Personal authentication using hand-geometry and palmprint features – the state of the art

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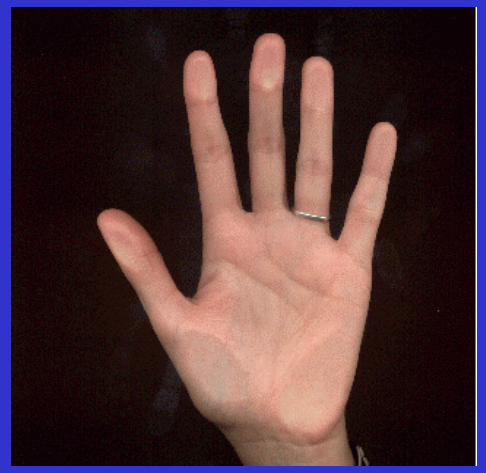
Contents:

Introduction

Human hand contains a wide variety of measurable characteristics that can be used by biometric authentication systems.



E.g.,

- **shape, palmprint, fingerprint**

on the palmar surface of the hand and

- **shape, veins**

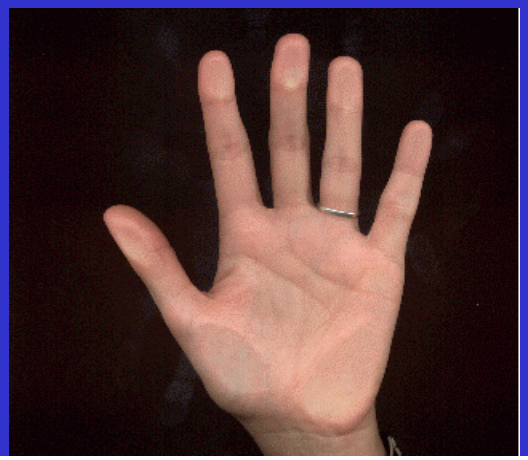
on the dorsum of the hand.

Introduction – Cont.

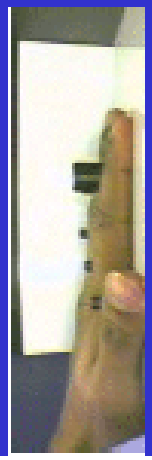
Hand characteristics are typically acquired by a sensor that captures visible light.

E.g., visible images of **palmar** (a), **lateral** (b) and **dorsal** (c) surface of the hand are displayed on the botom of the slide.

a)



b)

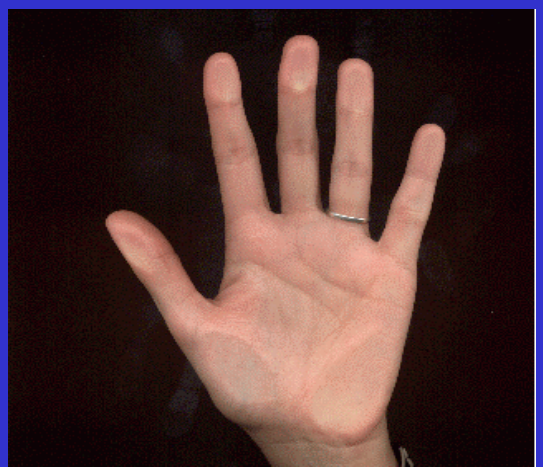


c)

Introduction – Cont.

The visible image of the **palmar surface** of the hand is typically acquired by:

- a **scanner** rated at >100 dots per inch (dpi)/256 grey levels or by
- a **low/medium/high-resolution CCD camera**, located under the transparent platform where the hand is placed.



Introduction – Cont.

The visible images of the **lateral and dorsal surfaces** of the hand are captured with

- a **low-resolution CCD camera** placed above the platform with a side-mounted mirror inclined at 45^{o} to the platform.

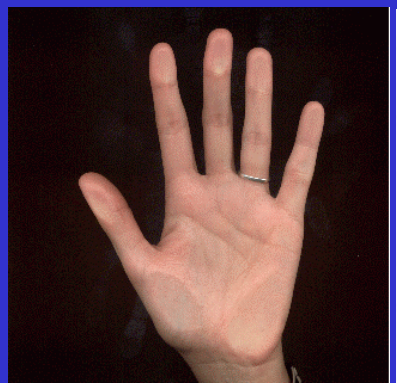
There are usually **4–6 pegs** on the platform to guide the placement of the user's hands. E.g.,

Jain et al. [1999]:

Introduction – Cont.

