



ISEL
INSTITUTO SUPERIOR
DE ENGENHARIA DE LISBOA

PROCESSAMENTO DE IMAGEM E BIOMETRIA

IMAGE PROCESSING AND BIOMETRICS

9. BIOMETRIC SYSTEMS – part 1

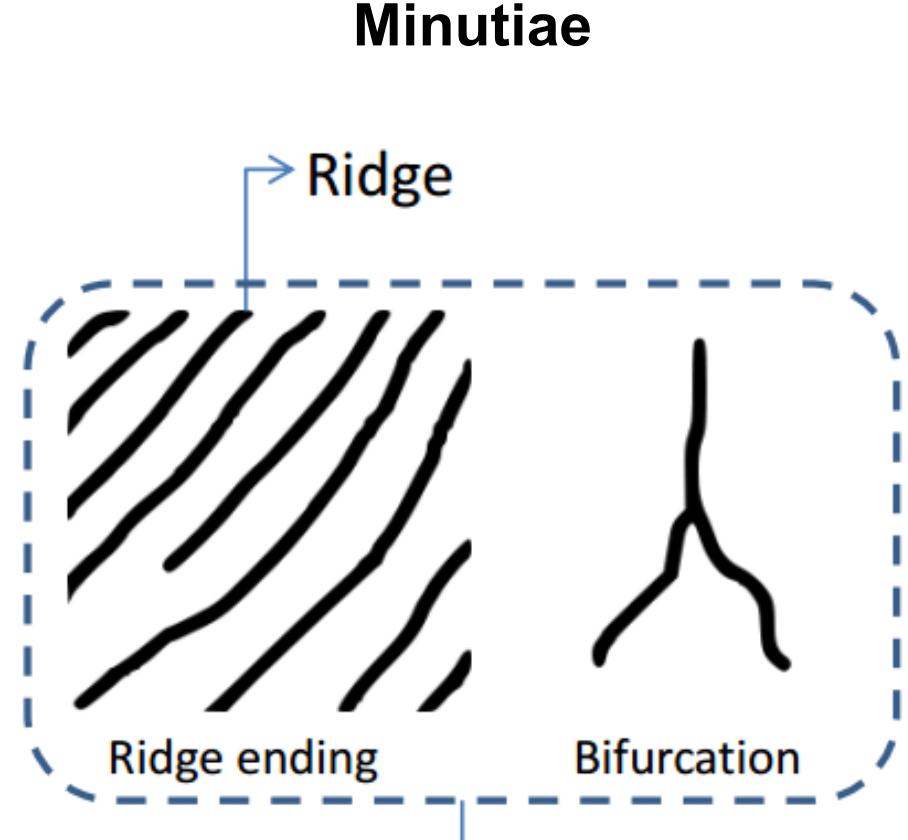
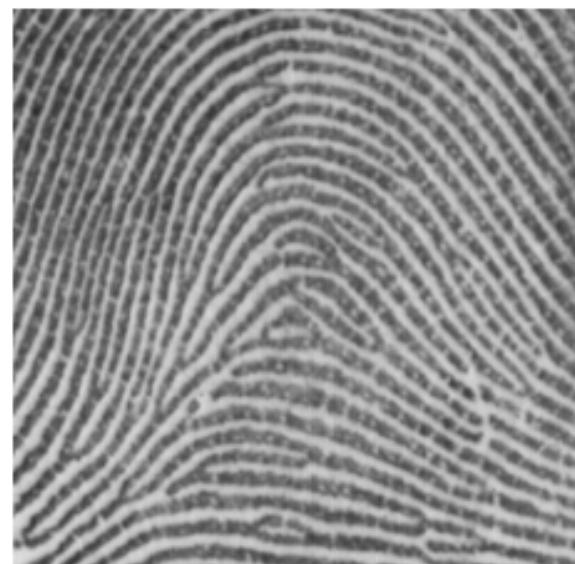
Summary

- Fingerprints
- Fingerprint Recognition System

Fingerprint (1)



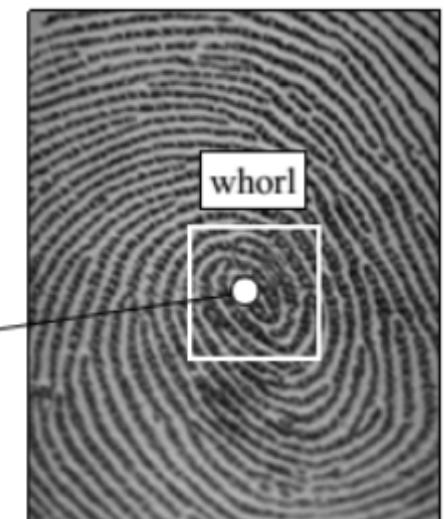
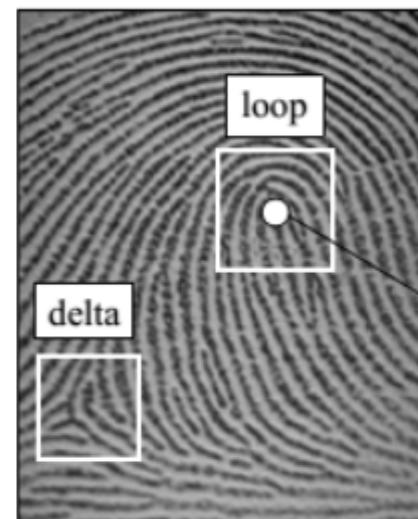
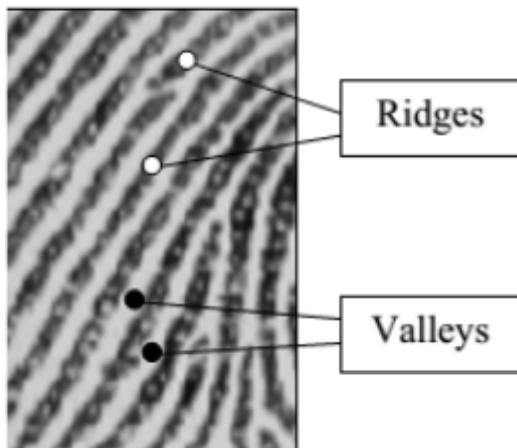
Fingerprints are graphical
flow-like ridges



Fingerprint (2)

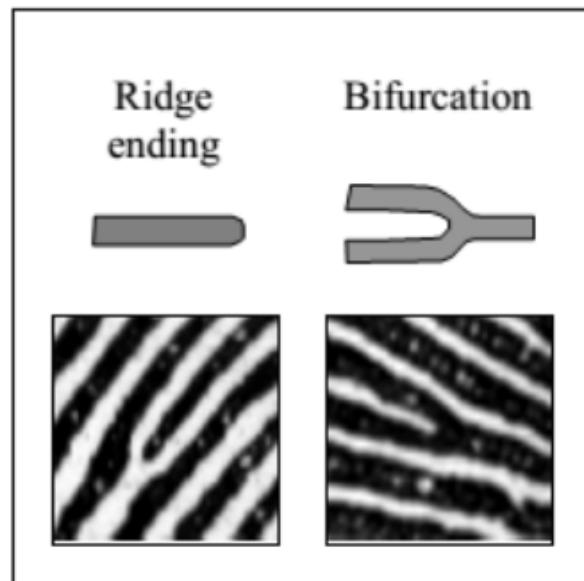
- Formation determined during the first 7 months of fetal development
- Fingerprints of identical twins are different

Minutiae



Fingerprint (3)

Minutiae



Fingerprint (4)

Minutiae

<https://en.wikipedia.org/wiki/Minutiae>

- ***Ridge ending*** – the abrupt end of a ridge
- ***Ridge bifurcation*** – a single ridge that divides into two ridges
- ***Short ridge, or independent ridge*** – a ridge that commences, travels a short distance and then ends
- ***Island*** – a single small ridge inside a short ridge or ridge ending that is not connected to all other ridges

Fingerprint (5)

Minutiae

<https://en.wikipedia.org/wiki/Minutiae>

Ridge enclosure – a single ridge that bifurcates and reunites shortly afterward to continue as a single ridge

Spur – a bifurcation with a short ridge branching off a longer ridge

Crossover or bridge – a short ridge that runs between two parallel ridges

Delta – a Y-shaped ridge meeting

Core – a U-turn in the ridge pattern

Fingerprint (6)

- 5 classes of fingerprints
- NIST - National Institute of Standards and Technology



Arch (6,2%)



Tented Arch (7,8%)



Left Loop (17%)



