



Technical University of Cluj - Napoca
Computer Science Department

Interfete om-calculator

Curs 2: Interfete biometrice



Biometrica

Defintie: *bios* = “viata” si *metron* = “măsurare”

Biometrica se refera la o clasa de tehnologii si tehnici folosite pentru a **identfica in mod unic persoane**

Utilizări variate:

- Scop primar: alternativa mai sigura la sistemele tradiționale de control al accesului folosite pt. protecția datelor personale si ale companiilor
- Problemele pe care interfețele biometrice încearcă sa le rezolve sunt legate de slăbiciunile sistemelor de control al accesului actuale:
 - Parole “slabe”
 - Prerogative partajate
 - Card-uri de acces pierdute



Sistem biometric

Solutii biometrice \Rightarrow verificarea unor trasaturi/caracteristici asociate cu corpul persoanei utilizatorului - înainte de a acorda acces la o clădire, sistem informatic etc.

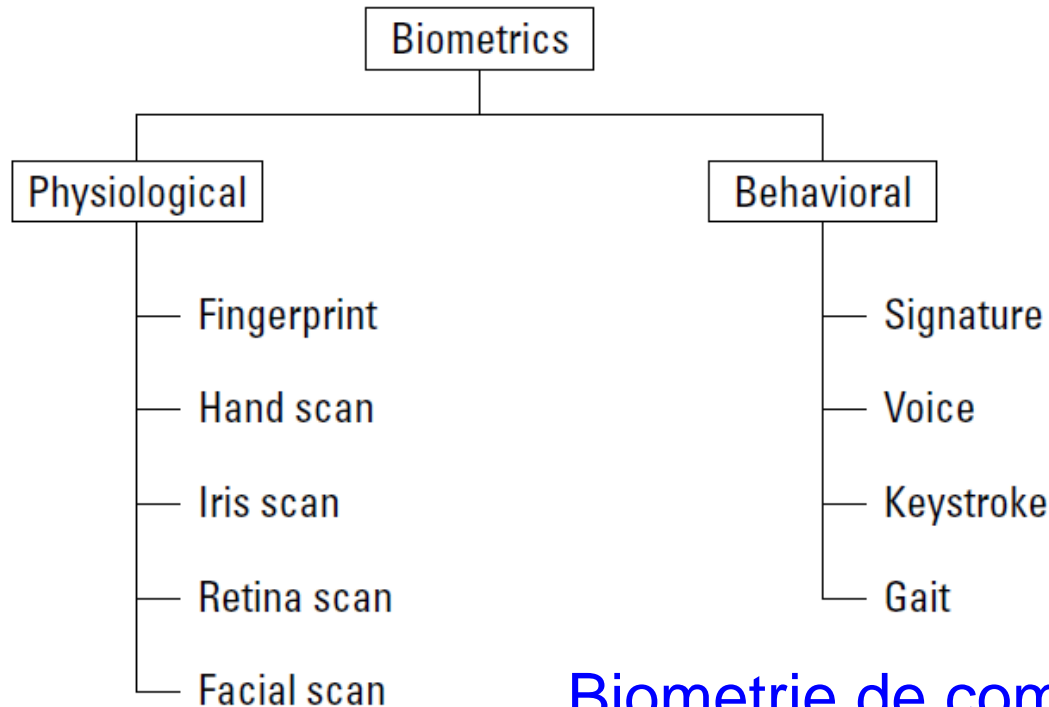
Sistem biometric := un sistem de control al accesului care utilizează elemente biometrice va include un dispozitiv electronic (sensor) care va măsura unele aspecte specifice ale corpului persoanei sau un anumit comportament care identifică în mod pozitiv acea persoană.

Dispozitivul ar putea fi:

- cititor de amprentă sau de scanare a palmei
- camera digitala pentru citirea imaginii irisului, fetei etc.
- un “pad” pt. semnătura



Tipuri de solutii biometrice [1]



Biometrie fiziologica ⇒
măsoară structura sau
forma unei părți a corpului
subiectului analizat

Biometrie de comportament
⇒ cum realizează subiectul o
anumita acțiune (în locul unei
măsurii statice a unei părți a
corpului)



Biometrie fiziologica

Amprentele digitale

Scanarea palmei: Geometria palmei umane este destul de unica, aproape la fel de mult ca amprentele digitale. De obicei, o scanare a mâinii se bazează pe lungimile și unghiurile degetelor, geometria întregii colecții de 27 oase, plus mușchi, ligamente, și a altor țesuturi

Structura venoasa a mâinii: Dacă emiteți o lumina puternică prin mâna, puteți vedea un șablon unic al venelor - și, de asemenea al oaselor și al altor elemente ale mâinii.

Scanarea irisului: Irisul uman, când este privit de aproape, este o colecție complexă de mușchi mici (care controlează diafragma pupilei), care sunt colorați în nuanțe diferite de maro, gri, albastru și verde după un șablon specific/unic fiecărei persoane.

Scanarea retinei: Retina nu este în mod normal vizibilă, cu excepția cazului când se emite perpendicular o lumină strălucitoare prin pupila. ("ochi roșii" din fotografii sunt reflexii ale retinei).

Recunoașterea de fețe



Biometrie comportamentala

Scrisul de mana: sistemele biometrice pot evalua semnăturile in moduri variate:

- *Imagini statice* (cea mai veche) \Rightarrow compara o semnătura memorata cu una noua
- *Dinamica semnăturii* \Rightarrow măsoară in plus:
 - (a) mișcarea unui “stylus”/stilou sau
 - (b) dinamica de realizare a semnăturii
- *Presiunea Stylus-ului* \Rightarrow măsoară in plus dinamica forței de apăsare a stylus-ului pe suprafața de scriere

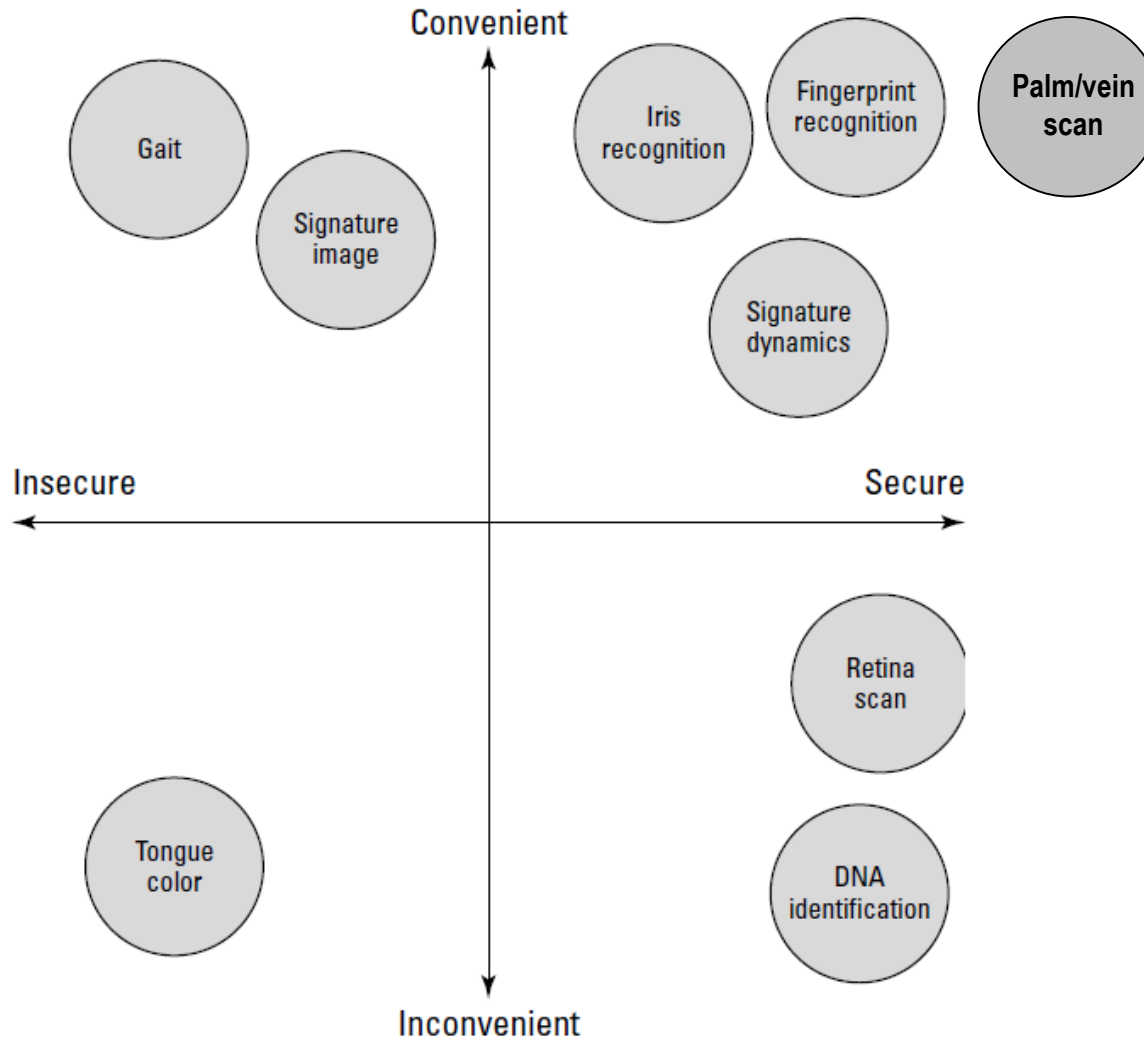
Dinamica de tastare: ritmul de dactilografiere (keyboarding) este la fel de unic ca semnătura cuiva

