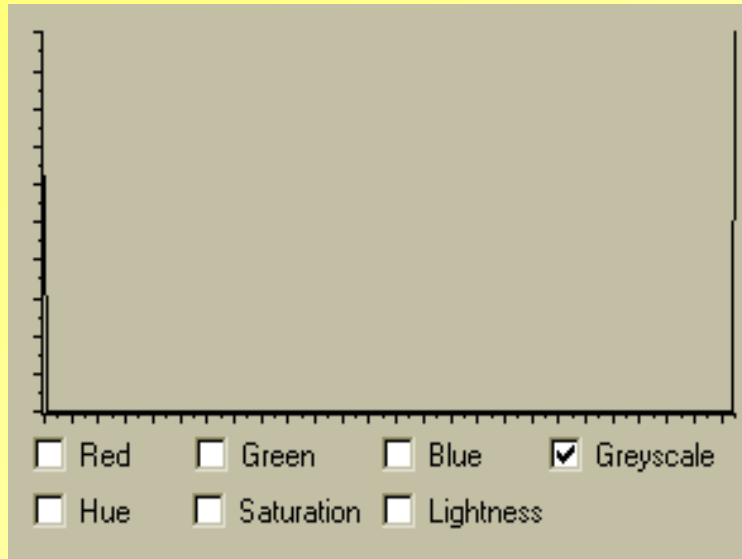


2 – Quality Measures from the Image Histogram

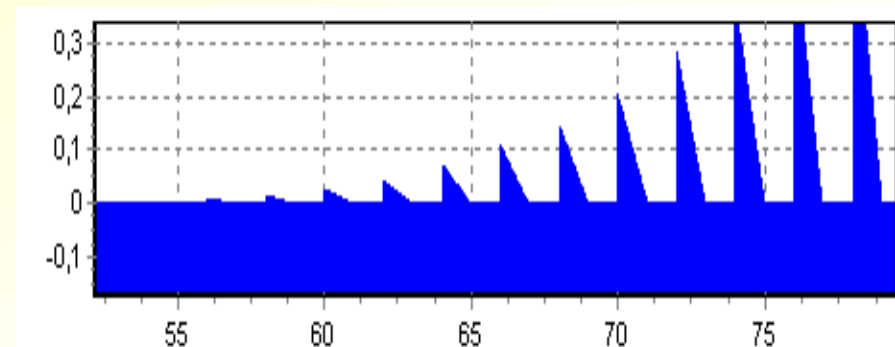
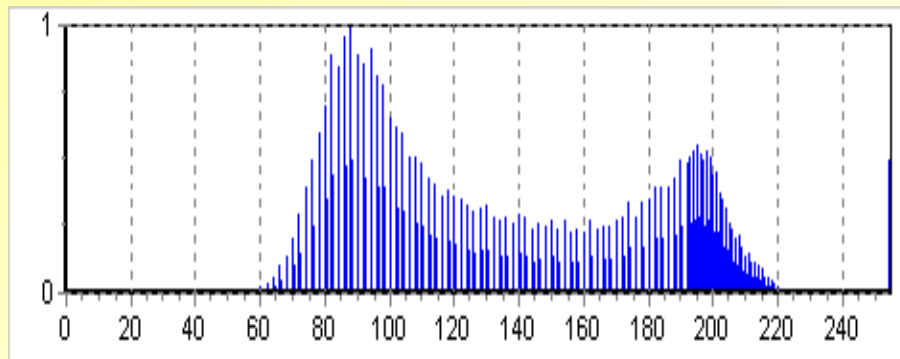


Histogram of a Fingerprint Image I.

→ Histogram – Example (Suprema SFM 3020 – B&W)

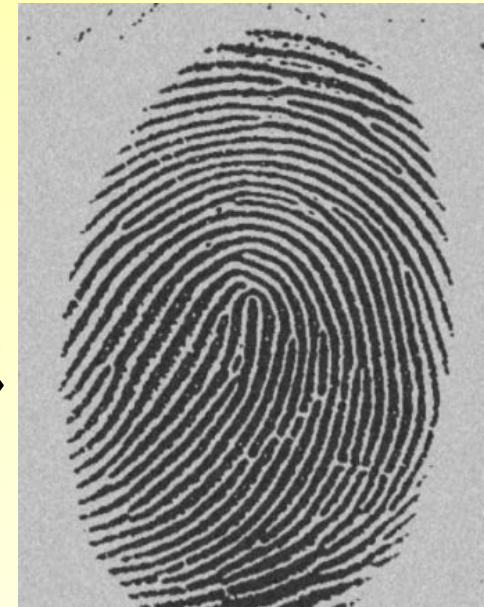
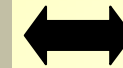
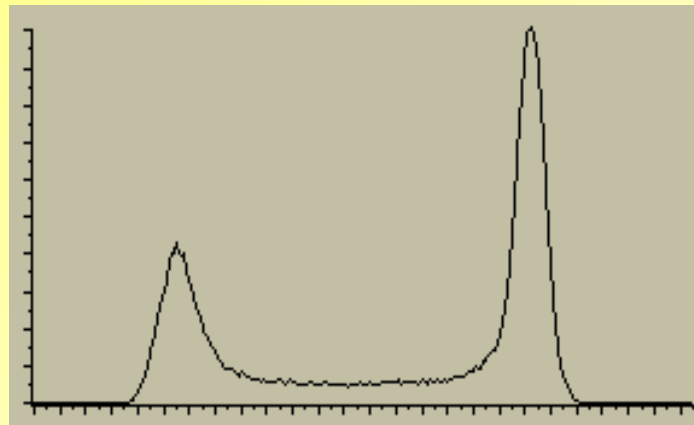


→ Histogram – Example (Suprema SFM 3050 – gaps)

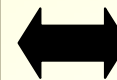
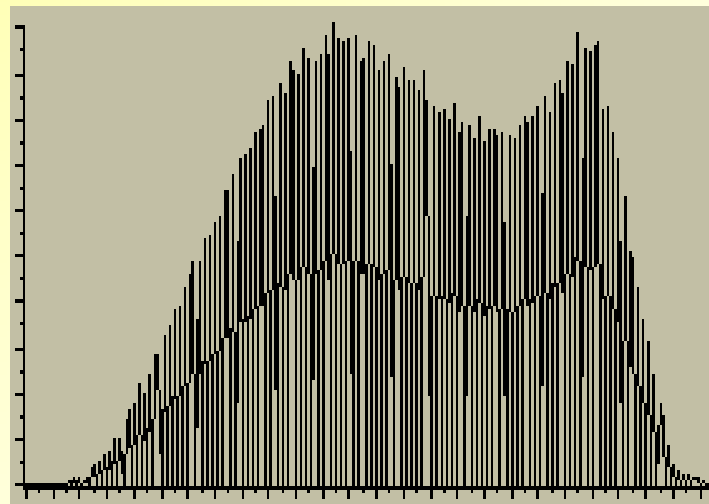


Histogram of a Fingerprint Image II.

→ Histogram – Access Control Systems



→ Histogram – Dactyloscopic (Identification) Systems



Quality of Fingerprints I.