From visible images of the **palmar, lateral and dorsal surfaces** of the hand 3 classes of biometric features can be extracted:

1. **hand-geometry features**, (e.g., width, thickness and area of the palm, lengths, widths and thickness of fingers),
2. **palmprint features** (e.g., principle lines, wrinkles, ridges, texture), and
3. **fingerprint features** (e.g., minutiae locations, types, number).



Hand-geometry-based systems

Hand-geometry features are usually extracted from visible images of lateral and dorsal surface of the hand.

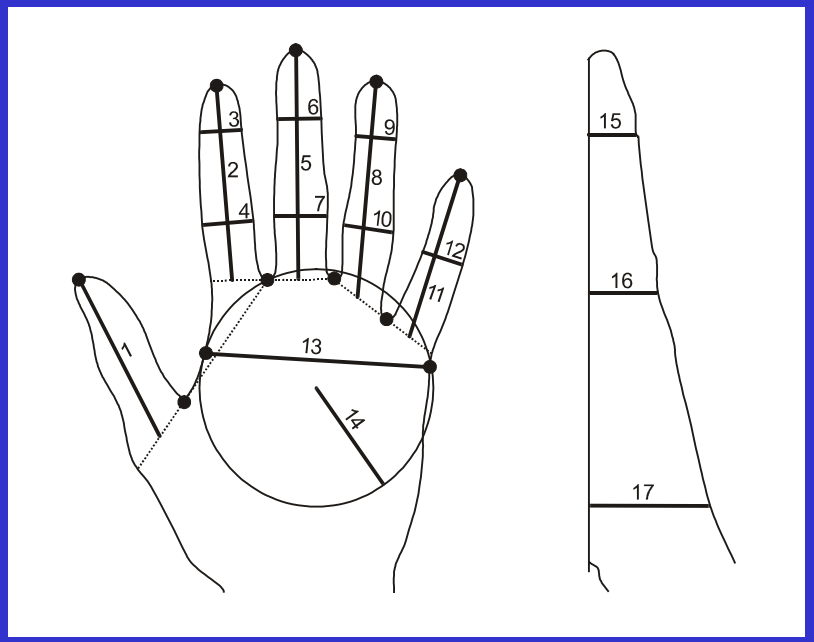
Several prototypal hand-geometry-based authentication systems have been proposed.

E.g., by:

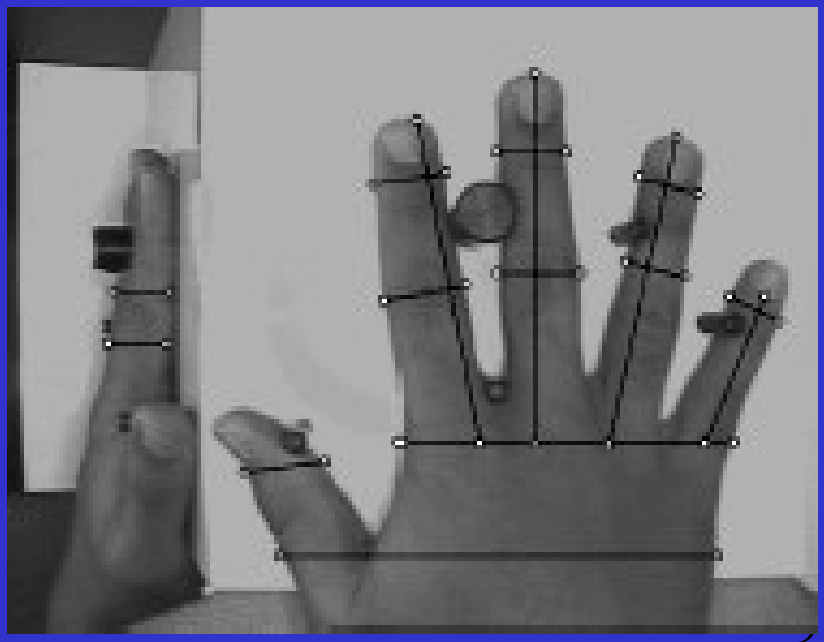
- ***Golfarelli et al.*** **[1997]**
- ***Jain et al.*** **[1999]**
- ***Sanches-Reillo et al.*** **[2000]**