Recunoașterea de voce:

Mersul/pasirea: felul in care o persoana paseste se poate încadra intr-un șablon unic



Biometrie – confort vs. securitate [1]





Biometrica amprentelor digitale

Senzori pt. amprente digitale:

Optici: similar scanner-elor de imagine (sursa de lumina proiectata pe zona scanata + matrice de senzori CCD/CMOS pt. achizitia imaginii reflectate de pe suprafata scanata)

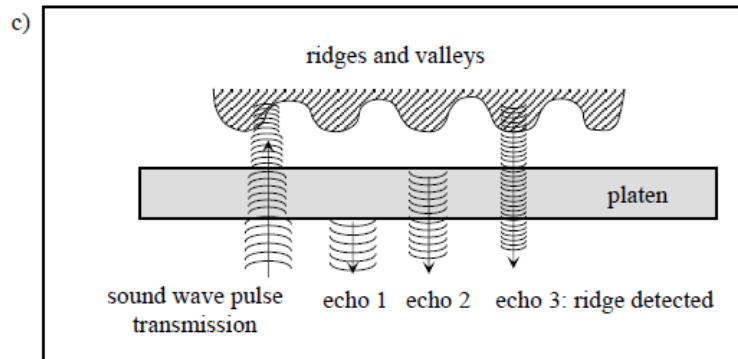
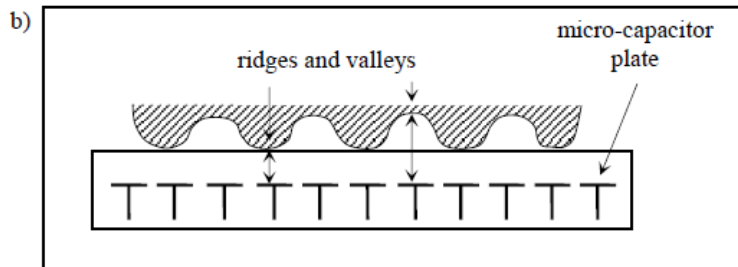
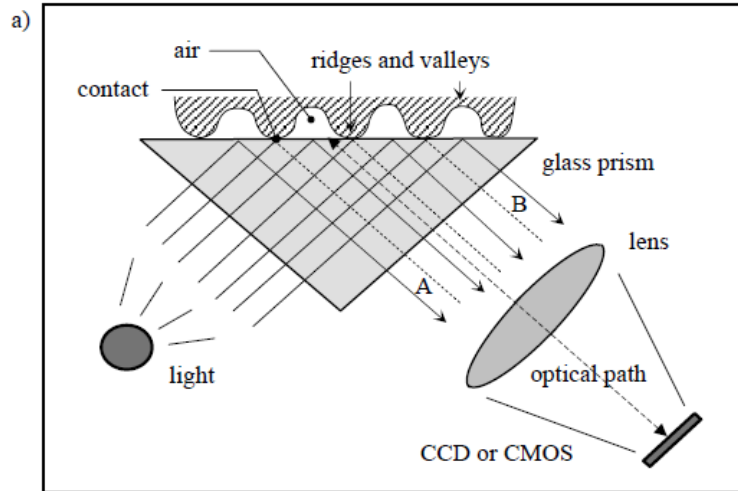
Termoelectrici: senzorul este un material cu proprietati electrice influentate de temperatura locala (deget) \Rightarrow variatiile electrice determina imaginea amprenteii

Capacitivi: senzorul este o matrice de electrozi, epiderma (non-conductiva) actioneaza ca dielectric, derma (conductiva) actioneaza ca al doilea electrod. Epiderma fiind neregulata (adancituri si ridicaturi) are coeficient dielectric variabil \Rightarrow amprenta. Senzori capacitivi pot fi pasivi sau activi

Ultrasunete: US de frecventa inalta \Rightarrow model 3D al amprenteii



Senzori pt. amprente digitale[2]



a) Senzor optici FTIR;

b) Senzori capacitivi

c) Principiul senzorului US.



Senzori commerciali pt. amprente digitale[2]

	Technology	Company	Model	Dpi	Area (h×w)	Pixels
Optical	FTIR	Biometrika www.biometrika.it/eng/	FX2000	569	0.98"×0.52"	560×296 (165,760)
	FTIR	Digital Persona www.digitalpersona.com	UareU2000	440	0.67"×0.47"	316×228 (72,048)
	FTIR (sweep)	Kinetic Sciences www.kinetic.bc.ca	K-1000	up to 1000	0.002"×0.6"	2×900 (H×900)
	FTIR	Secugen www.secugen.com	Hamster	500	0.64"×0.54"	320×268 (85,760)
	Sheet prism	Identix www.identix.com	DFR 200	380	0.67"×0.67"	256×256 (65,535)
	Fiber optic	Delsy www.delsy.com	CMOS module	508	0.71"×0.47"	360×240 (86,400)
	Electro- optical	Ethentica www.ethentica.com	TactilSense T-FPM	403	0.76"×0.56"	306×226 (69,156)
Solid-state	Capacitive (sweep)	Fujitsu www.fme.fujitsu.com	MBF300	500	0.06"×0.51"	32×256 (H×256)
	Capacitive	Infineon www.infineon.com	FingerTip	513	0.56"×0.44"	288×224 (64,512)
	Capacitive	ST-Microelectronics us.st.com	TouchChip TCS1AD	508	0.71"×0.50"	360×256 (92,160)
	Capacitive	Veridicom www.veridicom.com	FPS110	500	0.60"×0.60"	300×300 (90,000)
	Thermal (sweep)	Atmel www.atmel.com	FingerChip AT77C101B	500	0.02"×0.55"	8×280 (H×280)
	Electric field	Authentec www.authentec.com	AES4000	250	0.38"×0.38"	96×96 (9,216)
	Piezoelectric	BMF www.bm-f.com	BLP-100	406	0.92"×"0.63"	384×256 (98,304)



Biometrica amprentelor digitale

Utilizari biometrice ale amprentelor digitale:

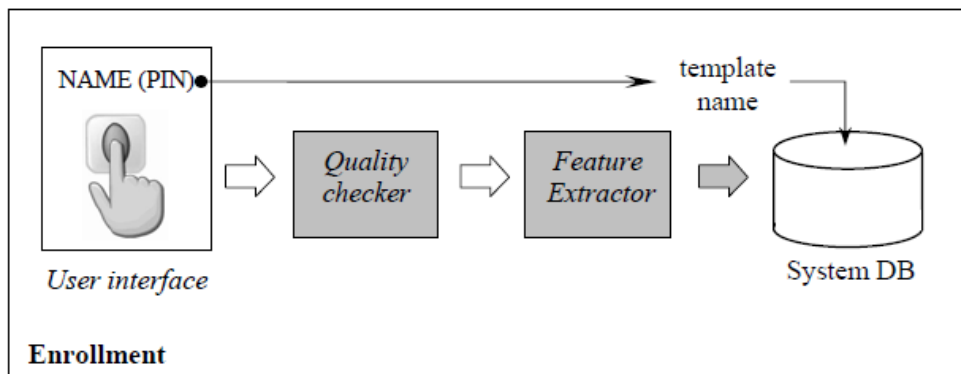
- Incuietori usi, acces laptopuri, terminale sau orice punct de acces