→ Image Contrast

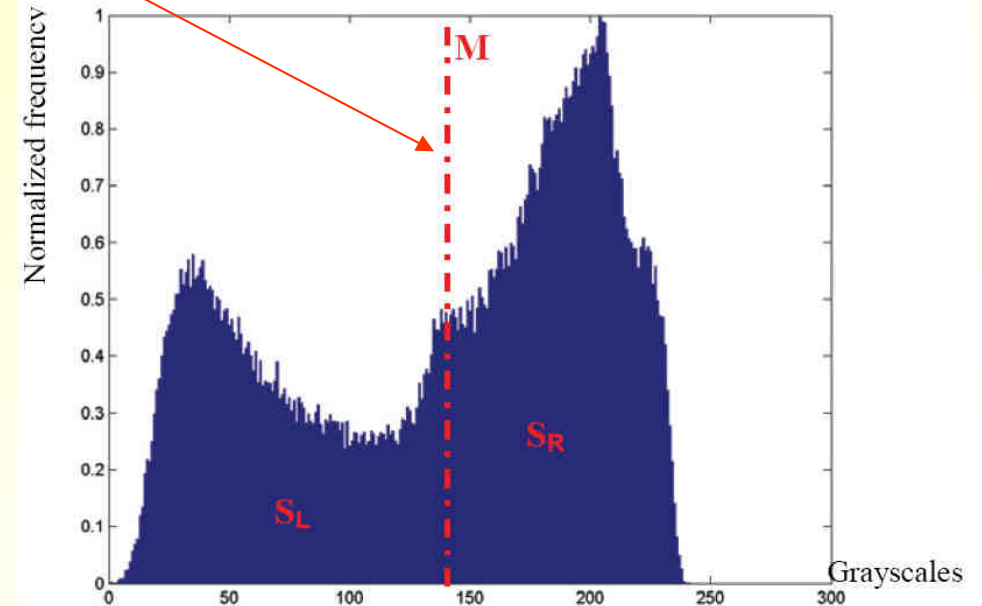
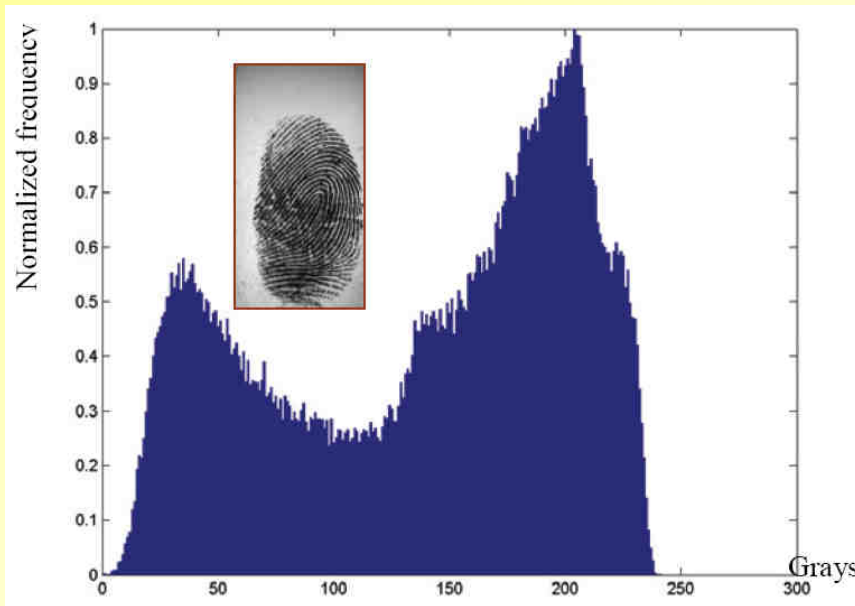
→ Weber Contrast $C_{Weber} = \frac{\Delta L}{L}$

→ Michelson Contrast $C_{Michelson} = \frac{(L_{max} - L_{min})}{(L_{max} + L_{min})}$

→ Average Value of Grayscale (∅ Full G-Scale = 128)

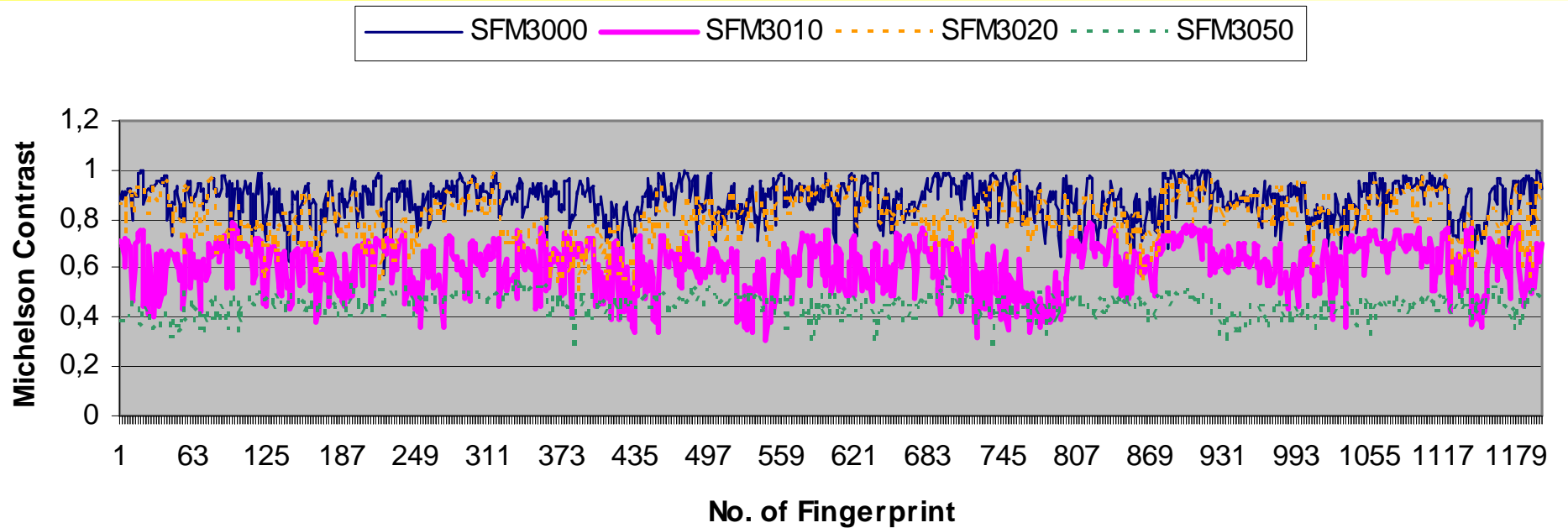
→ Separability of Histogram Peaks (B&W Maximums)

→ Mean Value of the Histogram (Usage of PDF)

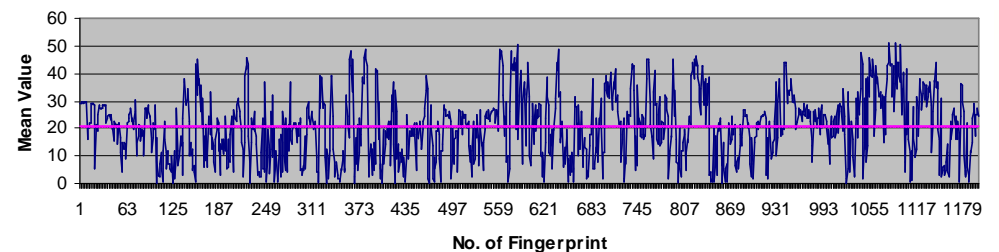
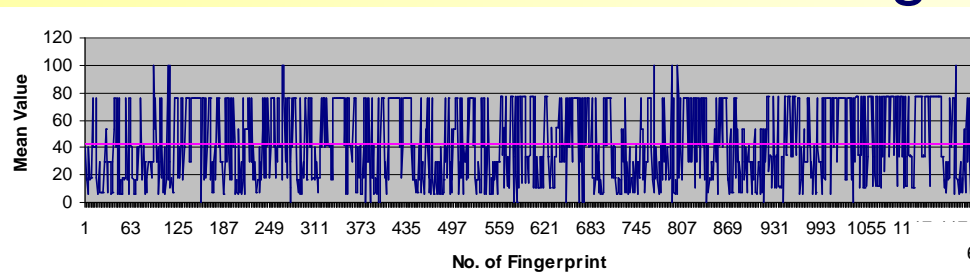


Quality of Fingerprints II.