Hand-geometry-based systems

- *Golfarelli et al.* : 17 hand-geometrical features (see image), Bayes classification rule
- *Jain et al.* : 16 hand-geometrical features (see image), 1-NN classification rule (4 distance metrics)



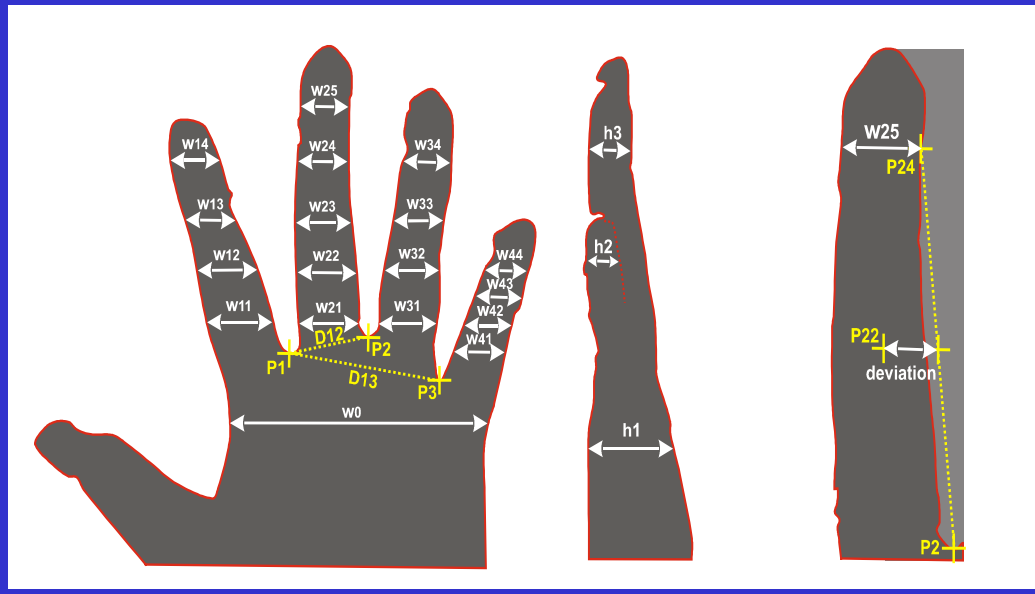
Golfarelli et al.



Jain et al.

Sanches-Reillo et al. - Features

- *31 geometrical features:*
  - 21 widths,
  - 3 heights,
  - 4 deviations, and
  - 3 angles,



are extracted from the contour image of the lateral and dorsal surfaces of the hand.

After a discriminatory analysis of features, the number of features is reduced to 25.

Sanches-Reillo et al. - Classification

Authentication experiments are made by use of:

- 1-NN classification rule (Euclidean and Hamming distance),
- Gaussian Mixture Models (GMMs), and
- Radial Basis Function Neural Networks (RBF).

The system was trained and tested using a database of 200 images of 20 people

Sanches-Reillo et al. - Results of classification tests

		d_E	d_H	GMMs	RBF
Number of enrolment vectors (25 features)	3	86%	75%	88%	90%
	4	85%	82%	93%	91%
	5	86%	87%	96%	91%
Feature vector size (5 enrolment vectors)	25	86%	87%	96%	91%
	21	84%	86%	97%	95%
	15	86%	88%	96%	89%
	9	77%	75%	91%	82%

Sanches-Reillo et al. - Results of verification tests

In verification experiments 5 enrolment vectors per user are used

- Best results are obtained using GMMs (EER≈5%)
- Results are similar for 25, 21 and 15 features in feature vectors.