Trei factori au influentat raspandirea larga a acestui mecanism de acces:

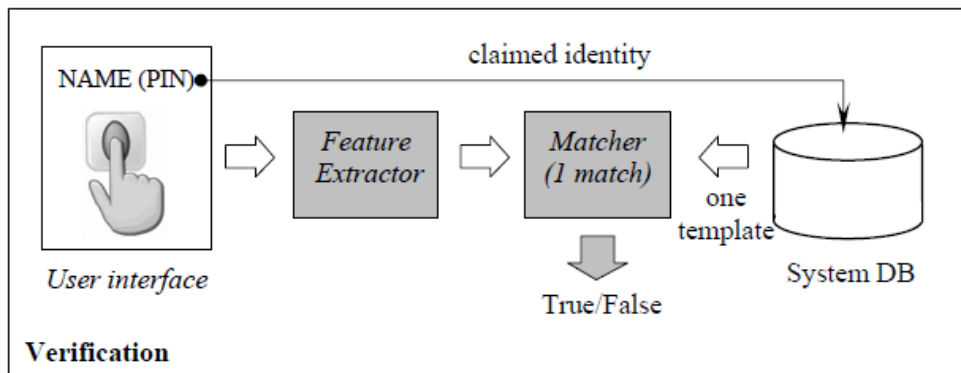
- Tehnologia de scanare ieftina
- Metoda de potrivire/validare a amprenteii relativ ieftina computational
- Metoda de scanare este mai confortabila (utilizarea degetului) in comparatie cu alte metode (scanarea oculara etc.)



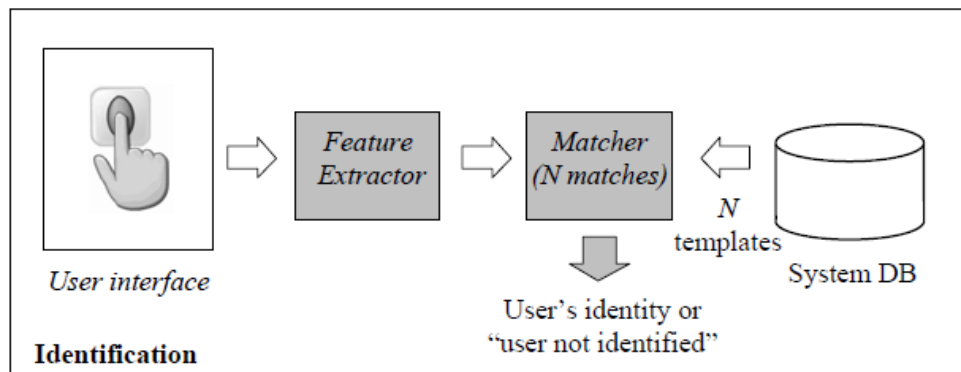
Task-uri pt. biometrice bazate pe amprente [2]



Luare in evidenta (a unui utilizator nou)



Verificarea identitatii unui utilizator cu ID dat (ex. card acces)



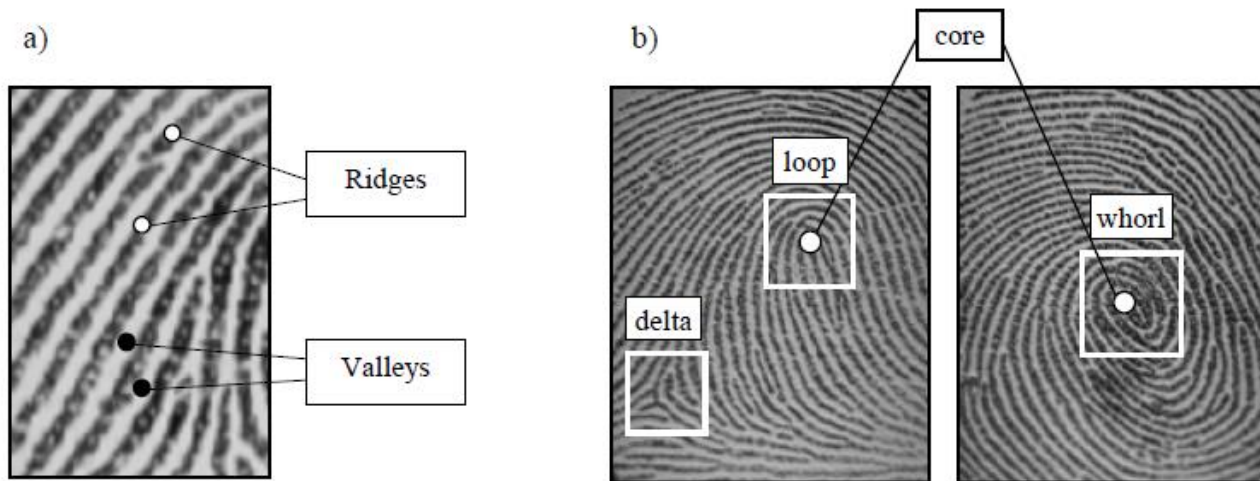
Identificarea unui utilizator/persoane pe baza unor inregistrari din BD



Trasaturi ale amprentelor [2]

Trasaturi

- Ridges (ridicaturi/creste) \Rightarrow linii (culoare inchisa)
- Valeys (vai/adancituri) \Rightarrow fond (culoare deschisa)



Regiuni singulare



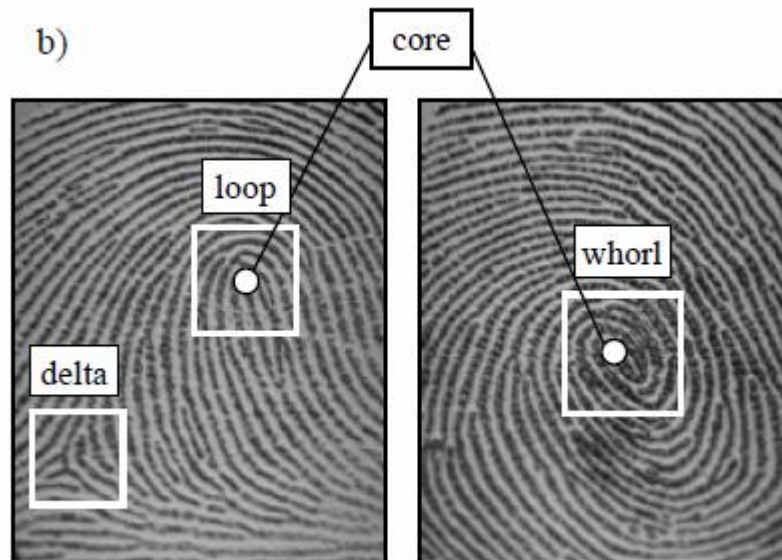
Trasaturi ale amprentelor [2]

Regiuni singulare

loop (\cap), delta (Δ), whorl (O)

Centrul (core) := cel mai nordic loop sau whorl \Rightarrow alinierea amprentelor înainte de recunoastere

\Rightarrow Impartire in sub-clase



Left loop



Right loop



Whorl



Arch



Tented Arch



Trasaturi ale amprentelor [2]