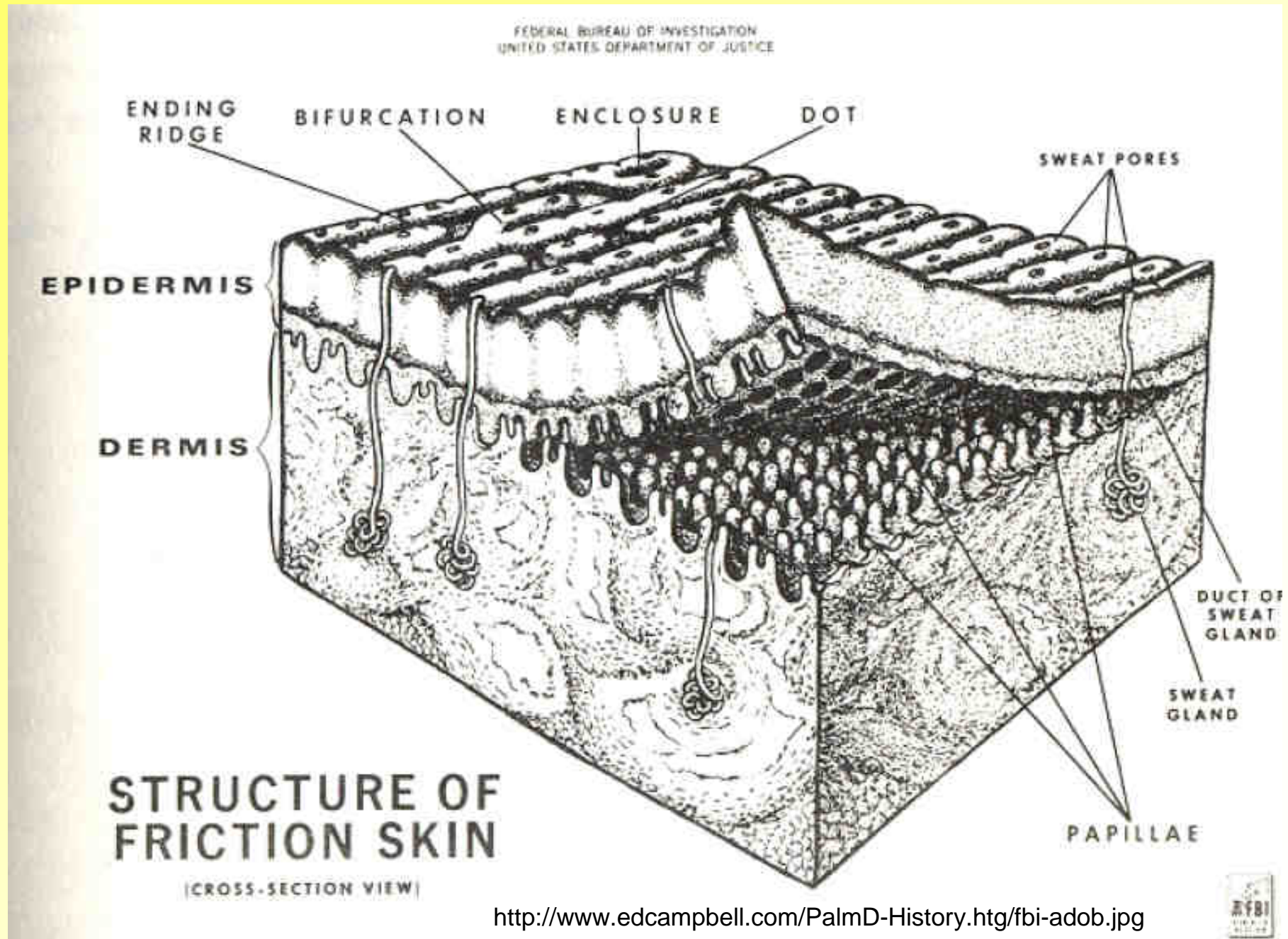
→ Michelson Contrast – Results by Suprema



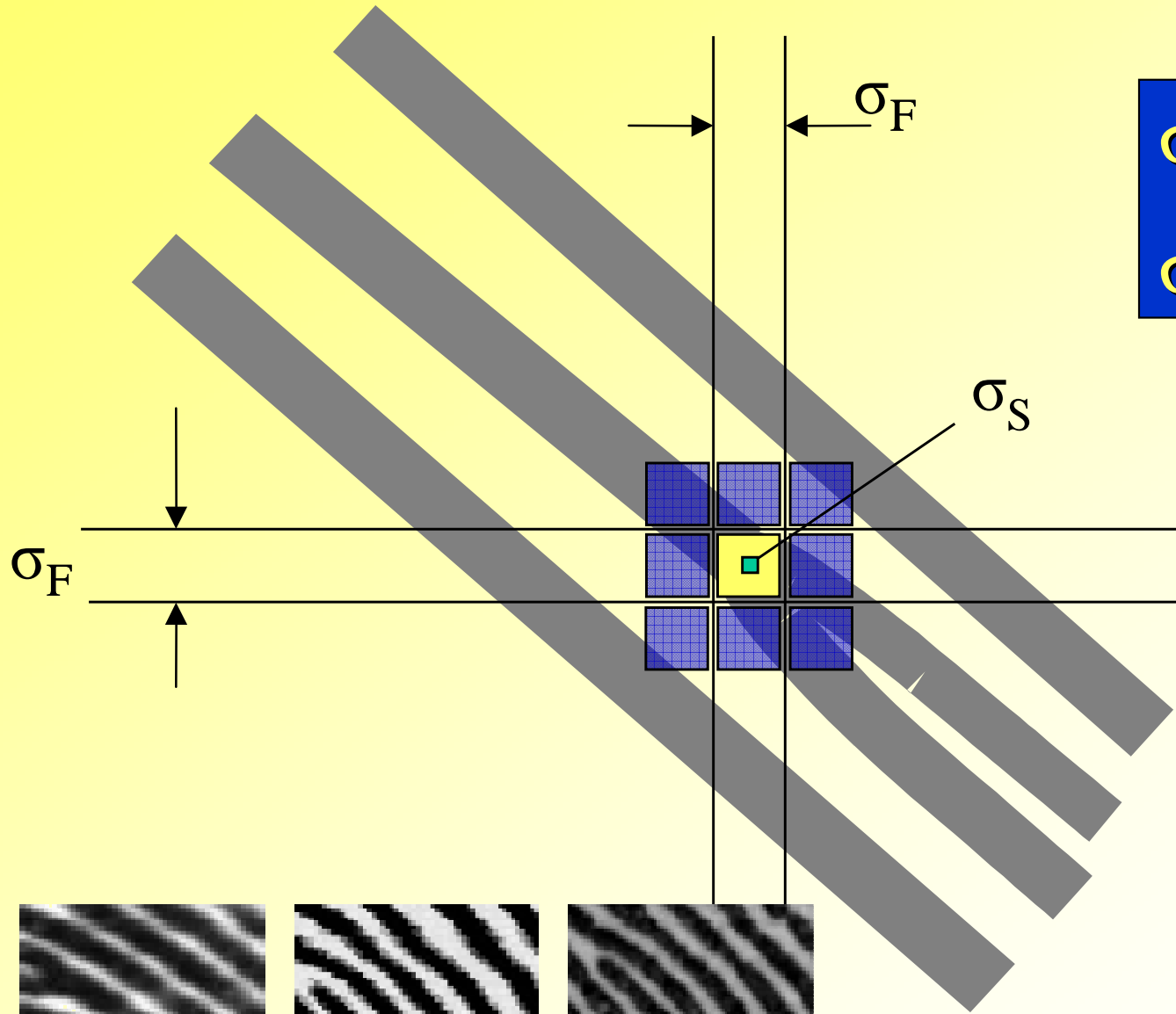
→ Mean Value of the Histogram (SFM3000 & SFM3050)