Commercial hand-geometry-based systems

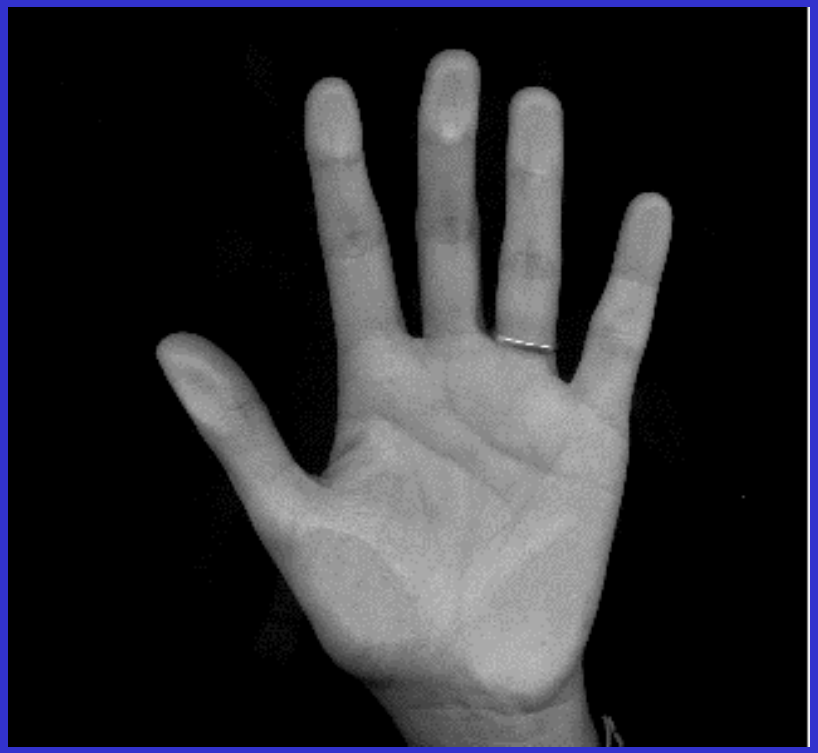
- Hand-geometry-based verification systems are predominantly manufactured by Recognition Systems, Inc. (http://www.recogsys.com/index.shtml)
- Products: HandKey ID3D and HandKey II

Commercial two-finger geometry-based system

- BioMet Partners Inc. (http://www.biomet.ch) manifactures two-finger geometry verification systems
- Products: VeryFast and FingerFoto

Palmprint-based systems

Palm-print features are usually extracted from visible images of palmar surface of the hand.



palm - the inner surface of the hand between the wrist and the fingers

Palmprint-based systems – Cont.

Recently, the problem of personal authentication using palmprint features has drawn considerable attention and several prototypal palmprint-based authentication systems have been proposed.

E.g., by:

- ***Zhang et al.*** **[1999]**
- ***Duta et al.*** **[2002]**
- ***You et al.*** **[2002]**
- ***Li et al.*** **[2002]**

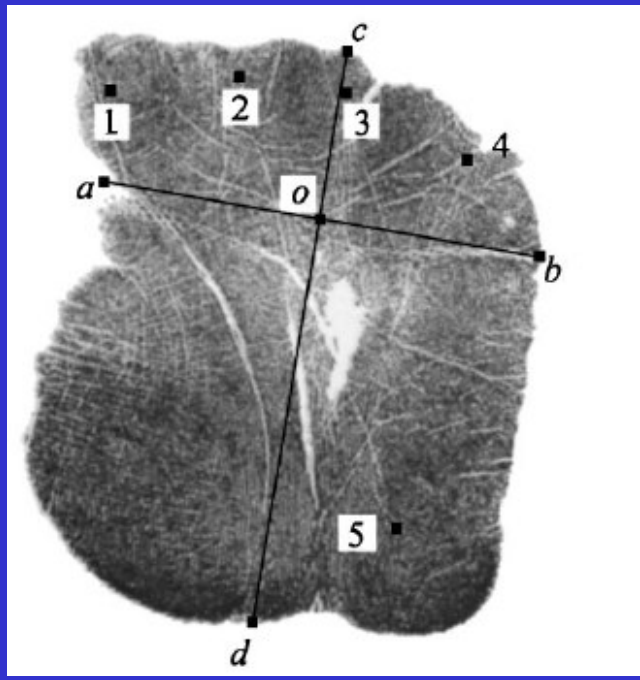
Palmprint-based systems – Cont.