Minutiae (discontinuitati): terminatie, bifurcatie

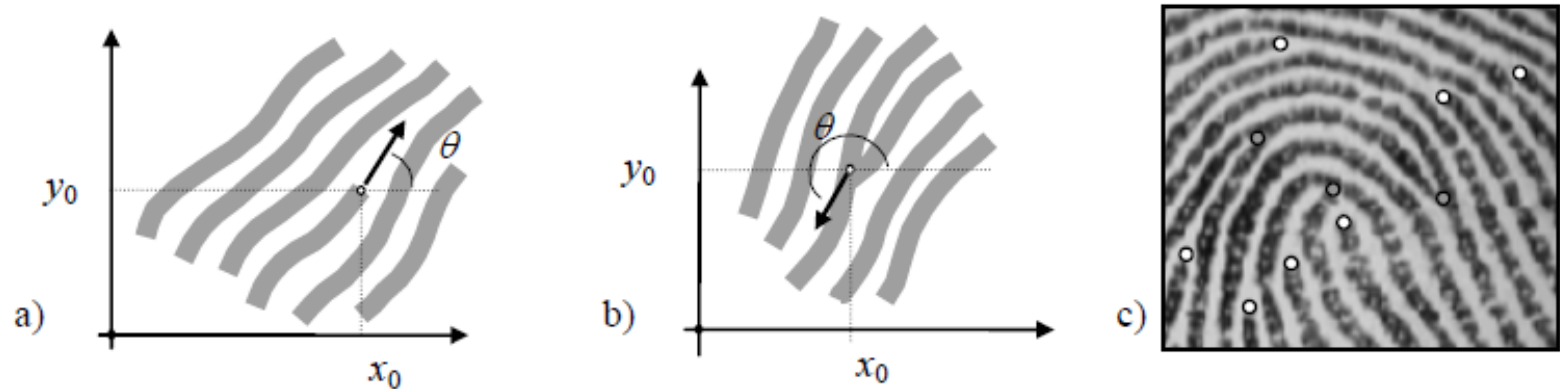
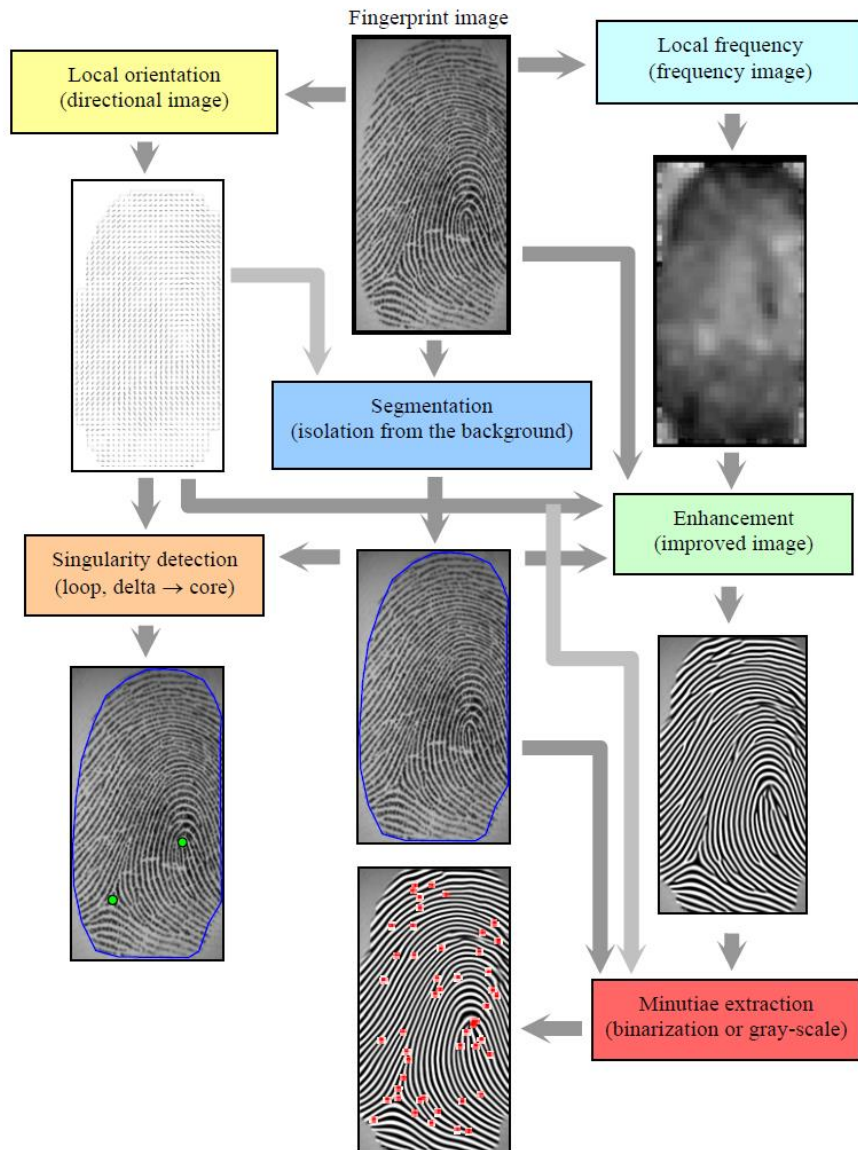


Fig. 7. a) A termination minutia: $[x_0, y_0]$ are the minutia coordinates; θ is the angle that the minutia tangent forms with the horizontal axis; b) a bifurcation minutia: θ is now defined by means of the termination minutia corresponding to the original bifurcation that exists in the negative image; c) termination (white) and bifurcation (gray) minutiae in a sample fingerprint.



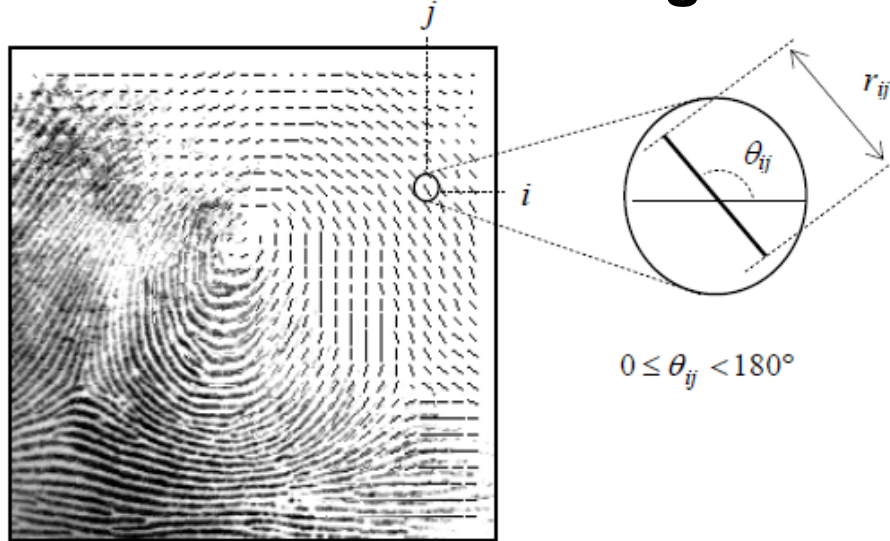
Etapele de extragere a trasaturilor pt. amprente digitale [2]





Extragerea trasaturilor amprentelor digitale[2]

Orientarea locala a “ridge-urilor”



Estimare:

- Calcul gradient local (discontinuitati la 90 grd)
- Mediere locala a gradientilor (robusta)

Frecventa locala a “ridge-urilor”

Estimare:

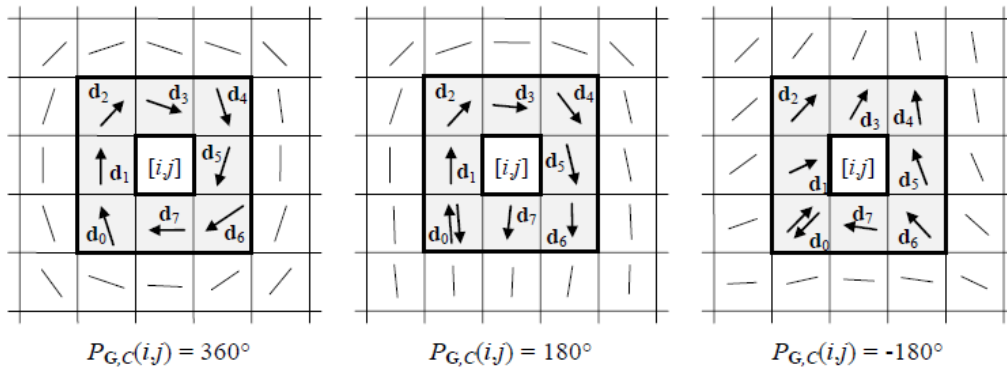
Nr. de ridge-uri pe unitatea de lungime pe o directie perpendiculara pe θ_{ij}