3 – Information Entropy in the Fingerprint



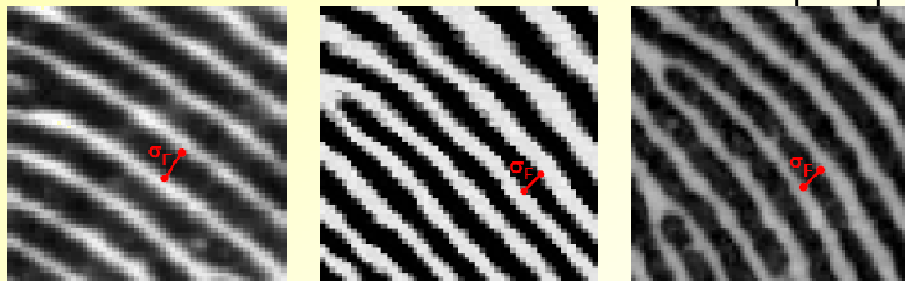
Resolution of a Papillary Line



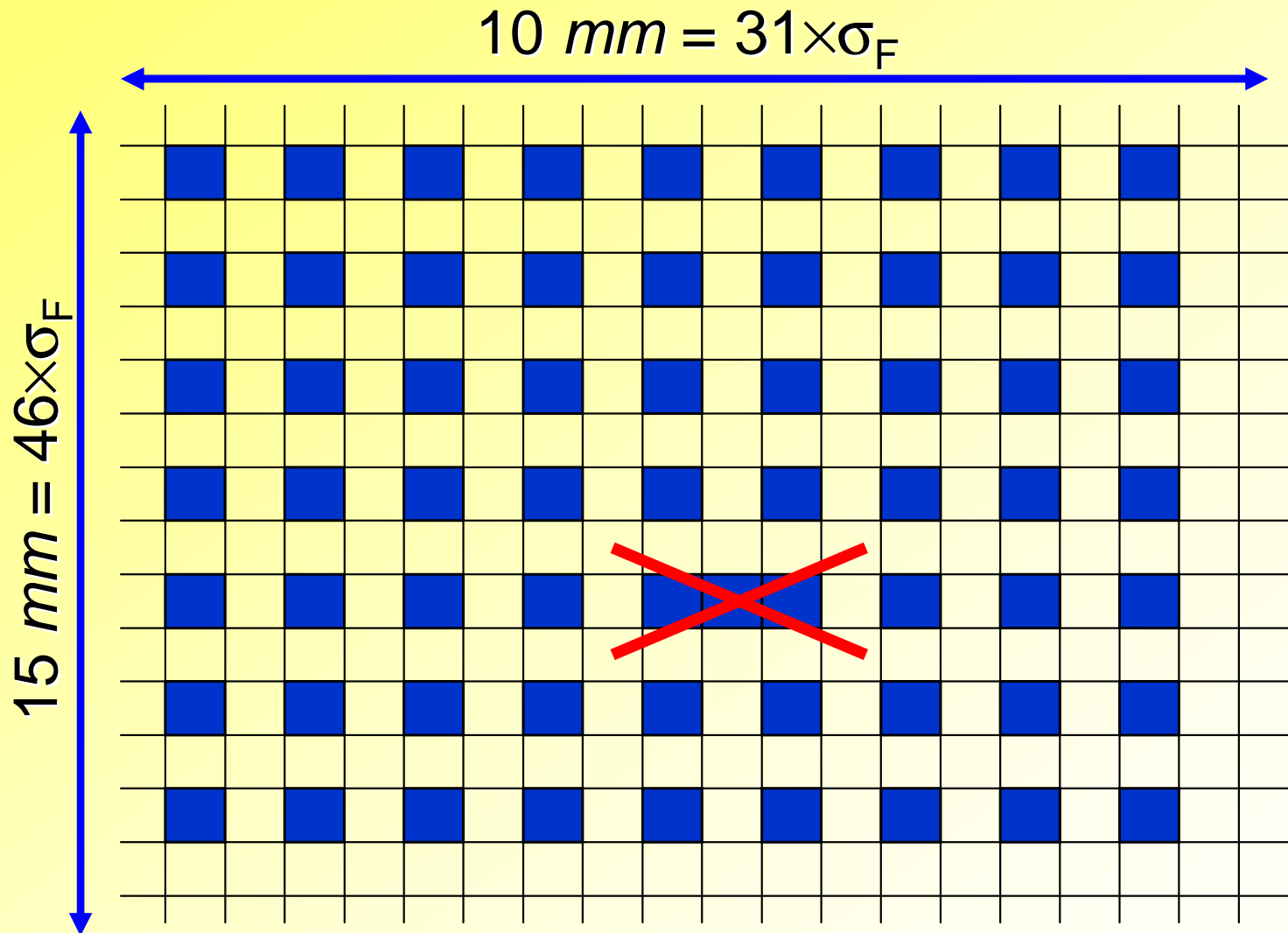
$$\sigma_F = 0,33 \text{ mm}$$

$$\sigma_S = 0,043 \text{ mm}$$

$$\sigma_F = 7,7 \times \sigma_S$$



Maximal Amount of Minutiae

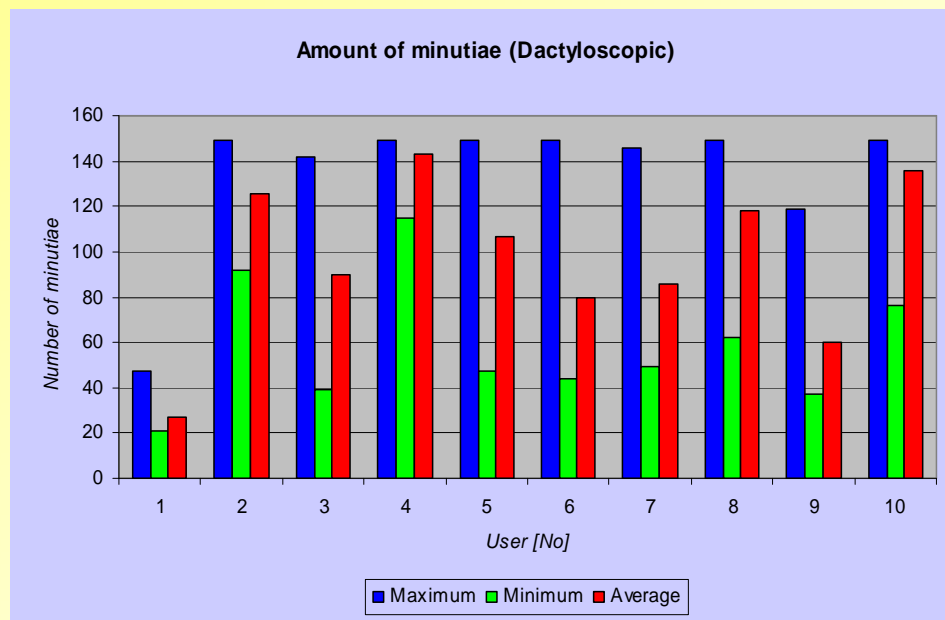
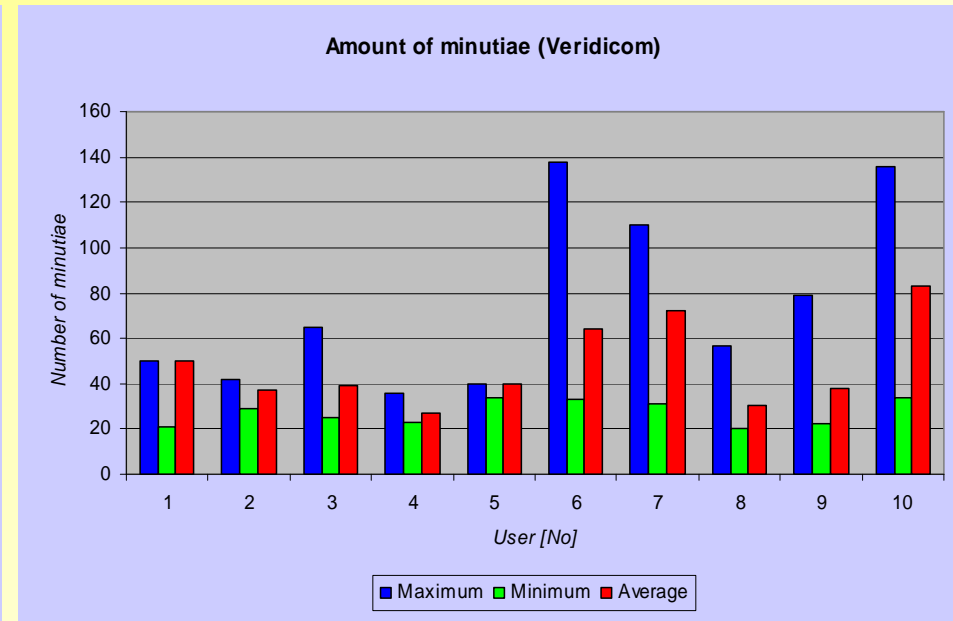
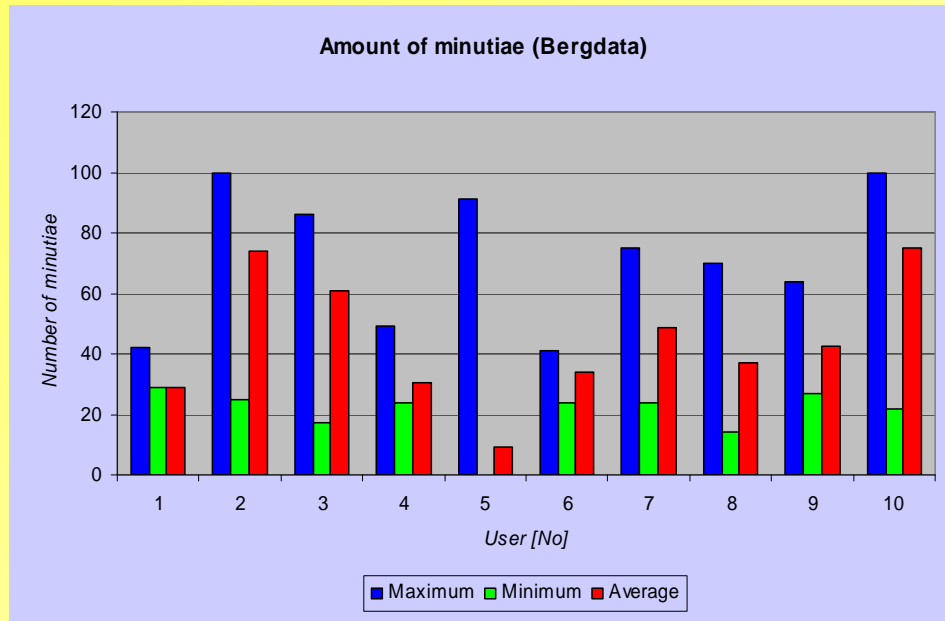


Maximum
 $M = 368$
 Minutiae

!
 $M \ll 368$

More in: *Drahansky, M.: Biometric Security Systems – Fingerprint Recognition Technology*, Dissertation, Brno University of Technology, Faculty of Information Technology, 2005

Real Amounts of Minutiae + Entropies



Entropy Computation:

$$E = \left(2^{N_B}\right)^{P_M-1} \cdot 2^{P_M} \cdot \left(2^{N_G}\right)^{P_M-1}$$

Maximal Entropy (368 minutiae):

$$\left(2^{17}\right)^{368-1} \cdot \left(2^{368}\right) \cdot \left(2^4\right)^{368-1} = 2^{8075} = 6,5647 \cdot 10^{2430}$$

Minimal Entropy (12 minutiae):

$$\left(2^{17}\right)^{12-1} \cdot \left(2^{12}\right) \cdot \left(2^4\right)^{12-1} = 2^{243} = 1,4135 \cdot 10^{73}$$

Quantization = Reduction of Entropy !!!

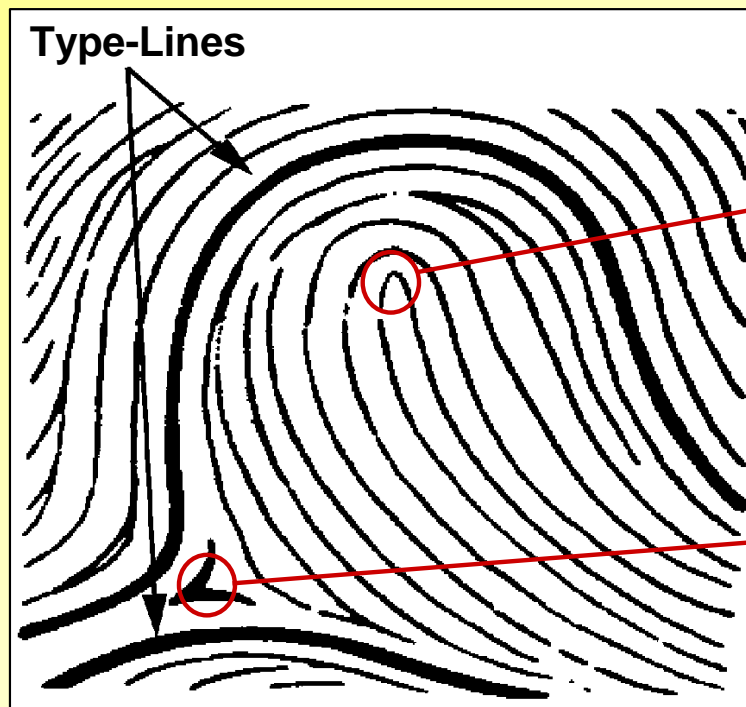
4 – Quality Estimation of a Papillary Line



<http://162.105.71.163/people/chenxg/fip.jpg>

Center Computation I.

- Finding of Fingerprint's Center
 - Gravity Center of the Minutiae (M1)
 - Vertical & Horizontal Maximums of Ridge Count (M2)
 - Middle of the Orientation Field (M3)