- ***Han et al.*** **[2003]**
- ***Ying-Han et al.*** **[2003]**
- ***Lu et al.*** **[2003]**
- ***Kong et al.*** **[2003]**
- ***Zhang et al.*** **[2003]**
- ***Wu et al.*** **[2003]**

Palmprint-based systems - Features

The most important features of a palm are:

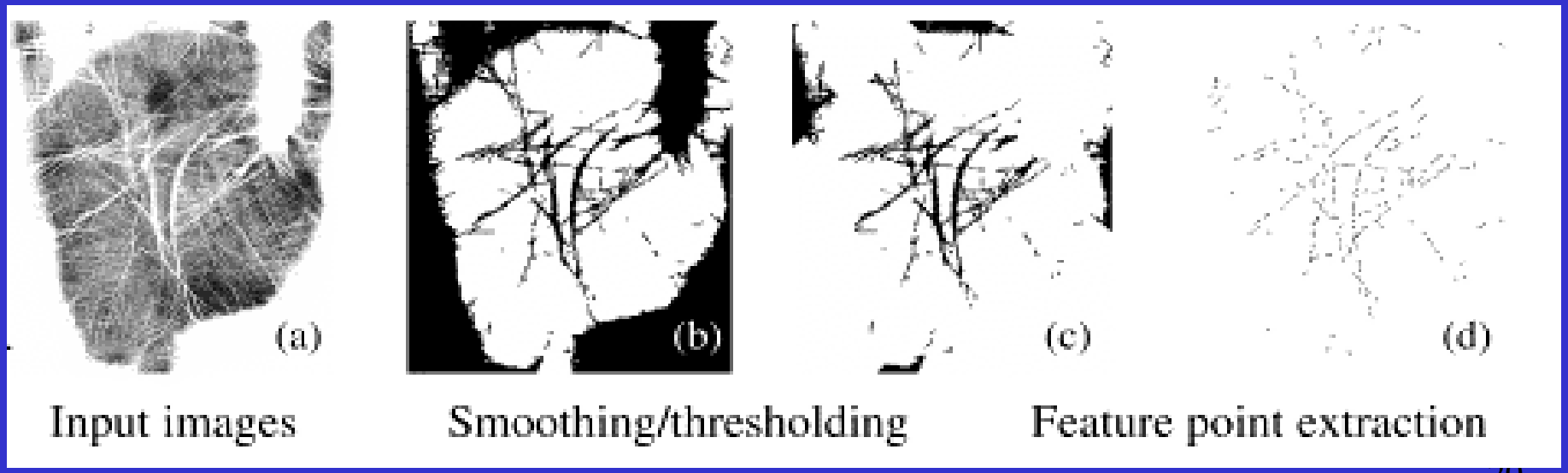
- ***Geometry features:*** width (a-b), length (c-d) and area of a palmprint
- ***Principal lines-based features*:** lines endpoints (a, b), their midpoint (o)
- ***Delta point-based features:*** centers of delta-like regions in a palmprint (points 1-5) (see image)



(*Zhang et al.*)