Detectia singularitatilor [2]

Poincaré index $P_{G,C}(i,j)$ in punctul (i,j) se calculeaza ca suma algebrica a diferentelor de orientare (ale ridge-urilor) intr-o vecinatate C a punctului

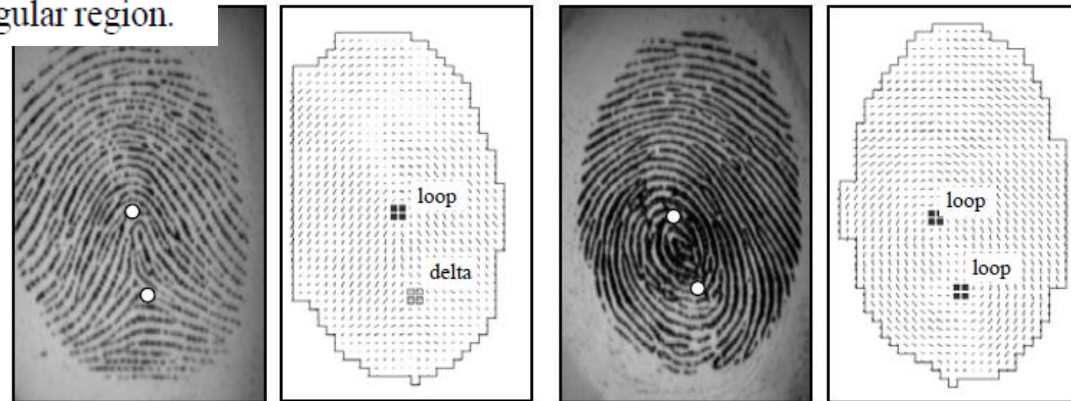


← Orientarea locala a ridge-urilor

d_0 – random

d_{i+1} cea mai apropiata directie de d_i

$$P_{G,C}(i,j) = \begin{cases} 0^\circ & \text{if } [i,j] \text{ does not belong to any singular region} \\ 360^\circ & \text{if } [i,j] \text{ belongs to a whorl type singular region} \\ 180^\circ & \text{if } [i,j] \text{ belongs to a loop type singular region} \\ -180^\circ & \text{if } [i,j] \text{ belongs to a delta type singular region.} \end{cases}$$





Imbunatatirea imaginilor si binarizare [2, 9]

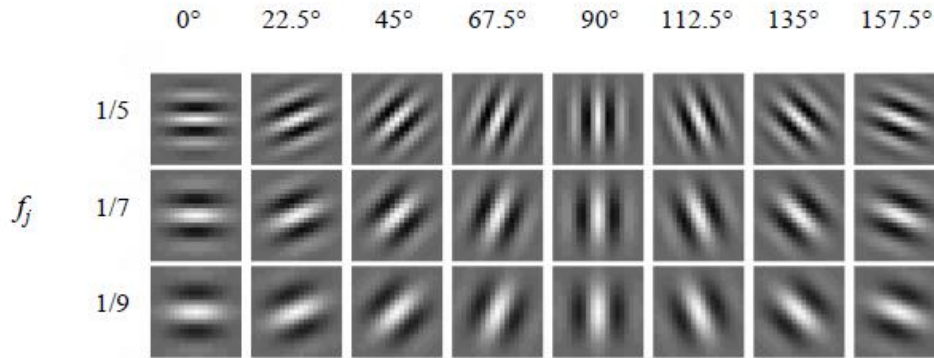
- *Filtre contextuale* - tipuri distincte de filtre sunt aplicate in functie de contextul local (orientarea si frecventa ridde-urilor)

24 Gabor filters

$$G(x, y; \theta, f) = \exp\left\{-\frac{1}{2} \left[\frac{x_{\theta'}^2}{\sigma_x^2} + \frac{y_{\theta}^2}{\sigma_y^2}\right]\right\} \cos(2\pi f x_{\theta})$$

$$x_{\theta} = x \cos \theta - y \sin \theta$$

$$y_{\theta} = x \sin \theta + y \cos \theta$$



Comparison of results of binarization and thinning before and after the enhancement process

Binarization Image after Image Enhancement	Binarization Image before Image Enhancement	Thinning Image after Image Enhancement	Thinning Image before Image Enhancement





Extragerea minutiiilor [2]

Extragerea minutilor

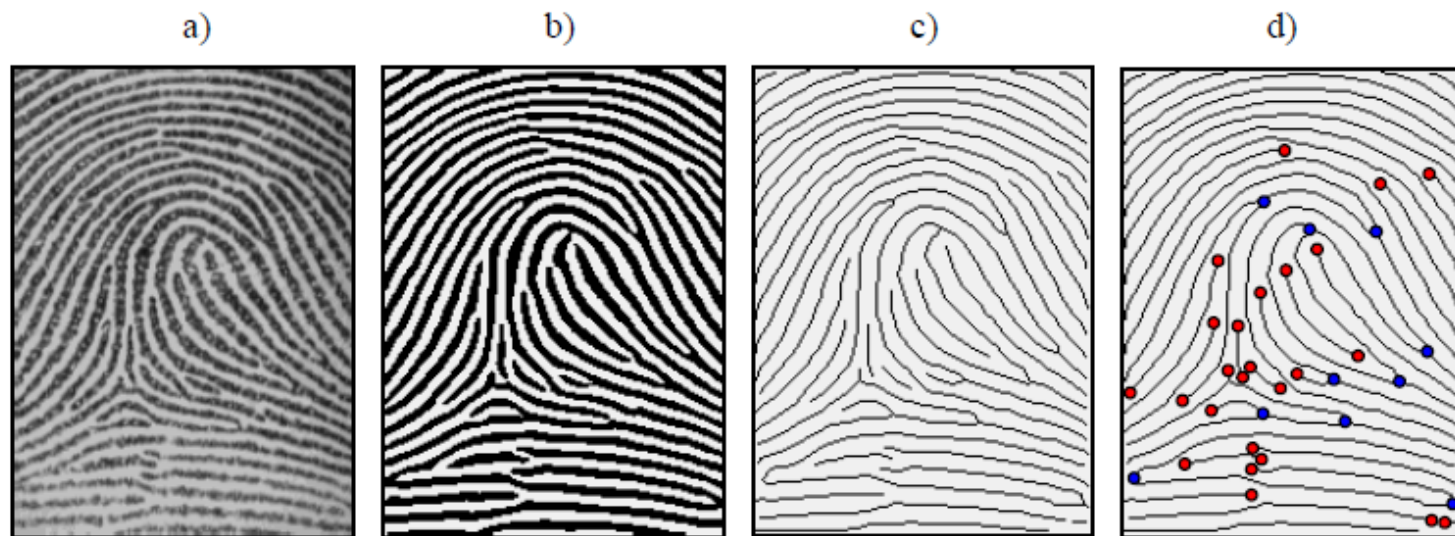


Fig. 14. a) A fingerprint gray-scale image; b) the image obtained after enhancement and binarization; c) the image obtained after thinning; d) termination and bifurcation minutiae detected through the pixel-wise computation of the crossing number.

Numaruri de traversari (crossing number) pt. un pixel (imagine binara) := $\frac{1}{2}$
suma diferentelor (abs.) dintre perechi de pixeli adiacenti intr-o $V_8 \Rightarrow$

- **1 terminatie**
- 2 pixel ridge intermediar
- **≥ 3 bifurcatie sau o minutie mai complexa**



Potrivirea amprentelor [2]

- *Potrivire bazata pe corelatie de imagini*: 2 imagini ale amprentelor sunt suprapuse si corelatia dintre pixeli corespondenti este calculata pt. diferite alinieri (translatii si rotatii).

$$S(\mathbf{T}, \mathbf{I}) = \max_{\Delta x, \Delta y, \theta} CC(\mathbf{T}, \mathbf{I}^{(\Delta x, \Delta y, \theta)})$$

$CC(\mathbf{T}, \mathbf{I}) = \mathbf{T}^T \mathbf{I}$ is the cross-correlation between \mathbf{T} and \mathbf{I} .