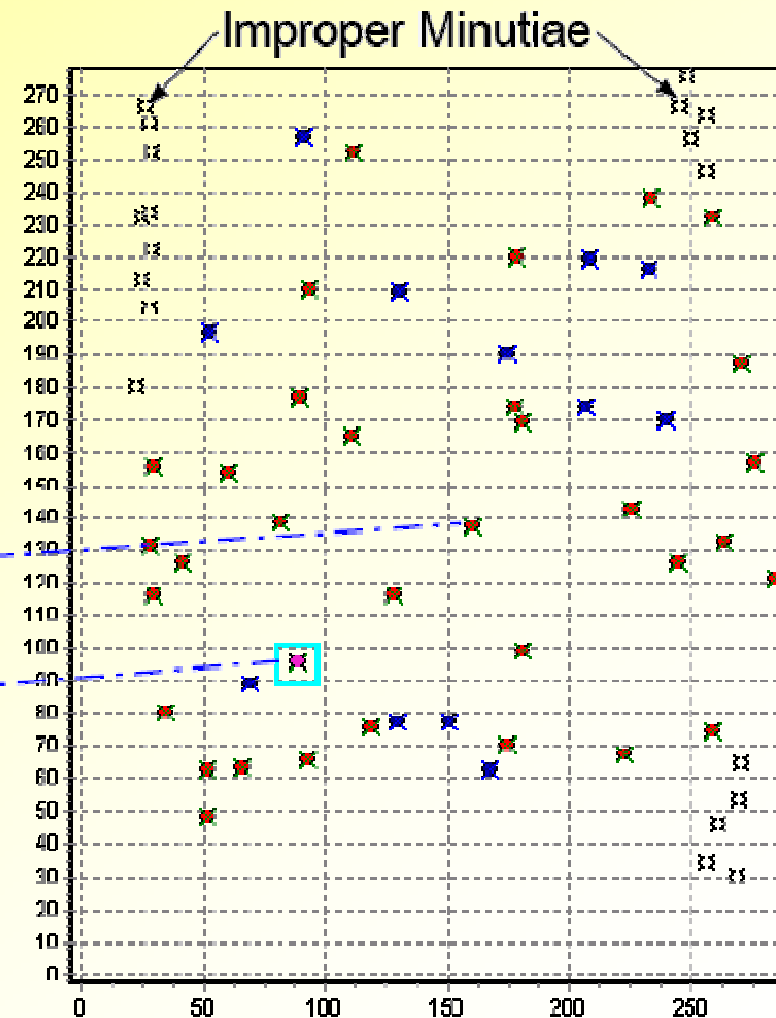
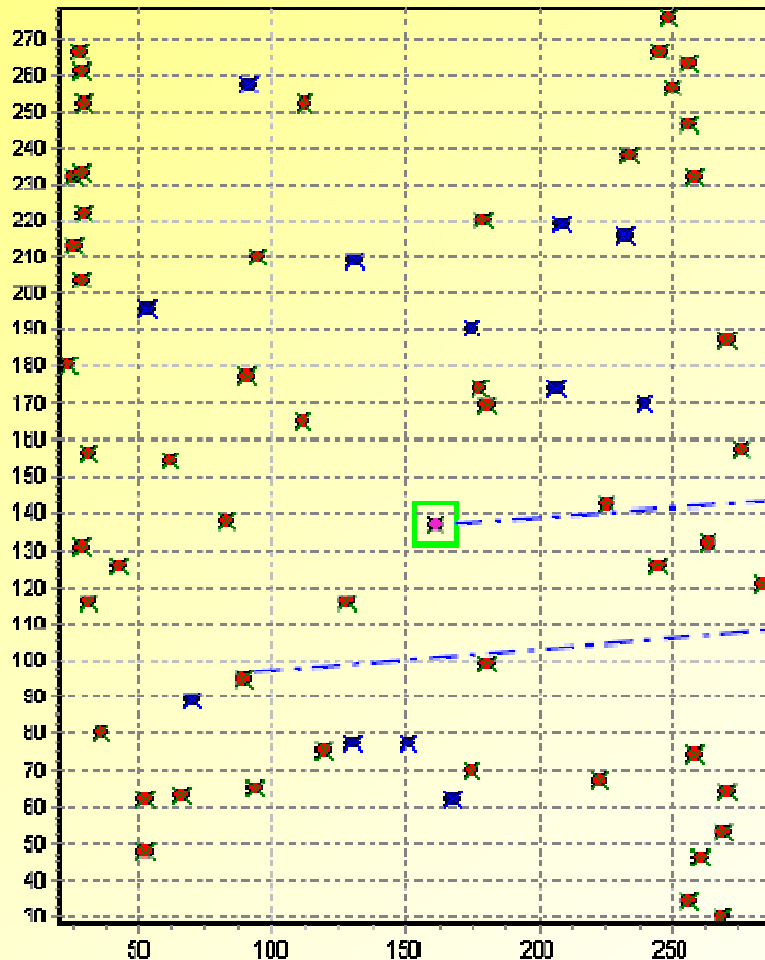
Core

Delta



→ Finding of Fingerprint's Center

→ Gravity Center of the Minutiae (M1)



→ Finding of Fingerprint's Center

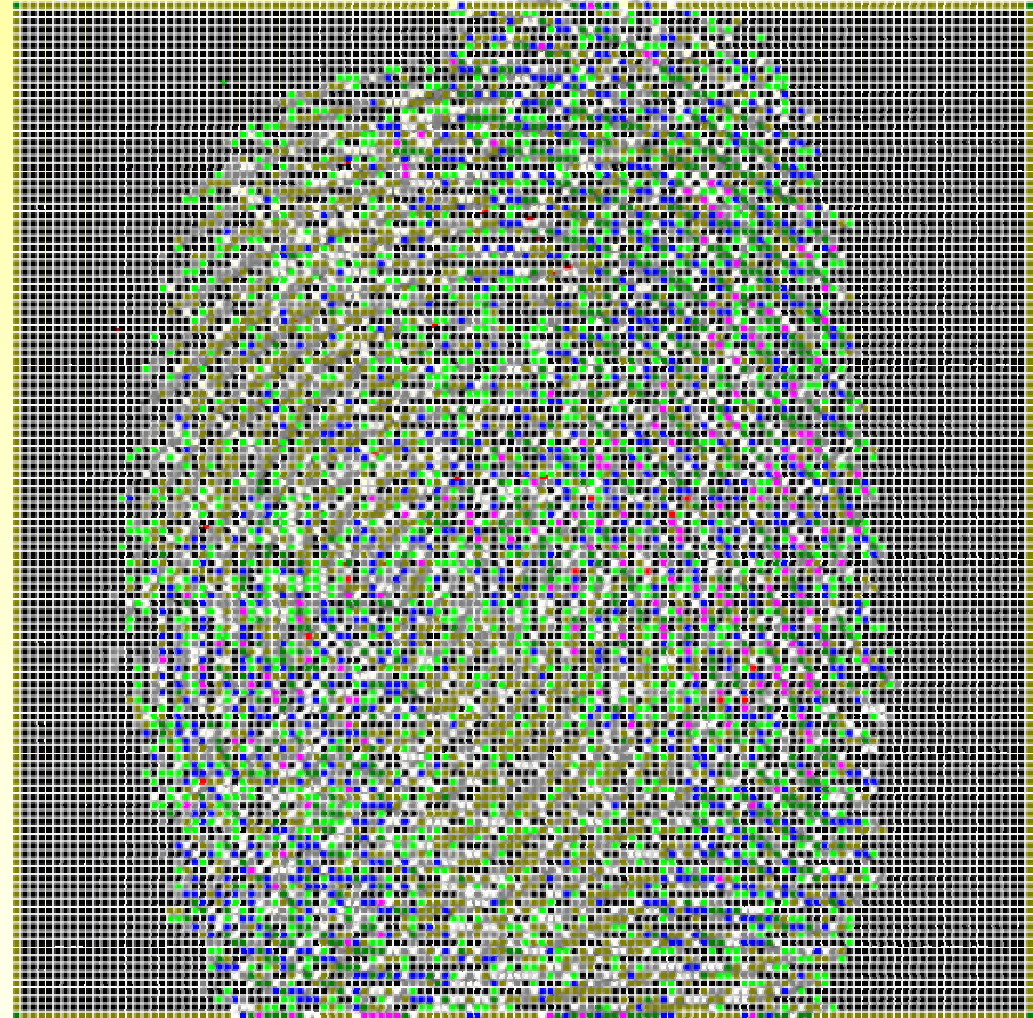
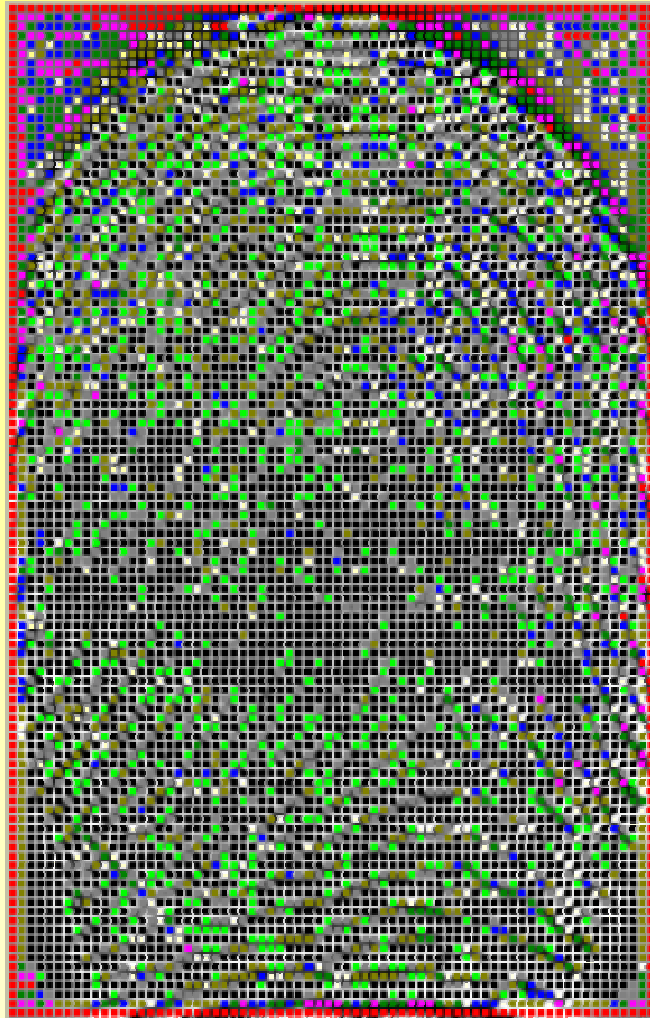
→ Vertical & Horizontal Maximums of Ridge Count (M2)