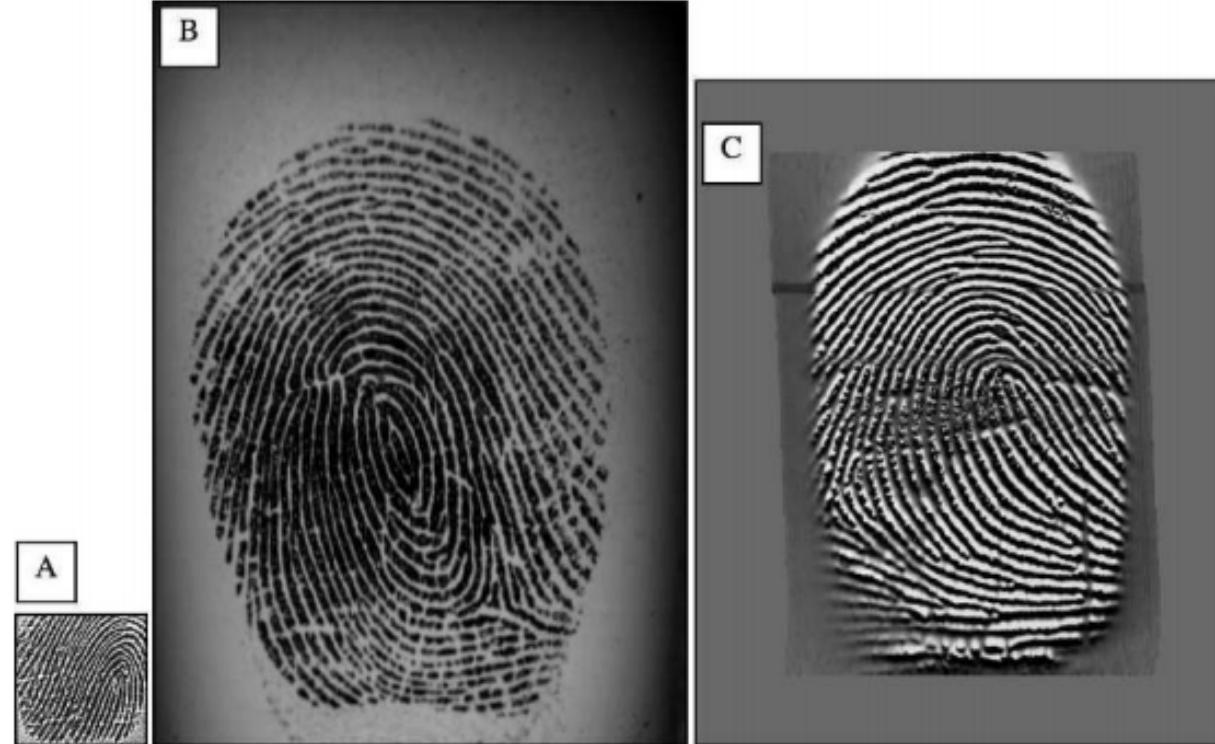
Right Loop (36,5%)



Whorl (32,5%)

Fingerprint (7)

- Fingerprint sensors



Solid-state
(Electric Field)
Authentec AES4000

Optical scanner
(FTIR)
Biometrika FX3000

Solid-state
(Thermal)
Atmel FingerChip

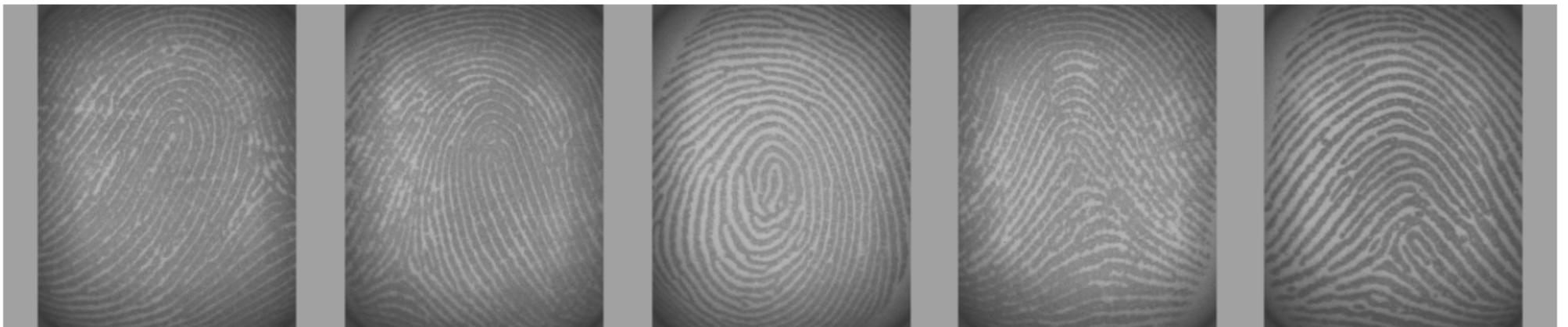
Fingerprint (8)

- Fingerprint sensors: optical, capacitive, ultrasound, pressure, thermal, electric field



Fingerprint (9)