Potrivirea amprentelor [2]

- Potrivire bazata pe minutii*: minutiiile sunt extrase pt. 2 amprente si stocate ca seturi de puncte in sistemul de coordonate 2D al imaginii. Potrivirea consta in gasirea alinierii dintre template si seturile de *minutii de intrare* \Rightarrow *setul maximal de potriviri de minutii*

$$\mathbf{T} = \{\mathbf{m}_1, \mathbf{m}_2, \dots, \mathbf{m}_m\}, \quad \mathbf{m}_i = \{x_i, y_i, \theta_i\}, \quad i = 1..m$$

$$\mathbf{I} = \{\mathbf{m}'_1, \mathbf{m}'_2, \dots, \mathbf{m}'_n\}, \quad \mathbf{m}'_j = \{x'_j, y'_j, \theta'_j\}, \quad j = 1..n$$

$$sd(\mathbf{m}'_j, \mathbf{m}_i) = \sqrt{(x'_j - x_i)^2 + (y'_j - y_i)^2} \leq r_0,$$

$$dd(\mathbf{m}'_j, \mathbf{m}_i) = \min(|\theta'_j - \theta_i|, 360^\circ - |\theta'_j - \theta_i|) \leq \theta_0$$

Includere rotatii si translatie:

$$map_{\Delta x, \Delta y, \theta}(\mathbf{m}'_j = \{x'_j, y'_j, \theta'_j\}) = \mathbf{m}''_j = \{x''_j, y''_j, \theta'_j + \theta\}$$

$$\begin{bmatrix} x''_j \\ y''_j \end{bmatrix} = \begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix} \begin{bmatrix} x'_j \\ y'_j \end{bmatrix} + \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix}.$$

dx, dy, teta <- transf Hogh generalizata

$$mm(\mathbf{m}''_j, \mathbf{m}_i) = \begin{cases} 1 & sd(\mathbf{m}''_j, \mathbf{m}_i) \leq r_0 \quad \text{and} \quad dd(\mathbf{m}''_j, \mathbf{m}_i) \leq \theta_0 \\ 0 & \text{otherwise.} \end{cases}$$

$$\text{maximize}_{\Delta x, \Delta y, \theta, P} \sum_{i=1}^m mm(map_{\Delta x, \Delta y, \theta}(\mathbf{m}'_{P(i)}), \mathbf{m}_i)$$



Biometrica amprentelor digitale

Exemple de sisteme comerciale:

<http://www.svtech.ro/component/virtuemart/svtech/svtech-fpswitch-detail>

<http://www.neurotechnology.com/verifinger.html>

<http://www.digitalpersona.com/>

Fingerprint SDK

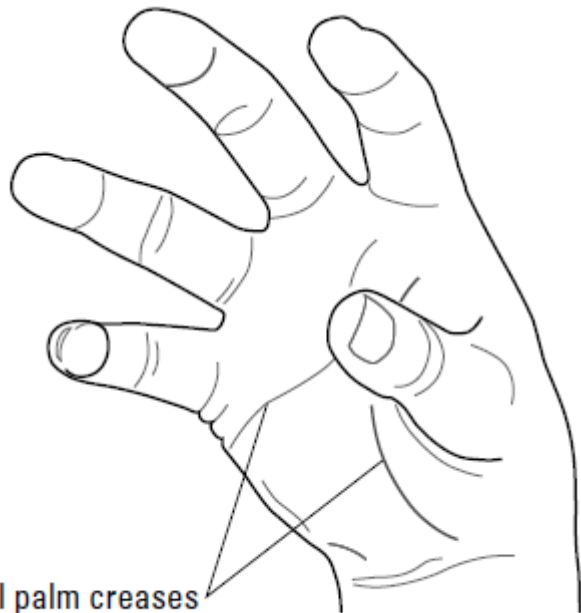
<http://www.softpedia.com/get/Programming/SDK-DDK/VeriFinger-Extended-SDK.shtml>

<http://www.neurotechnology.com/free-fingerprint-verification-sdk.html>



Biometrica mainii [1]

Scanarea palmei



- Grad ridicat de detaliere - > precizie ridicata
- Echipament de scanare mai costisor decat in cazul amprentelor (dimensiunea senzorului creste)
- Tinde sa fie inlocuita de scanarea venelor

<http://techbiometric.com/biometric-products/hand-scanner/>



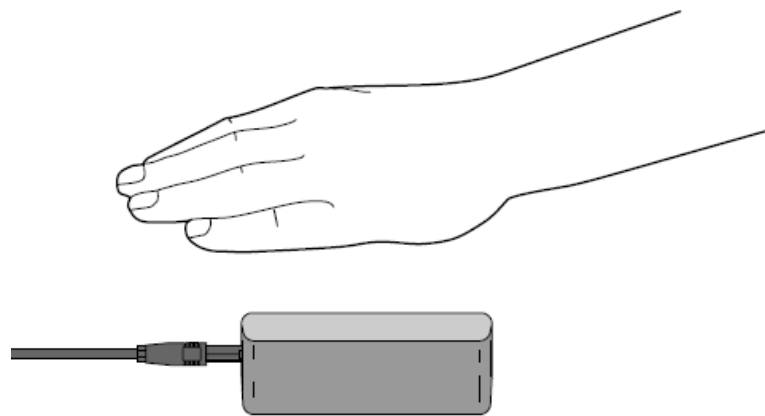
Biometrica mainii [1]

Scanarea venelor

⇒ Cea mai buna rata (TPR , FPR) de recunoastere

Principiu de functionare:

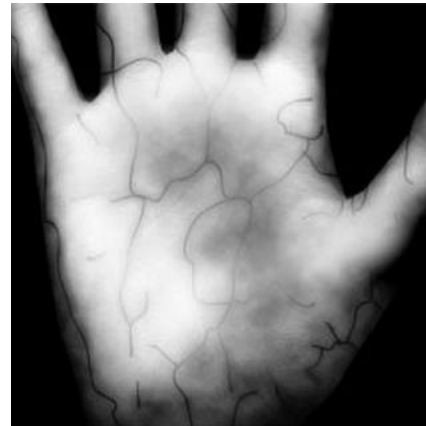
- Iluminarea mainii cu lumina in spectrul IR sau IR apropiat
- Venele (culoare rosie in spectrul vizibil) vor apare in imaginea IR negre, restul tesutului muscular fiind alb
- Rezulta o imagine de contrast ridicat a structurii venoase (unica pt. un individ) ⇒ utila pt. comparatii in scop de autentificare





Biometrica mainii

Scanarea venelor



http://www.youtube.com/watch?v=nspqfuMW5_A&feature=related

<http://www.youtube.com/watch?v=9eHDz0r7rOc&feature=related>



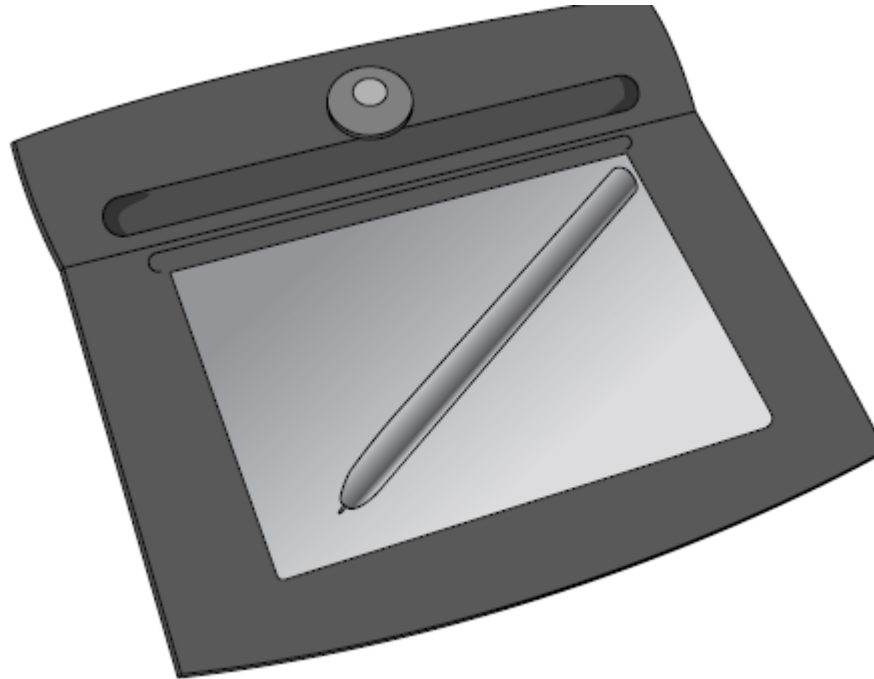
Biometrica mainii – comparatie [1]