| Sensor (Suprema SFM3xxx) | 000 | 010 | 020 | 050 |
|--------------------------------|-------|-------|-------|-------|
| Horizontal minimum | 6,00 | 6,00 | 9,00 | 10,00 |
| Horizontal average | 12,86 | 19,30 | 19,93 | 21,25 |
| Horizontal maximum | 23,00 | 27,00 | 30,00 | 31,00 |
| Vertical minimum | 5,00 | 3,00 | 11,00 | 11,00 |
| Vertical average | 13,26 | 33,18 | 22,79 | 25,67 |
| Vertical maximum | 24,00 | 51,00 | 31,00 | 37,00 |

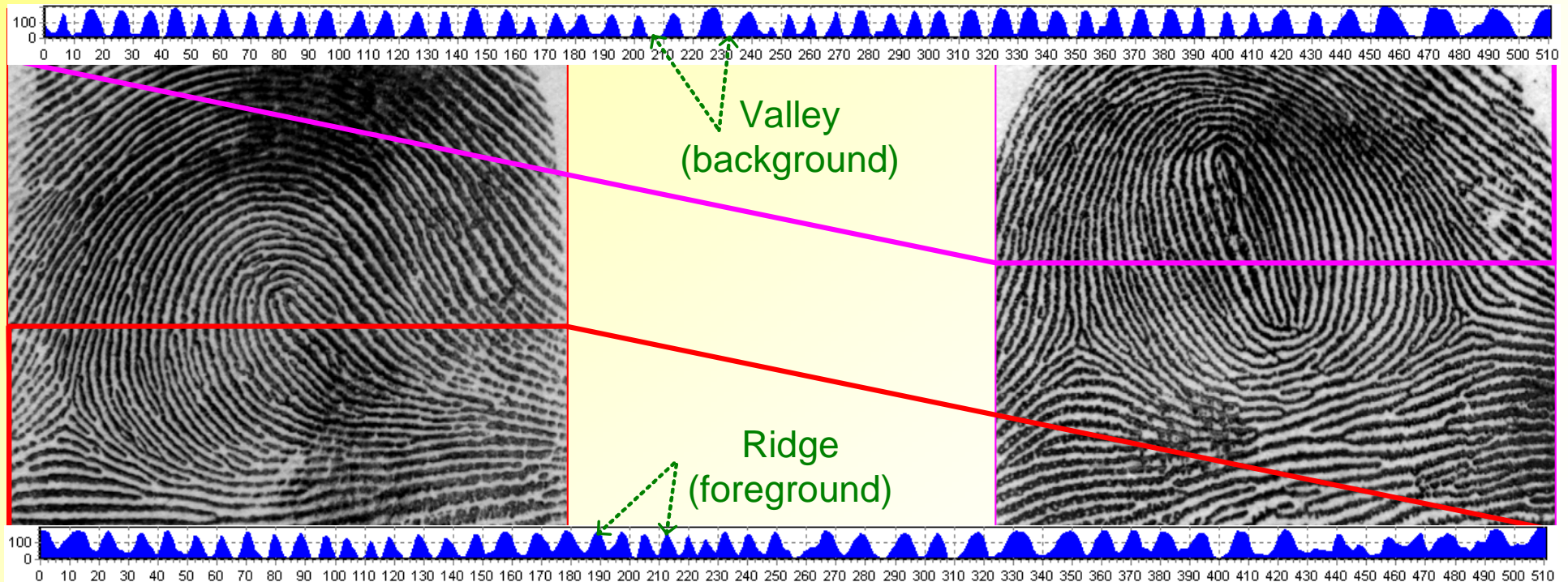
Center Computation IV.

- Finding of Fingerprint's Center
 - Middle of the Orientation Field (M3)



Crosscut Through the Fingerprint Image I.

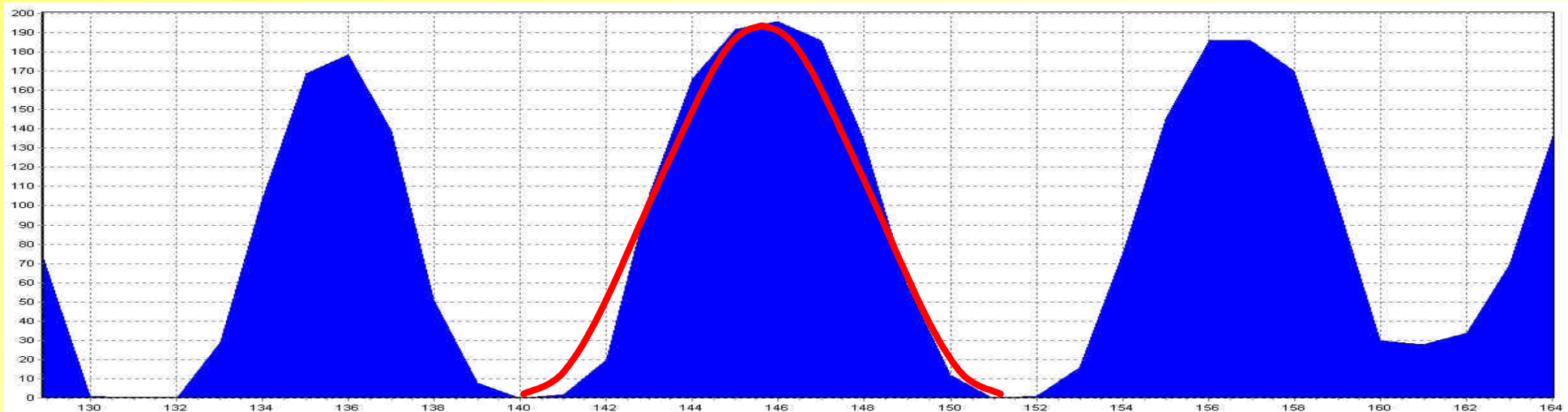
- Crosscut Through the Fingerprint in the Center
- Reason: Perpendicularity of the Cut to Papillary Line
- Same for Horizontal and Vertical Cuts



Crosscut Through the Fingerprint Image II.