Palmprint-based systems -Features

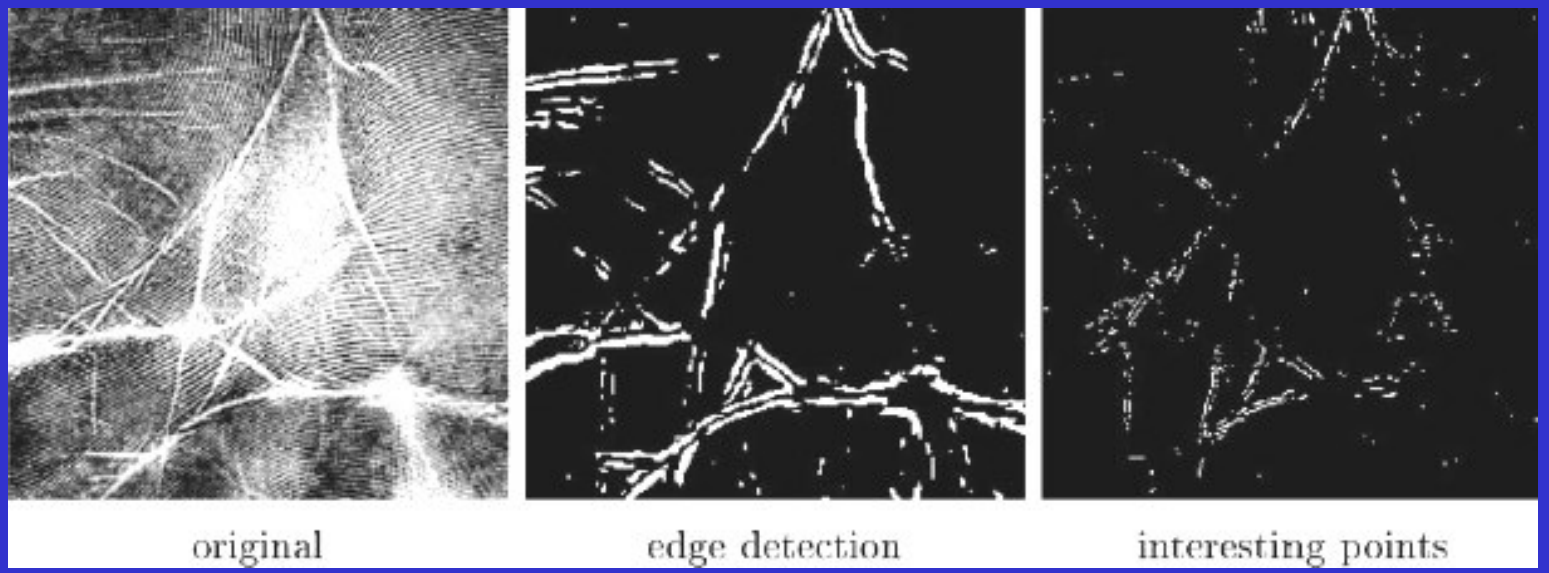
- ***Wrinkle features:*** Thin and irregular lines and curves different from principal lines
- ***Minutiae features:*** Significant feature measurement of ridges existing in a palm.
- ***Feature points/orientations* along prominent palm lines** (see image)



(*Duta et al.*)

Palmprint-based systems - Features

- ***Texture:*** local texture energy, standard deviation
- ***Moments:*** Zernike, pseudo Zernike and Legendre moments
- ***Interesting points*** (see image)



(You et. al.)

Palmprint-based systems - Features

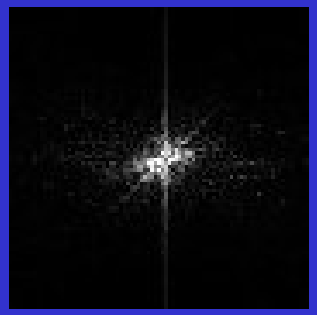
- ***Coefficients and functions of transforms:***
  Fourier, Karhunen-Loeve, Fisher`s linear discriminant, *Gabor filters*

E.g., Fourier transform (*Li et al.*)

***Li et al.* [2002]**

palmprint

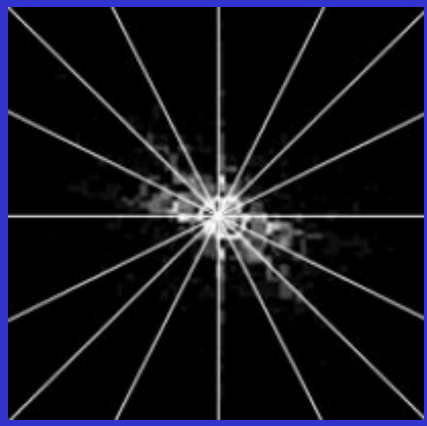
ROI



ROI in freq. domain

R - features

Θ - features



Palmprint-based systems – Classification & Results

Authentication experiments are made by use of:

- 1-NN classification rule (Hamming, Euclidean, weighted Euclidian and Hausdorff distance, correlation),
- Backpropagation neural network

Systems were trained and tested with databases containing from 30 to 3056 palmprints