	<i>Strengths</i>	<i>Weaknesses</i>	<i>Cost</i>	<i>Counter-measures</i>	<i>Convenience</i>
Fingerprint	Simple, cheap	Easily spoofed	Low	Live guards to watch the process	Good
Palm scan	Able to deal with small variations	Cost, large scanner	Medium	Live guards	Good
Hand vein	Accurate, proof of life	Cost, not yet mature	Medium to high	Largely unneeded	Excellent
Sonar	Accurate, able to deal with small variations	Cost, not yet mature	High	Unknown	Good



Biometrica semnaturii [1]

Recunoscerea semnaturii



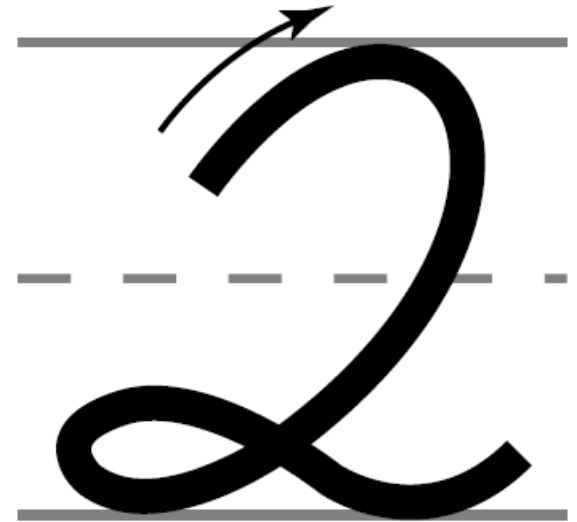
Electronic signature pad



Biometrica semnăturii [1]

Dinamica de miscare a stylus-ului
(dinamica 2D: x, y)

- Viteza
- Ordonarea (temporală) și direcția de scriere a caracterelor sau partilor componente ale caracterelor sau simbolurilor

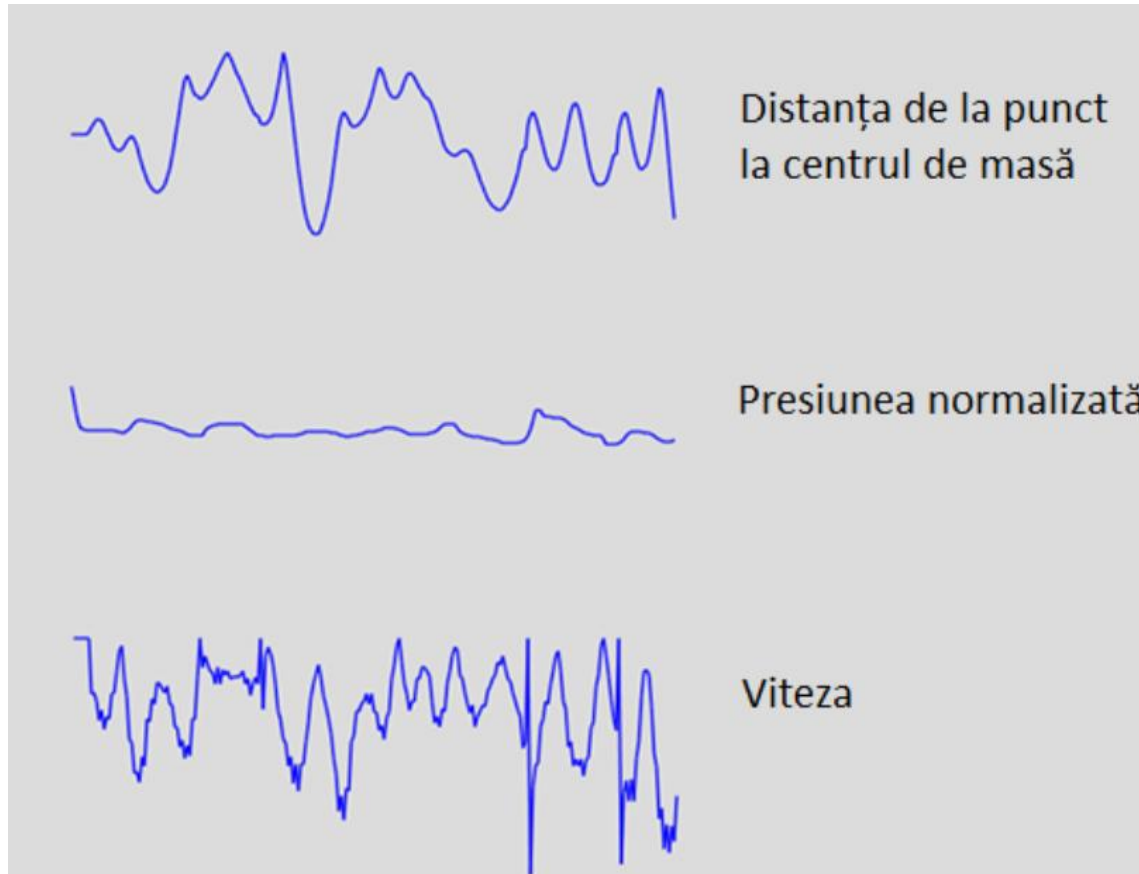


Dinamica de presiune a stylus-ului (dinamica 3D: x, y, z)



Biometrica semnăturii

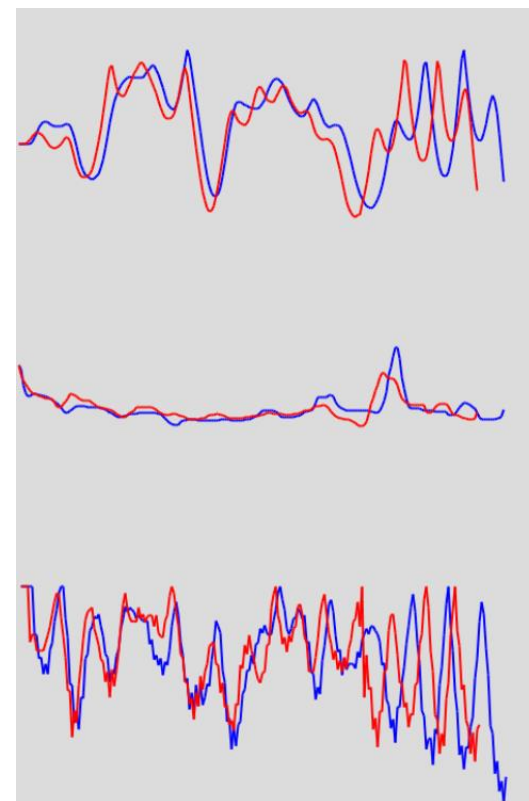
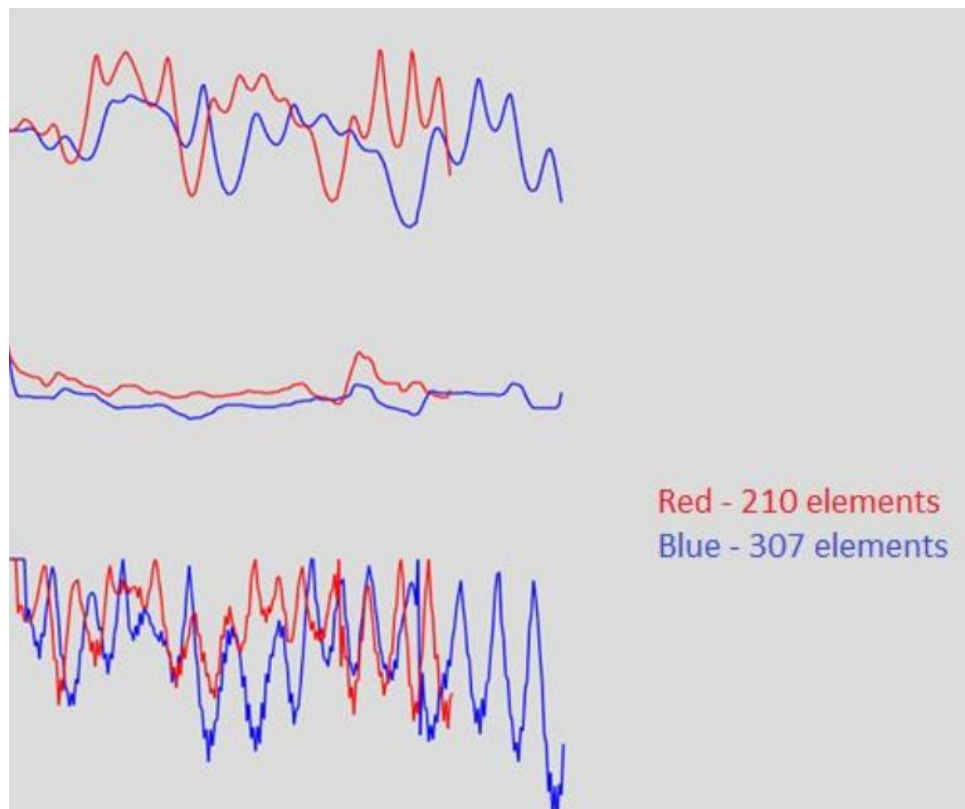
Vectorul de trasaturi normalizat: $V_i = \{(d_i, p_i, v_i), i=1 \dots n\}$