→ Comparison with the *Sine* Function

→ Range: $\left\langle -\frac{\pi}{2}, \frac{3\pi}{2} \right\rangle$



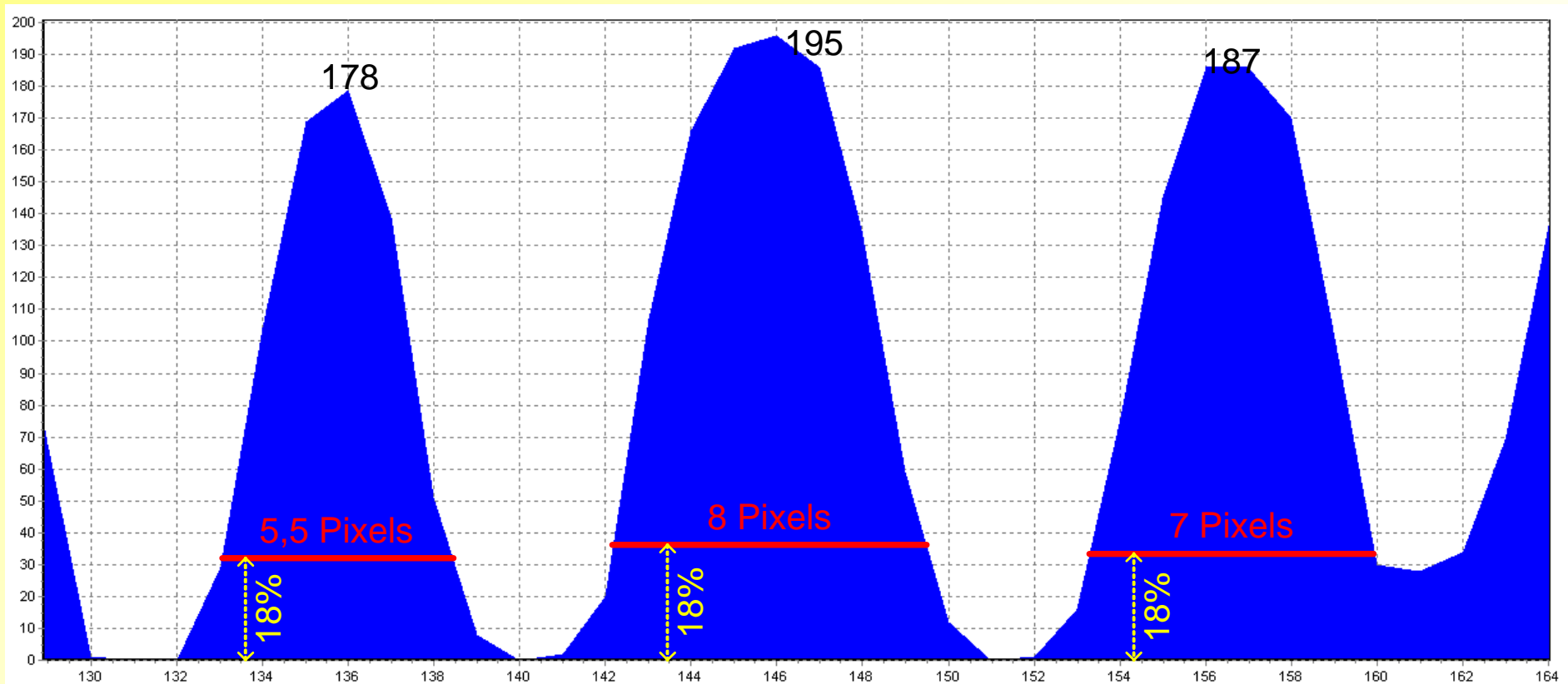
→ Deviation of the Curvature from the *Sine* Function

$$D_A = \left(\frac{A_{FA}}{A_{\sin}} - 1 \right) \cdot 100\% \quad \dots \quad A_{FA} = \int_{x_S}^{x_E} f(x) dx \quad \& \quad A_{\sin} = \int_{x_S}^{x_E} \sin(x) dx$$

Crosscut Through the Fingerprint Image III.

→ Thickness of the Papillary Line $Th = \frac{2,54}{R_{DPI}} \cdot N_{Pix} [cm]$

→ Deviation of the Thickness from the Defined One (0,33 mm)

$$D_{Th} = \left(\frac{Th}{0,033} - 1 \right) \cdot 100\%$$


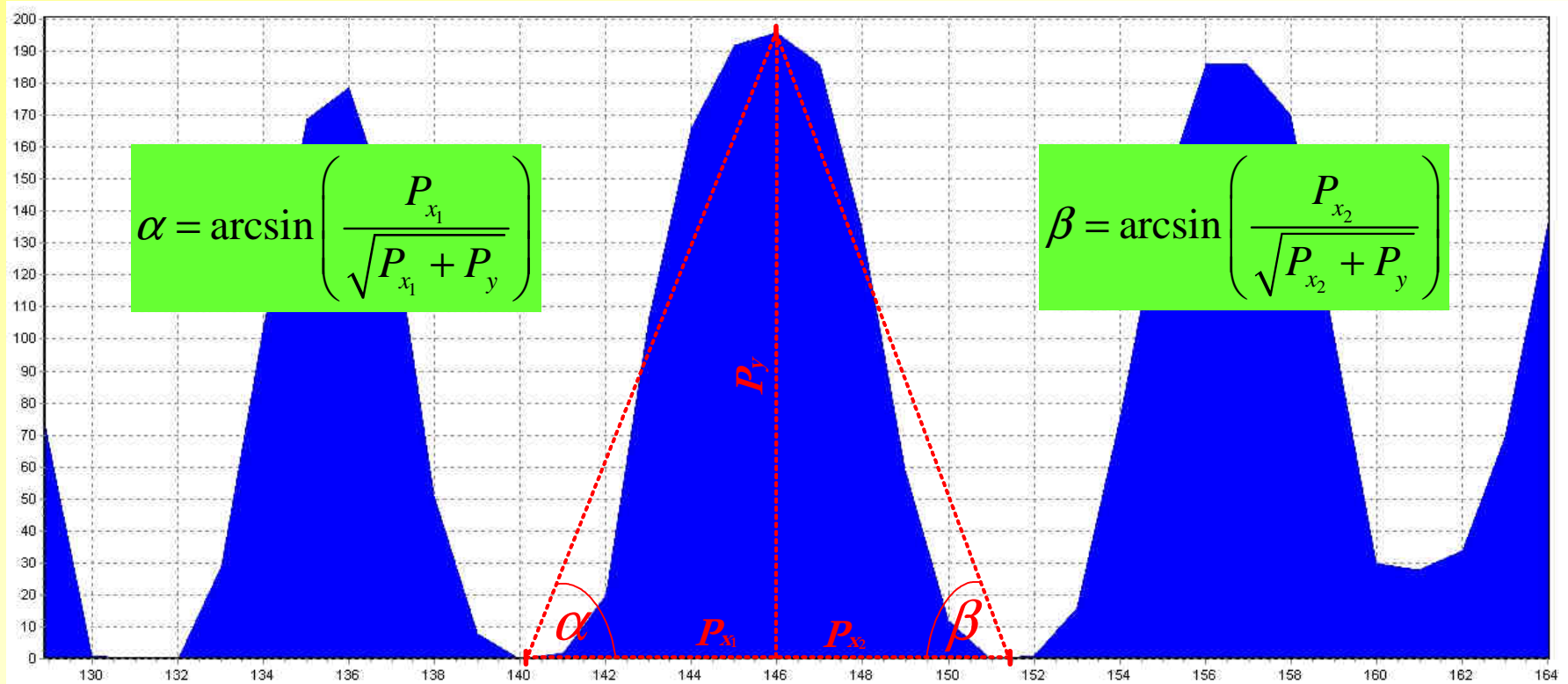
Crosscut Through the Fingerprint Image IV.

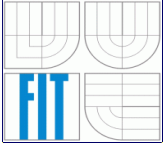
→ Steepness of the Papillary Line

→ Deviation of the Steepness from Ideal Triangle

$$D_{\alpha} = \frac{|\alpha - 60^{\circ}|}{60^{\circ}} \cdot 100\%$$

$$D_{\beta} = \frac{|\beta - 60^{\circ}|}{60^{\circ}} \cdot 100\%$$





The End

→ Thank you for your attention!

→ Thanks to MSM 0021630528 – Security-Oriented Research in IT