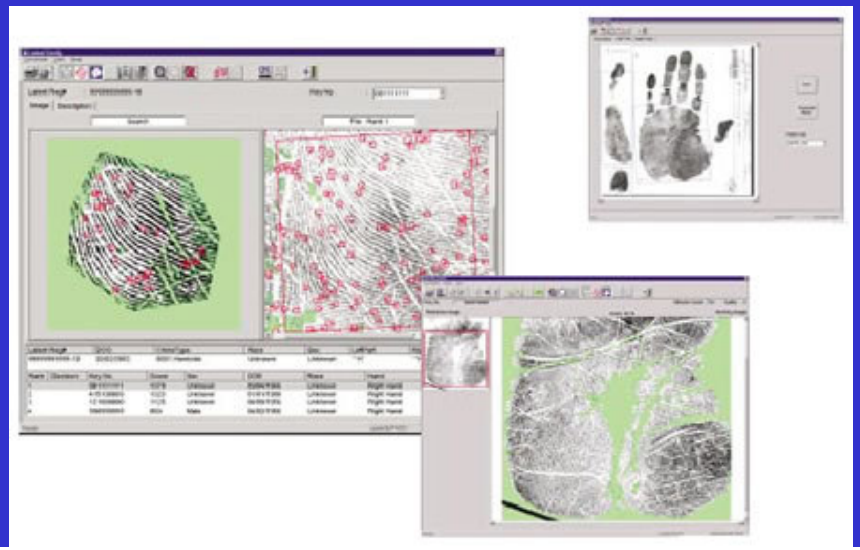
- Recognition rates reported: 95% to 99,75 %
- Equal Error Rate (ERR) < 1%

Commercial palmprint-based systems

The latest generation of automated fingerprint identification systmes (AFIS) by NEC and MOTOROLA

- Automated PalmPrint™ System (http://www.necsam.com/idsolutions/products/law_enforcement.cfm)
- Omnitrak™ AFIS/Palmprint Identification Technology (http://www.motorola.com/LMPS/RNSG/pubsafety/40-70-10.shtml)

include modules for palmprint identification.

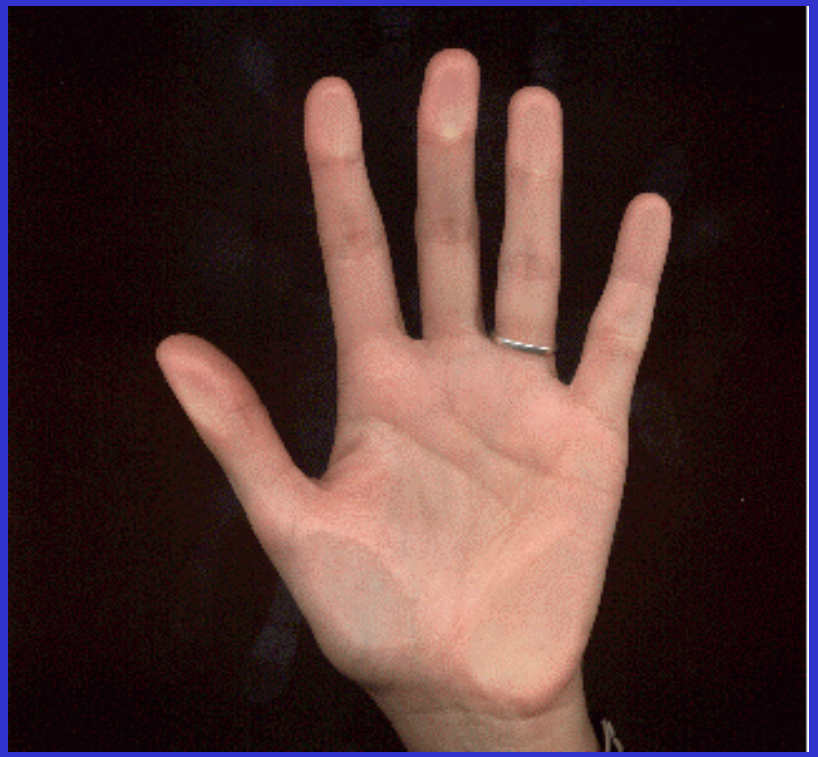


Systems based on the fusion of palmprint and hand-geometry features

A high-resolution sensor of a visible image of the palmar surface of the hand can **simultaneously** capture

- hand-geometry,
- palmprint, and
- fingerprint

features of the hand.



Systems based on the fusion of palmprint and hand-geometry features – Cont.