- Images acquired with a fingerprint optical sensor



(a) left loop

(b) right loop

(c) whorl

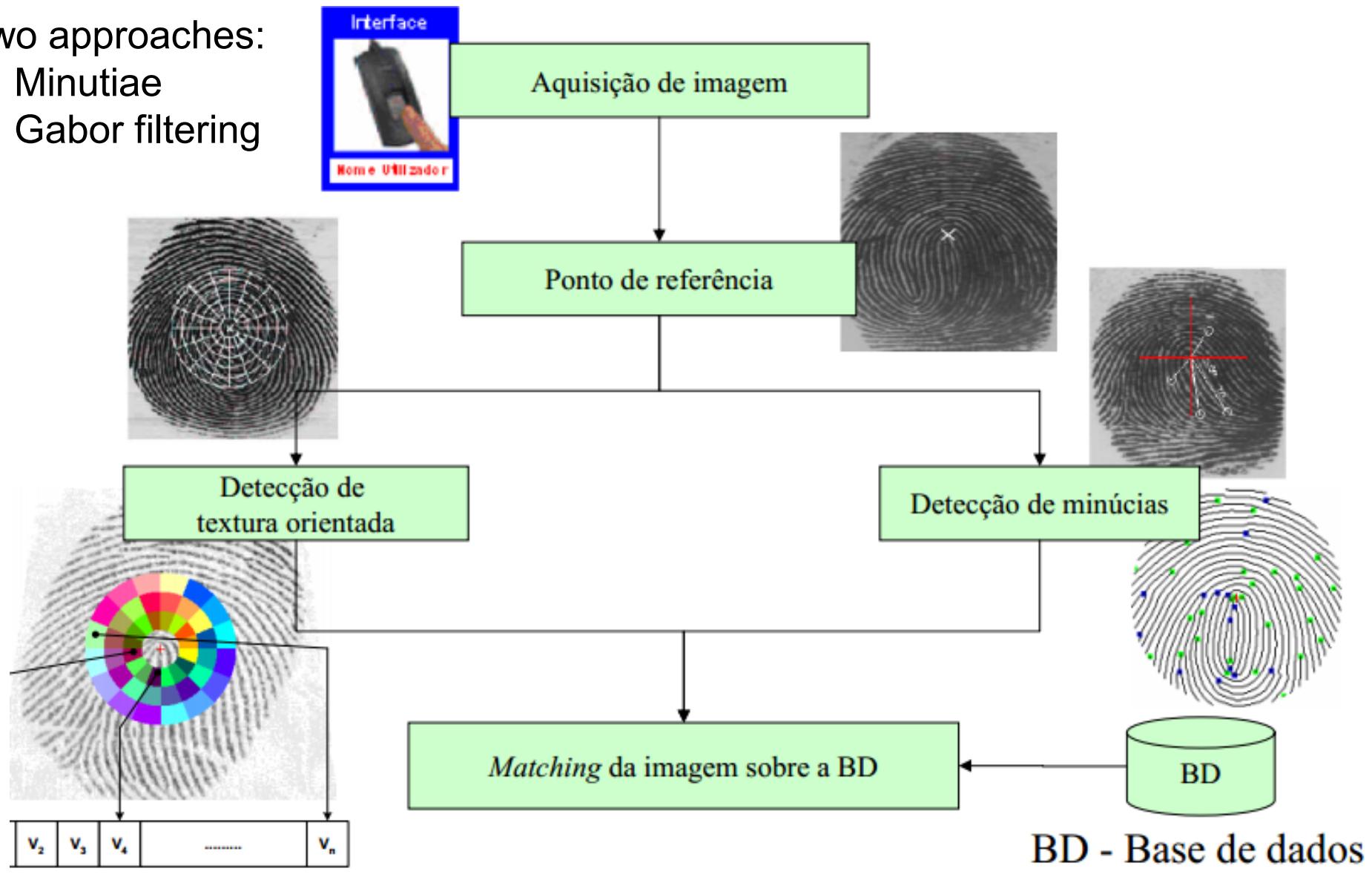
(d) arch

(e) tented arch

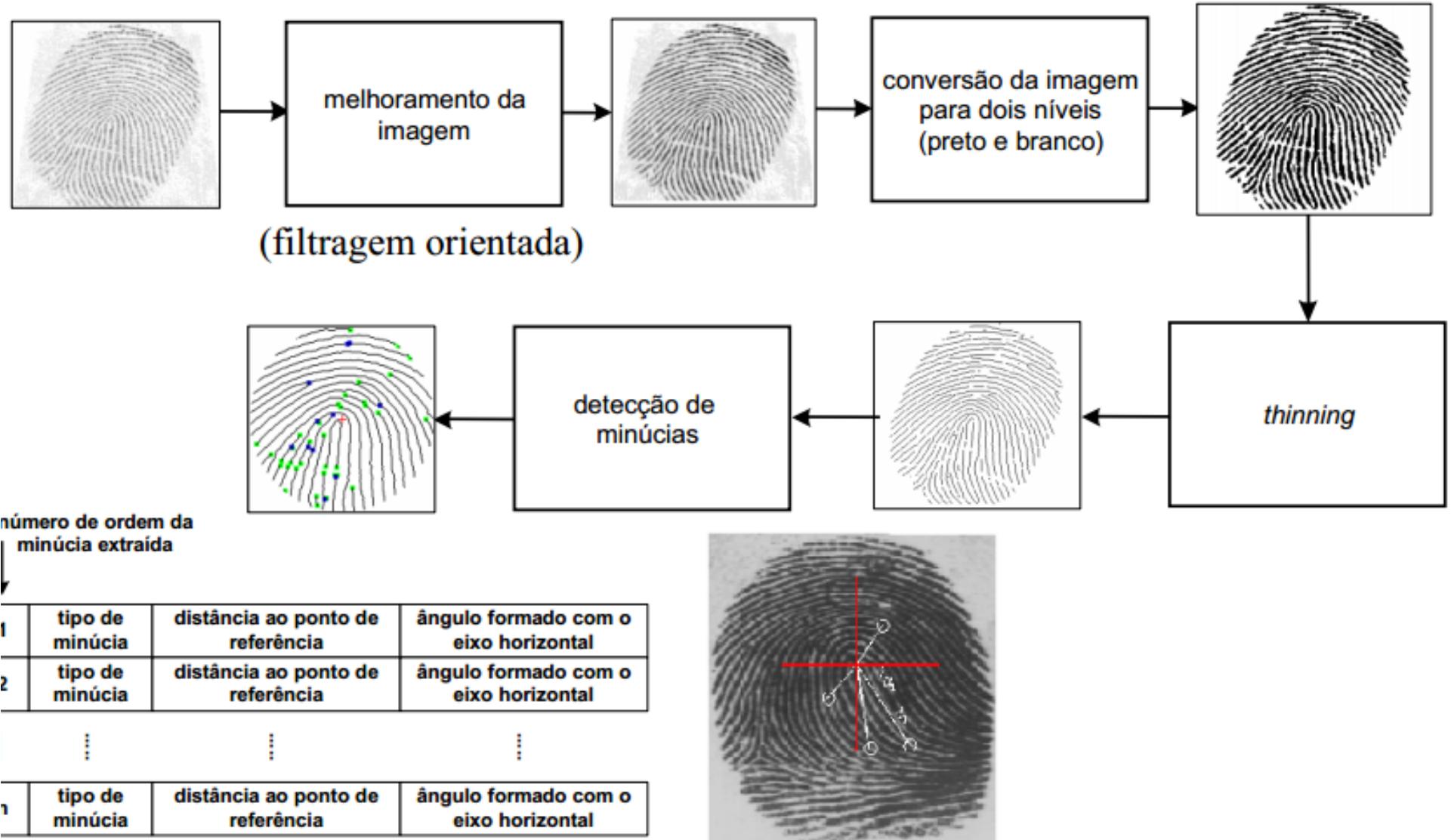
Fingerprint Recognition (1)

Two approaches:

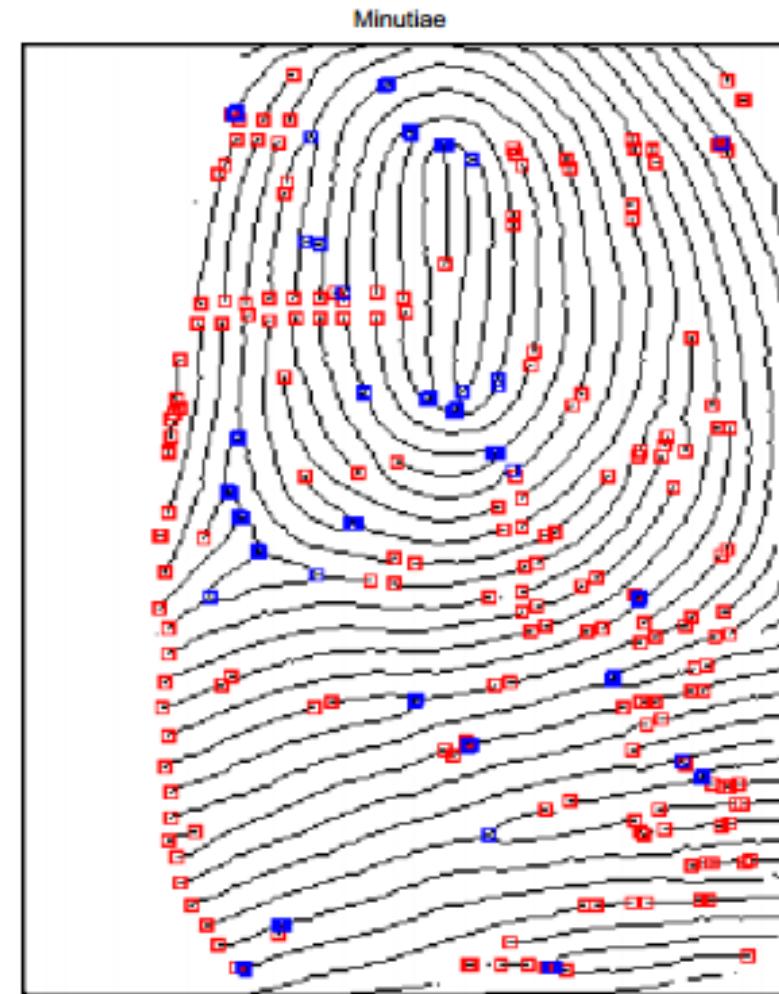
- Minutiae
- Gabor filtering



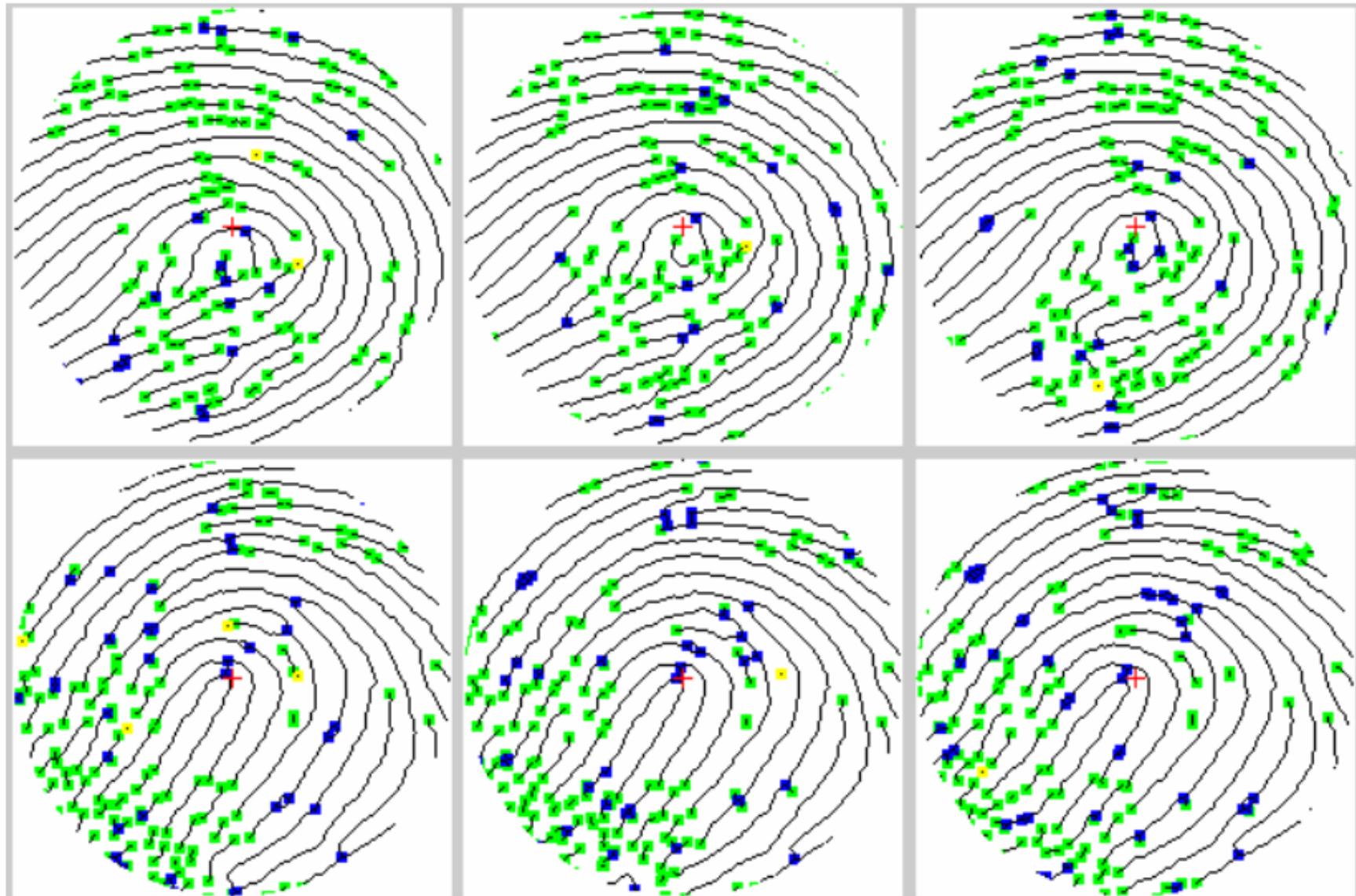
Fingerprint Recognition (2)