Biometrica semnaturii

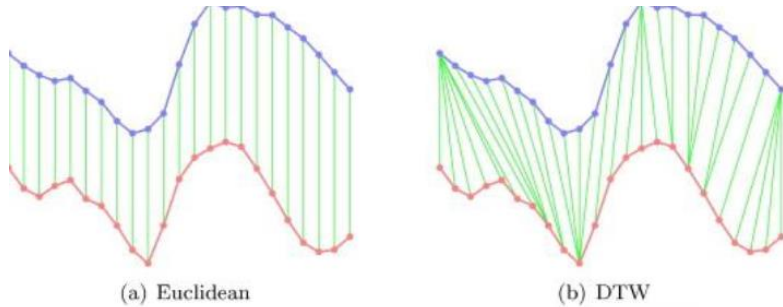
Comparare vectori de trasaturi: redimensionare





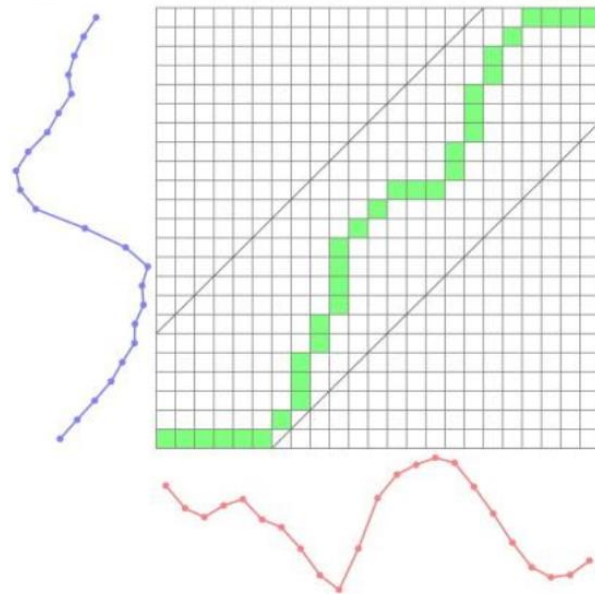
Biometrica semnaturii

Comparare vectori de trasaturi: DTW (Dynamic Time Warping)



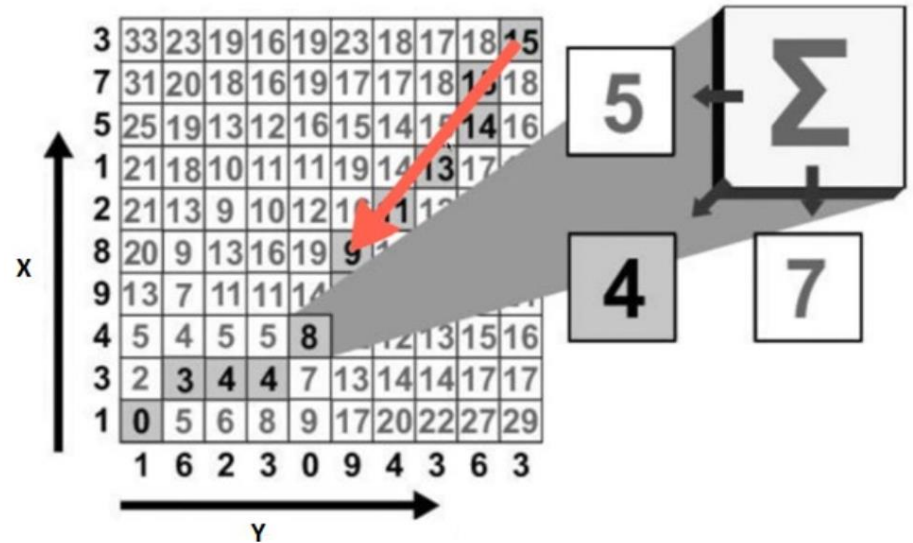
(a) Euclidean

(b) DTW



(c) warping path

Matricea de cost acumulat \Rightarrow backtracking (greedy) \Rightarrow calea de cost minim (warping path) \Rightarrow cost total = suma costurilor de pe warping path





Biometrica semnaturii [1]

<i>Signatures</i>	<i>Strengths</i>	<i>Weaknesses</i>	<i>Cost</i>	<i>Counter-measures</i>	<i>Convenience</i>
Image only	Simple, cheap	Easily forged	Low	Witnesses to watch the process	Excellent
Image with 2D acceleration	Nearly impossible to forge	Requires many comparison samples	Low	Protected connections to database	Excellent
Image with Stylus pressure dynamics	Follows traditional signature comparison standards	Somewhat more complicated signature pads	Low to medium	Protected connections to database	Excellent
Image with 3D movement dynamics	Excellent non-repudiation characteristics	Complicated capture hardware	Medium to high	Protected connections to database	Excellent



Biometrica irisului

Hardware (iris scanners):

<http://www.irittech.com/products/hardware>

Software

<http://www.irittech.com/products/software>

<http://www.neurotechnology.com/verieye.html>

<http://www.mathworks.com/matlabcentral/fileexchange/15652-iris-segmentation-using-daugman-s-integrodifferential-operator>

Metode de referinta (<https://www.cl.cam.ac.uk/~jgd1000/>)

- Daugman J (2007) "New methods in iris recognition." *IEEE Trans. Systems, Man, Cybernetics B* **37**(5), pp 1167-1175. ([PDF](#))
- Daugman J (2006) "Probing the uniqueness and randomness of IrisCodes: Results from 200 billion iris pair comparisons." *Proceedings of the IEEE*, **94**(11), pp 1927-1935. ([PDF](#))



Bibliografie

- [1] P. Gregory, M.A. Simon, Biometrics For Dummies, Wiley Publishing, 2008.
- [2] [D. Maltoni](#), "A Tutorial on Fingerprint Recognition", in Massimo Tistarelli, Josef Bigun, Enrico Grosso, Advanced Studies in Biometrics: Summer School on Biometrics, Alghero, Italy, June 2-6, 2003. Revised Selected Lectures and Papers, Springer-Verlag, 2005.
- [3] D. Maltoni, D. Maio, A.K. Jain, S. Prabhakar, Handbook of Fingerprint Recognition - Second Edition, Springer, London, 2009
- [4] Andrew Ackerman, Rafail Ostrovsky, Fingerprint Recognition
<http://www.cs.ucla.edu/honors/UPLOADS/andrew/thesis.pdf>
- [5] <http://arxiv.org/ftp/arxiv/papers/1001/1001.4186.pdf>
- [6] <http://www.biometricnewsportal.com/default.asp>
- [7] http://www.biometric-solutions.com/solutions/index.php?story=iris_recognition
- [8] Anil K. Jain, Arun A. Ross, Karthik Nandakumar (Ed.), Introduction to Biometrics, Springer 2011.
- [9] Erwin et al 2019 J. Phys.: Conf. Ser.1196 012045,