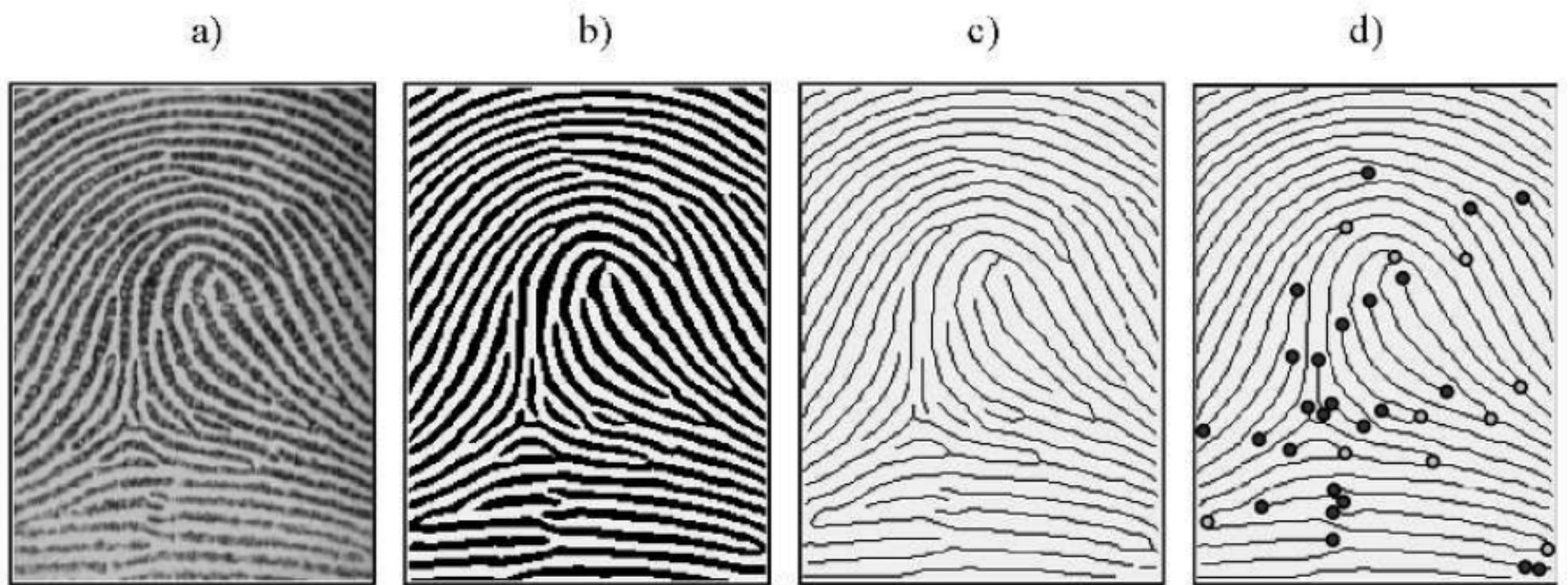
Fingerprint Recognition (3)



Fingerprint Recognition (4)

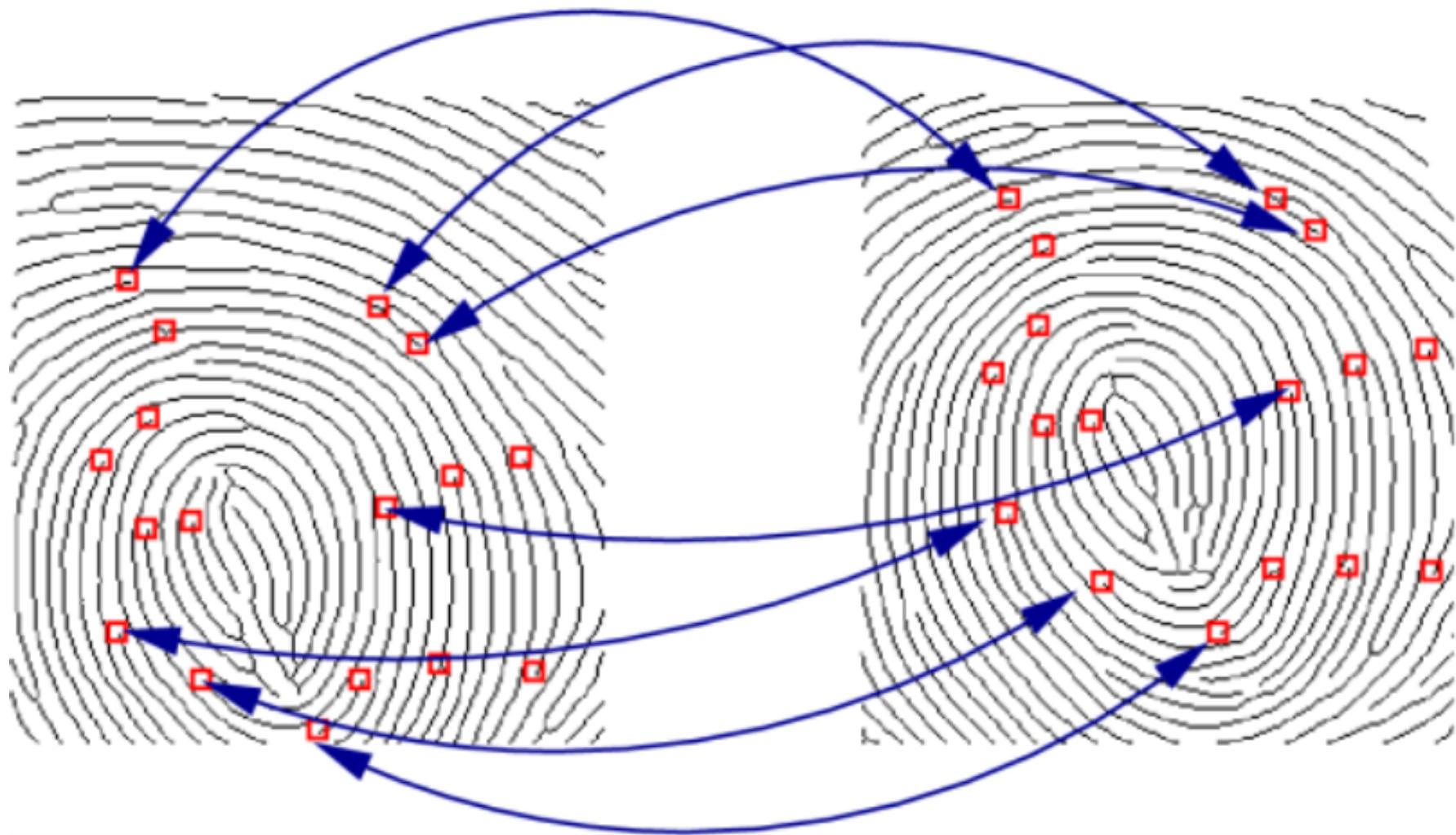


Fingerprint Recognition (5)

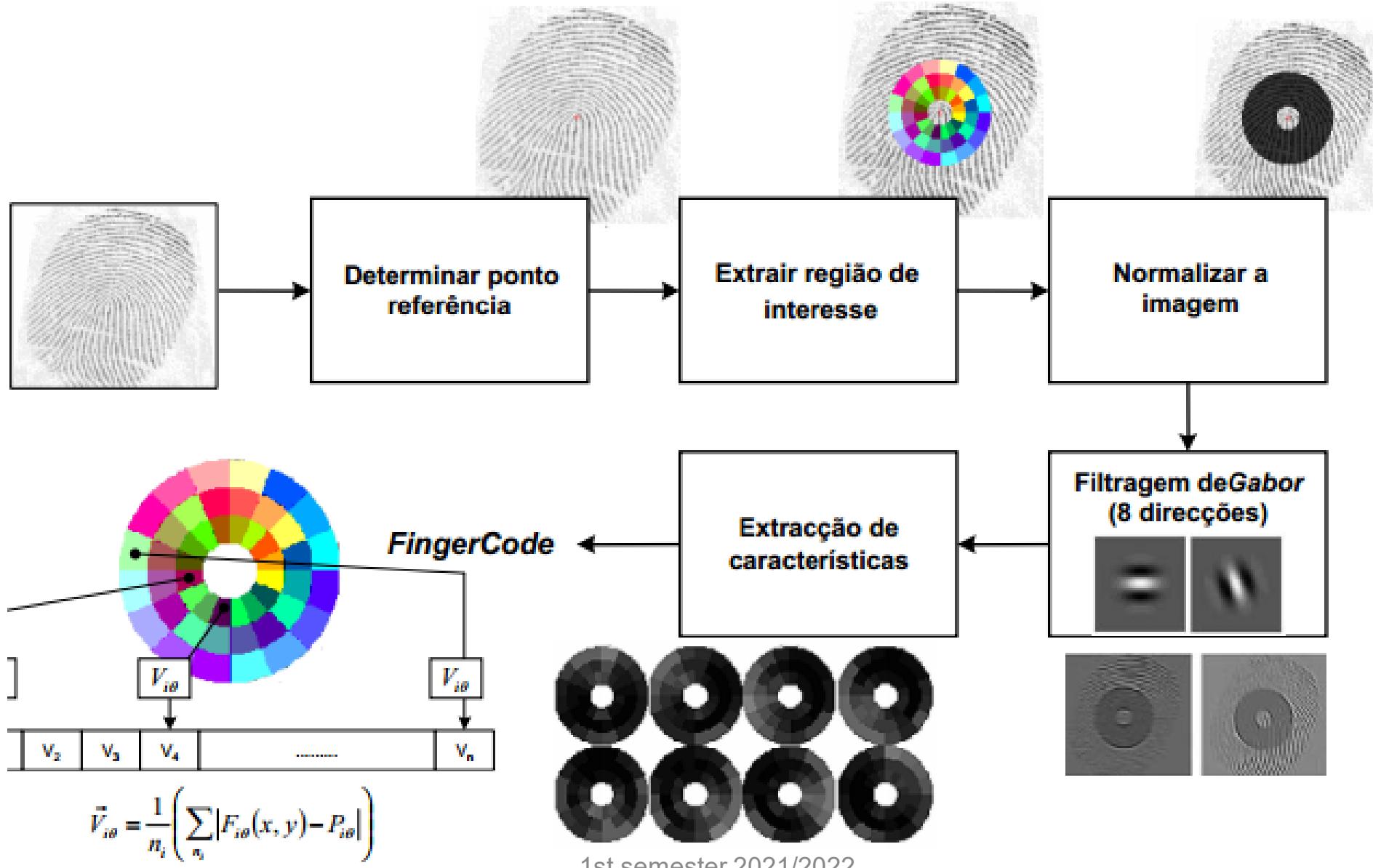


a) A fingerprint gray-scale image; b) the image obtained after enhancement and binarization; c) the image obtained after thinning; d) termination and bifurcation minutiae detected through the pixel-wise computation of the crossing number.

Fingerprint Recognition (6)

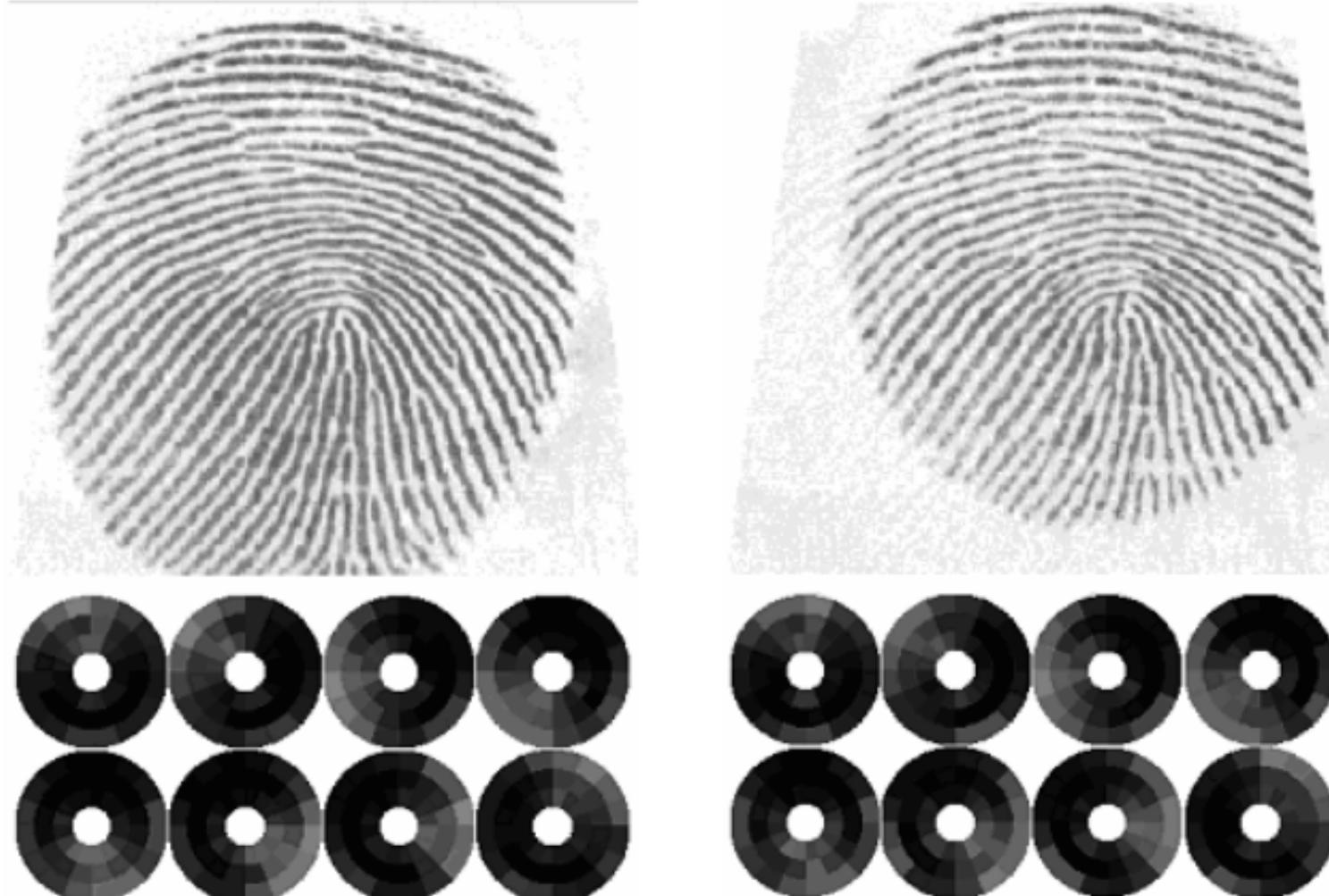


Fingerprint Recognition (7)



Fingerprint Recognition (8)

- Two different images of the same fingerprint



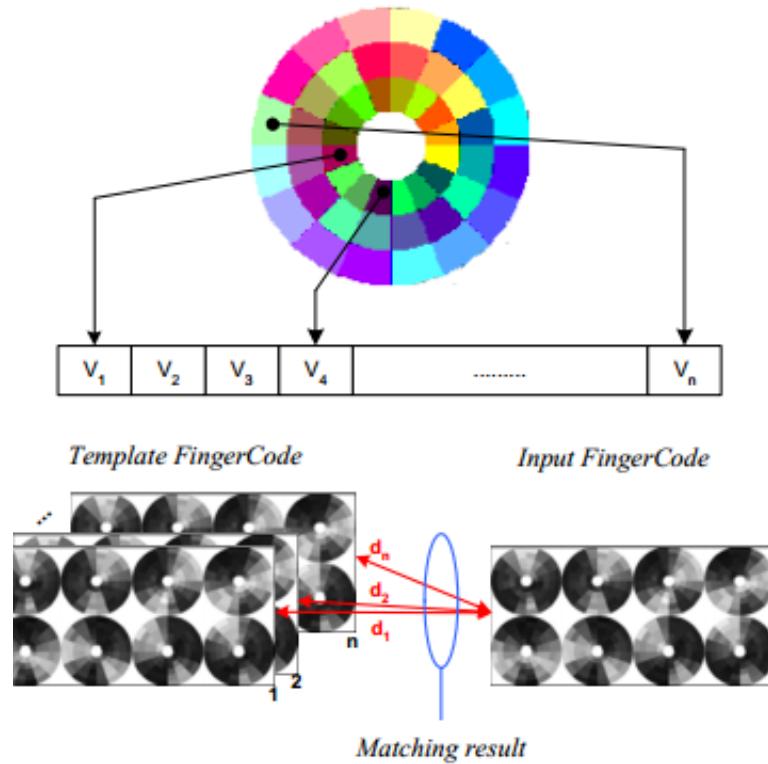
Fingerprint Recognition (9)

- Two images of different fingerprints



Fingerprint Recognition (10)

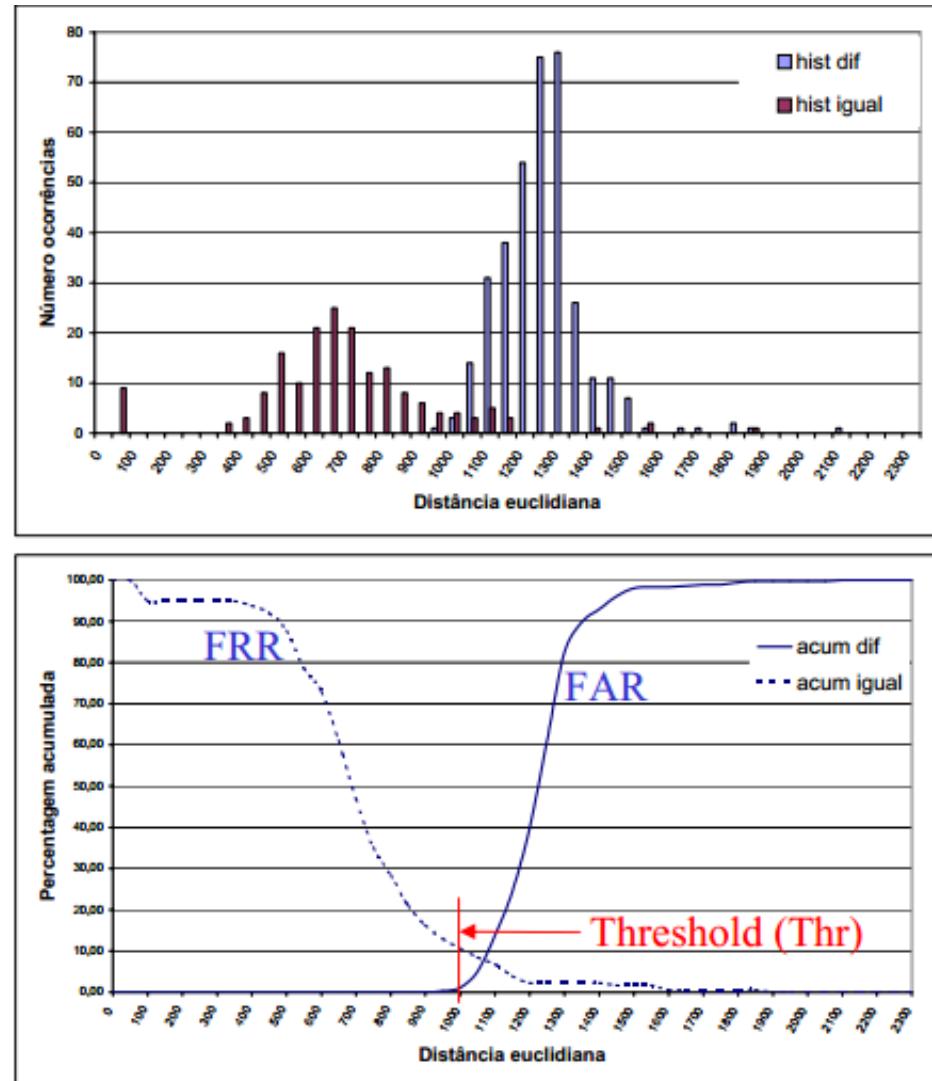
- Matching



$$d_i = \sqrt{\sum_j (FC_i(j) - FC_{\text{input}}(j))^2}$$

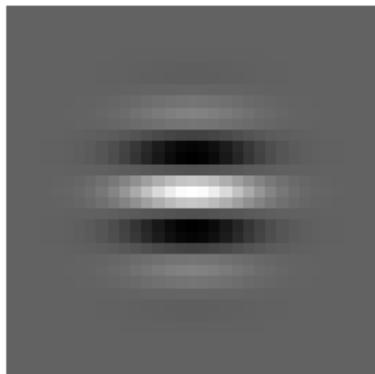
com $i \in \{1, \dots, N_{\text{Finger}}\}$ e $j \in \{1, \dots, N_{\text{Sect}}\}$

$$d = \min(d_i)$$

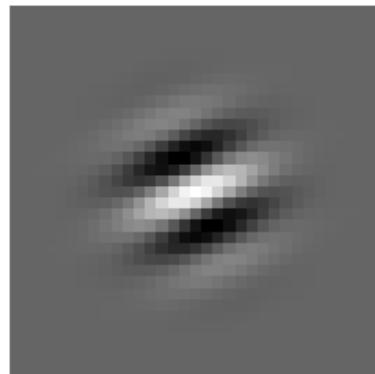


Fingerprint Recognition (11)

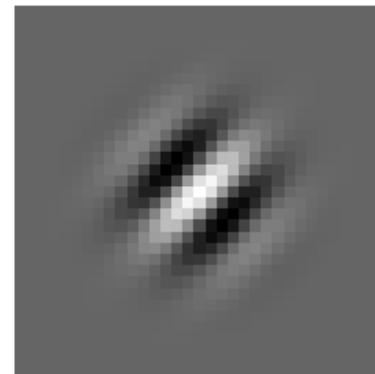
- Gabor Filtering



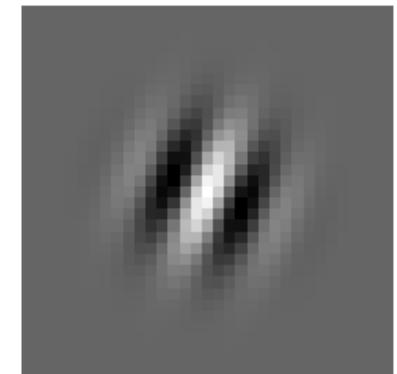
(a) 0°



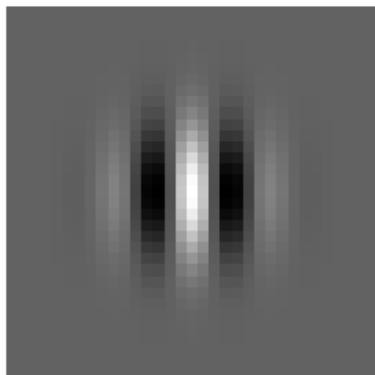
(b) $22,5^\circ$



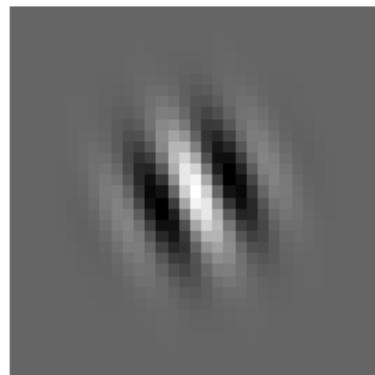
(c) 45°



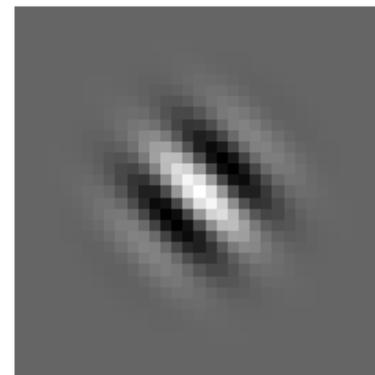
(d) $67,5^\circ$



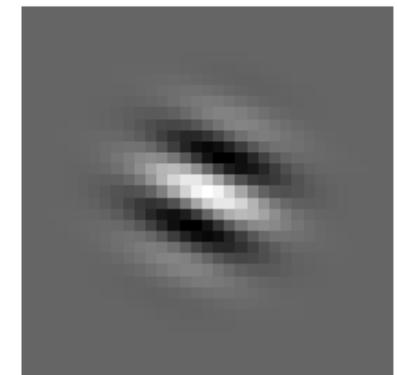
(e) 90°



(f) $112,5^\circ$



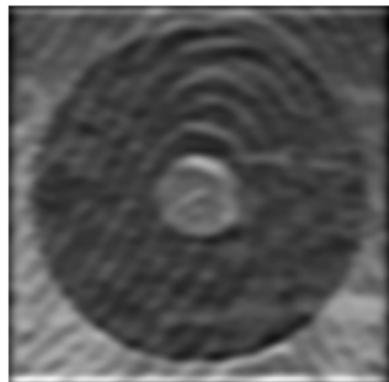
(g) 135°



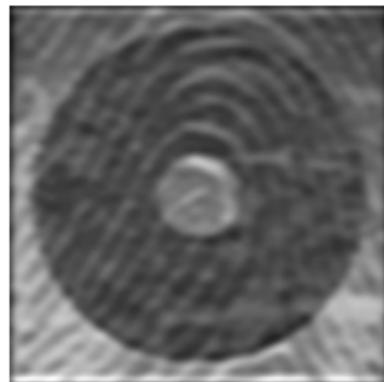
(h) $157,5^\circ$

Fingerprint Recognition (12)

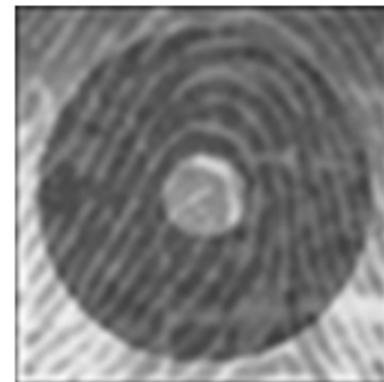
- Gabor Filtering – filtered images



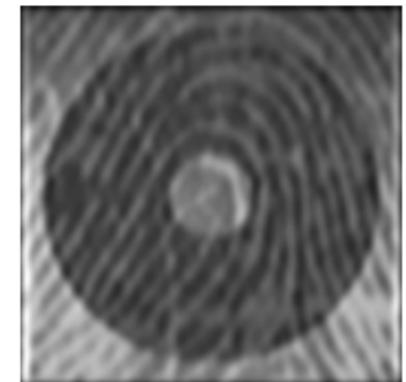
(a) 0°



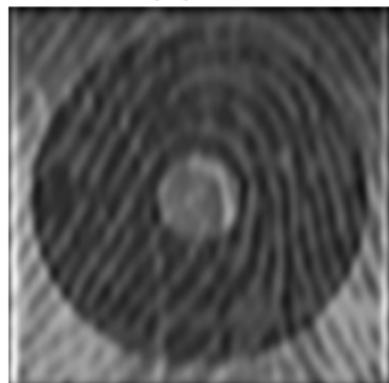
(b) $22,5^\circ$



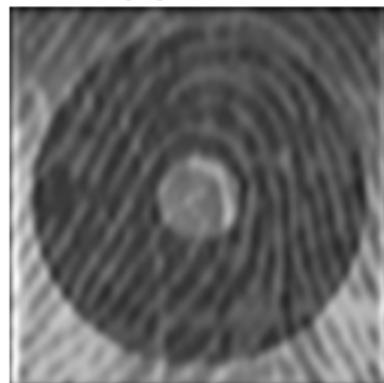
(c) 45°



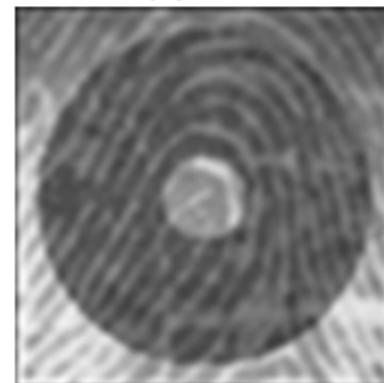
(d) $67,5^\circ$



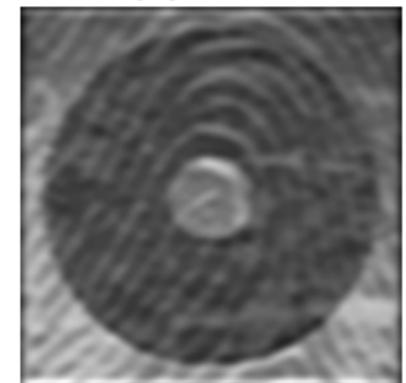
(e) 90°



(f) $112,5^\circ$

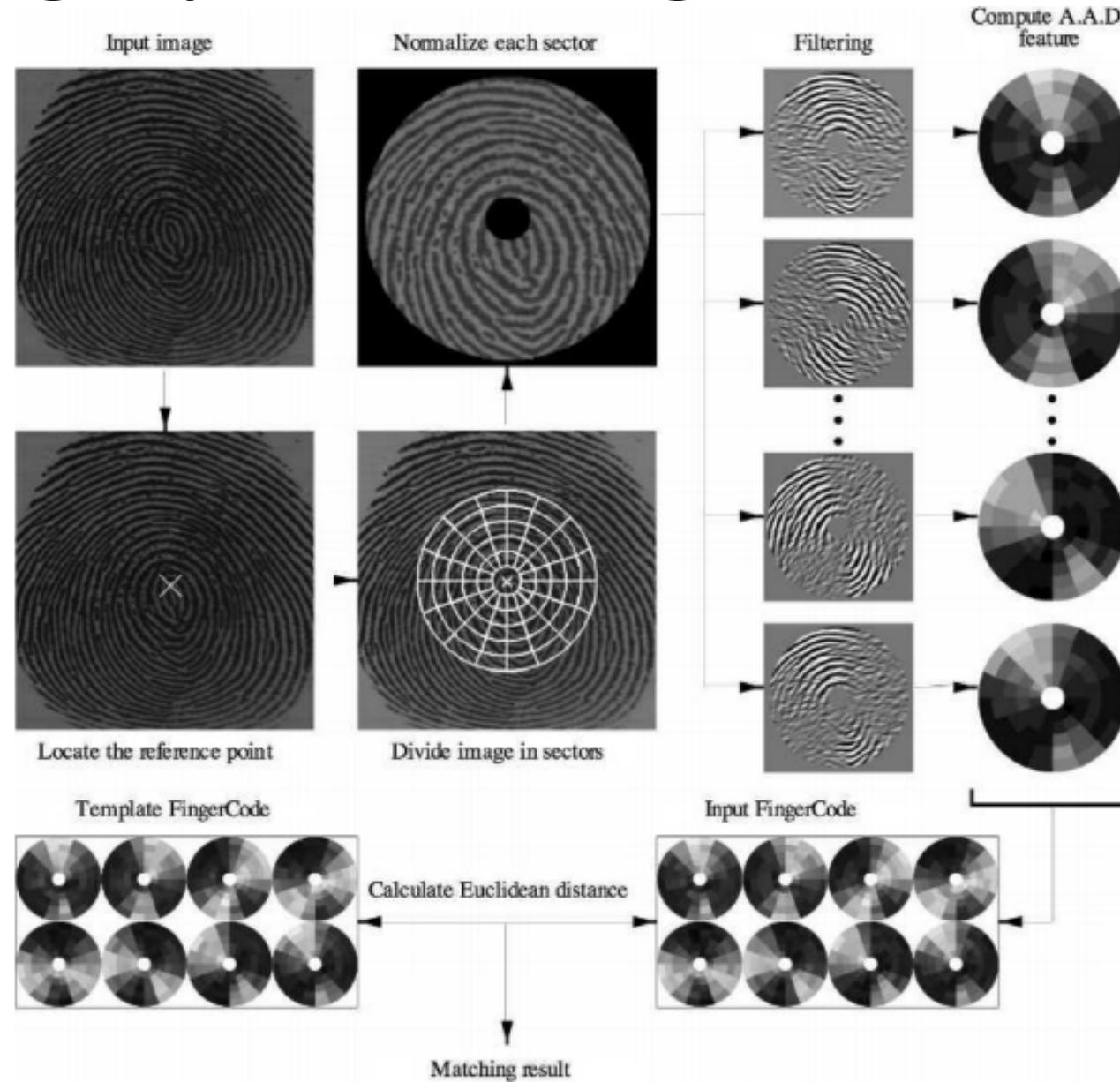


(g) 135°



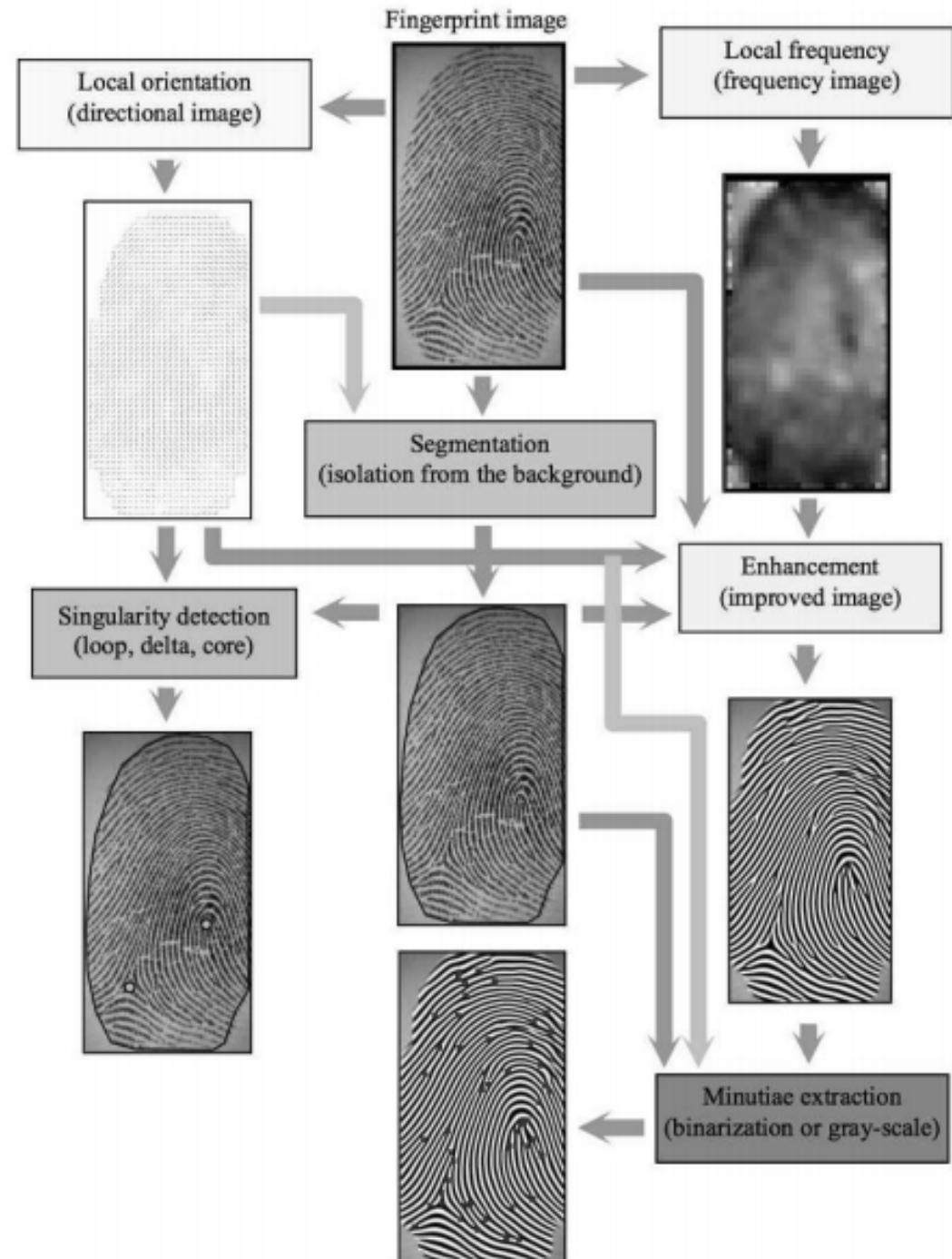
(h) $157,5^\circ$

Fingerprint Recognition (13)



Fingerprint Recognition (14)

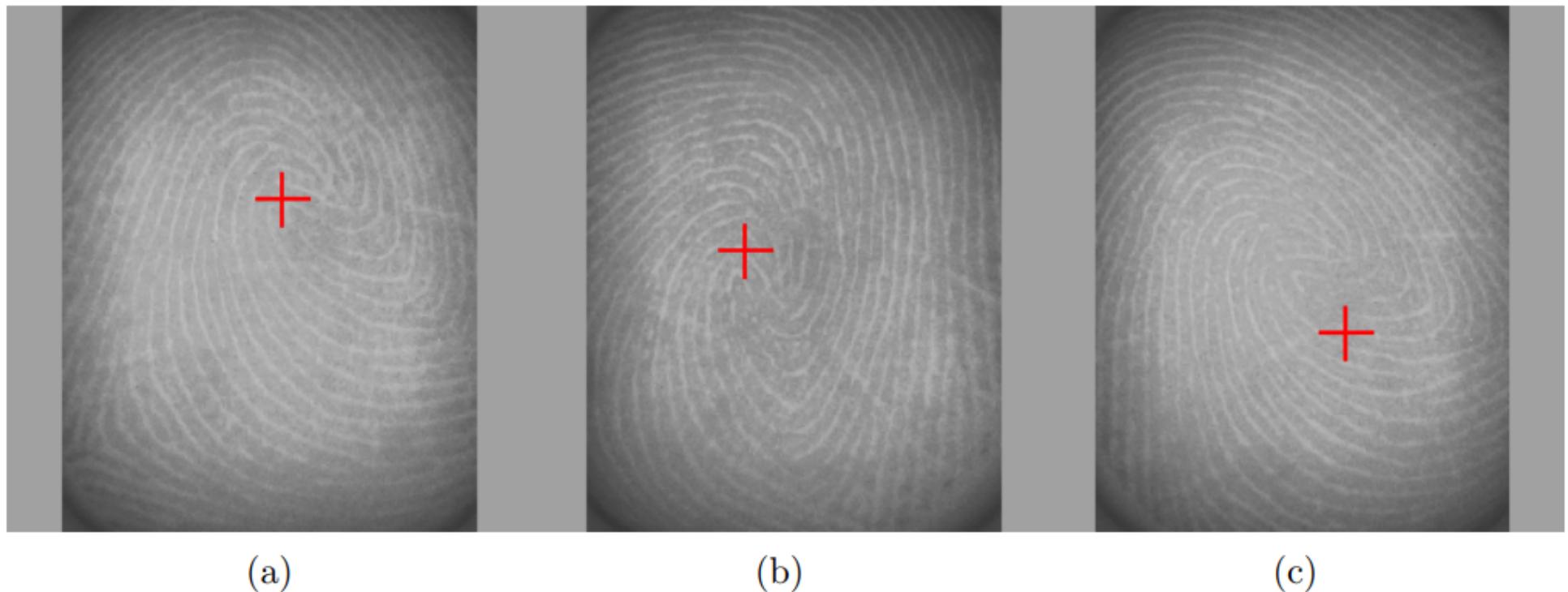
Digital image processing
steps on the fingerprint
recognition system



Fingerprint Recognition (15)

Reference Point

Reference point location: some examples



(a)

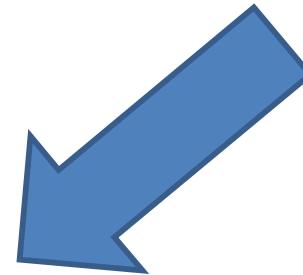
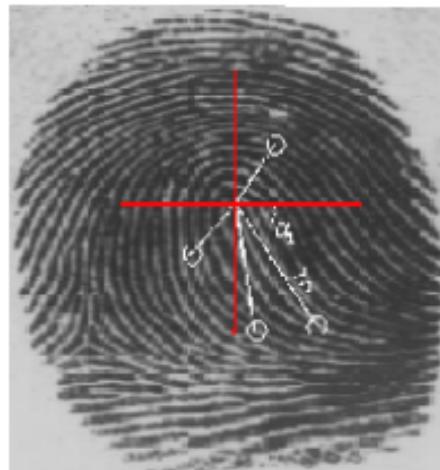
(b)

(c)

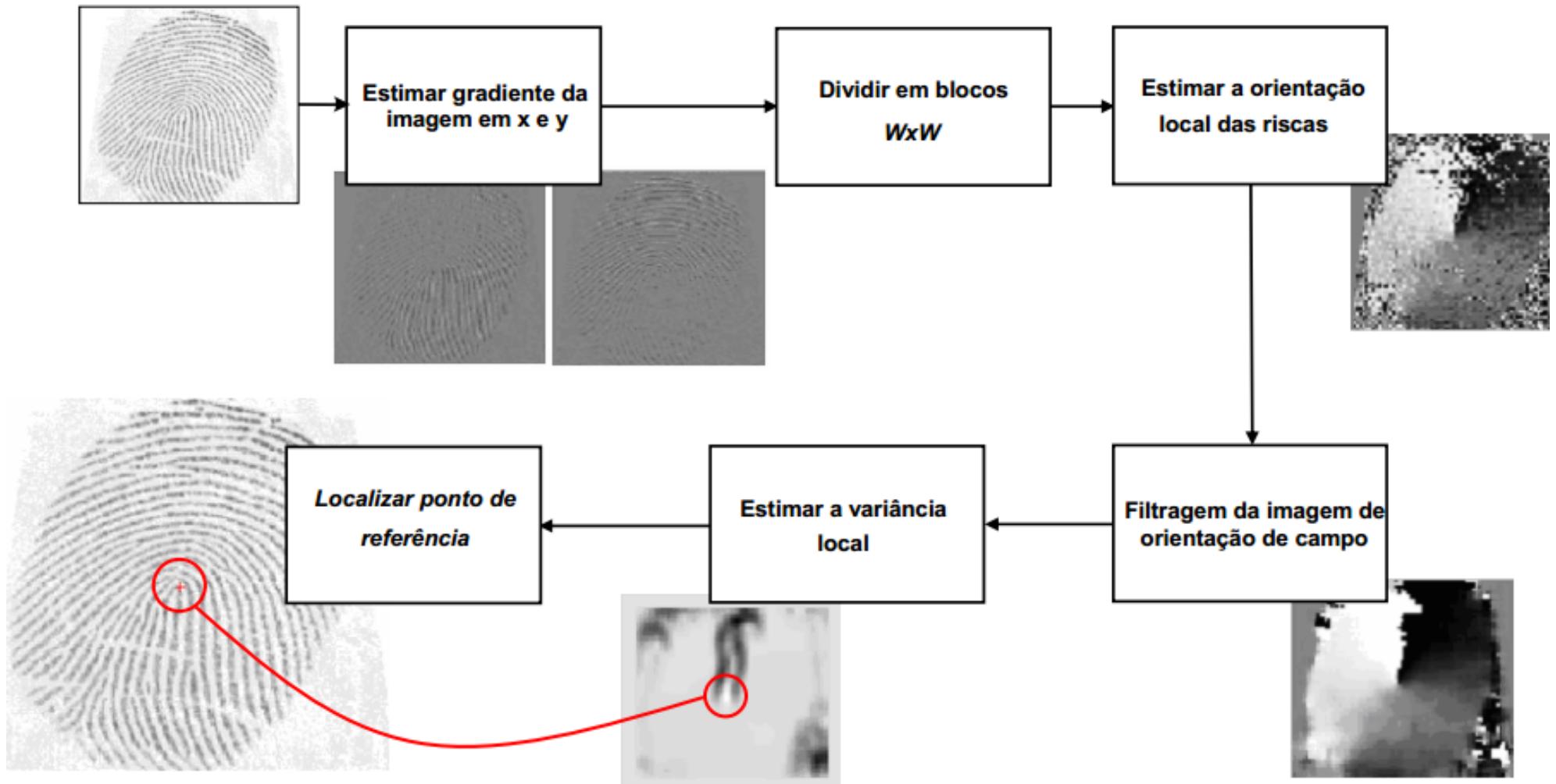
Fingerprint Recognition (16)

The reference point location is crucial for both methods

- Minutiae
- Gabor filtering



Fingerprint Recognition (17)



SFinGe software

<http://biolab.csr.unibo.it/home.asp>

The screenshot shows the Biometric System Laboratory website and the SFinGe software interface side-by-side.

Biometric System Laboratory
DISI - University of Bologna

Welcome to BioLab

Activities Projects

- Home
- People
- Research
- Publications

Activities

- Fingerprint
- Feature Extraction
- Fingerprint Matching
- Fingerprint Classification
- Fingerprint Generation
- Reconstruction from T
- Fake Finger Detection
- Scanner Quality
- Fingerprint Alterations
- Fingerprint Application
- Face
- Hand

SFinGe - Synthetic Fingerprint Generator - Demo Version

Biometric System Laboratory
University of Bologna

SFinGe web site: <http://biolab.csr.unibo.it/sfinge.html>
BioLab web site: <http://biolab.csr.unibo.it>

Generate... Copy image to clipboard
Create database... Save image to file...
Client mode... Save ISO template to file...
About... Exit

A synthetic fingerprint image with various points of interest marked by colored circles (red, green, blue) and lines, representing different fingerprint features.

shapes (characterized by high curvature, frequent termination, etc.). These regions (cal be classified into three typologies: *loop*, *delta*, and *whorl*.

Bibliography

- A. Jain, P. Flynn, A. Ross, *Handbook of Biometrics*, Springer, 2008, ISBN: 9780387710402
- D. Maltoni, D. Maio, A. Jain, S. Prabhakar, *Handbook of Fingerprint Recognition*, Second edition, Springer Science & Business Media, 2009, ISBN: 9781848822535
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