Since the palmprint and hand-geometry features can be extracted from the same image, the performance and robustness to the fraudelent technologies of a hand-based authentication system can be easily increased by integrating palmprint and hand-geometry features.

Systems based on the fusion of palmprint and hand-geometry features – Cont.

Systems based on the fusion of **palmprint** and **hand-geometry** features have been proposed by:

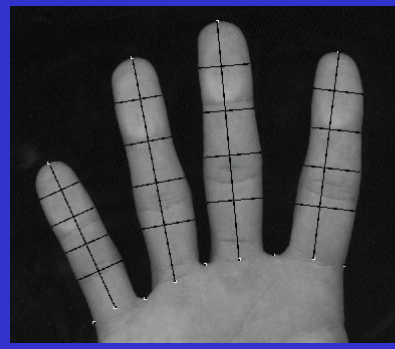
- ***Ribaric et al.*** [**2002**]
- ***Kumar et al.*** **[2003]**

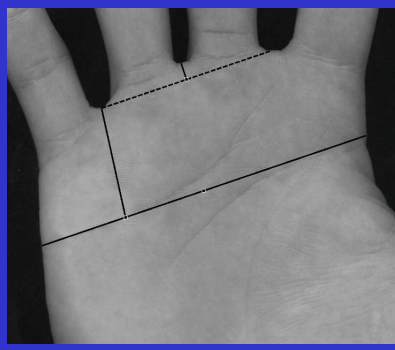
Ribaric et al. - Features

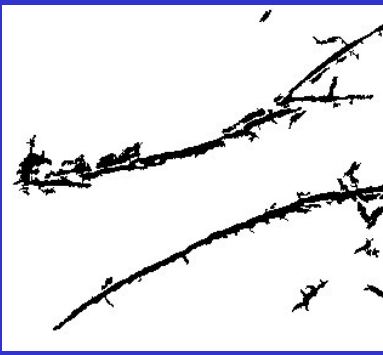
- 20 finger-geometry features,
- 4 hand-geometry features, and
- 399 palmprint features

are fused at **decision level**.

The system was trained and tested using a database of 555 images of 111 people







Ribaric et al. – Results of verification tests

	FAR	FRR
FG	0%	5.2%
PG	32.6%	27.7%
P	8.1%	6.1%
FG-PG	0%	4.6%
PG-P	2.6%	2.3%
FG-P	0%	1.8%
FG-PG-P	0%	1.7%

FG, PG and P denote finger-geometry, palm-geometry and palmprint features, respectively.

Kumar et al. - Features

- 16 hand-geometry features (4 finger lengths, 8 finger widths, palm width, palm length, hand area, and hand length) and
- *n* palmprint features

  are fused at

  - **feature-generation level** and at
  - **decision level**.

The system was trained and tested using a database of 472 images of 100 people

Kumar et al. – Results of verification tests

	FAR	FRR	Threshold
Palmprint	4.49%	2.04%	0.9830
Hand-geometry	5.29%	8.34%	0.9314
FGL	5.08%	2.25%	0.9869
FDL	0%	1.41%	0.9840

FGL and FDL denote fusion at feature generation level and fusion at decision level, respectively.

Summary

- Hand-geometry-based authentication systems are attractive because measurements are easily collectible and non-intrusive.

The main drawbacks of such systems are the low uniqueness and accuracy, as well as the low scalability.

Summary

- Palmprint-based authentication systems, due to the uniqueness and permanence of the palmprint features, are considered as highly accurate and scalable systems.

- Authentication systems based on fusion of hand-geometry and palmprint features increase the performance and they are generally more robust to fraudulent technologies.

Summary

- For still higher accuracy and scalability, a multimodal authentication system that integrates features which can be extracted from the **palmar surface** images, i.e.:
  - hand-geometry,
  - palmprint and
  - fingerprint

  features is proposed to be developed.

- All these features can be obtained from only **one high-resolution single-shot image**.

E.g.,

from the image captured with TouchPrint™ 3800 Full Hand Scanner by Identix, Inc.

(http://www.identix.com/)

which scans entire palmar surface of the hand at 1000 dpi resolution.

1. **Fingerprints**
2. **Interdigital region**
3. **Cup of the palm**
4. **Thenar**
5. **Hypothenar**
6. **Carpal Crease**

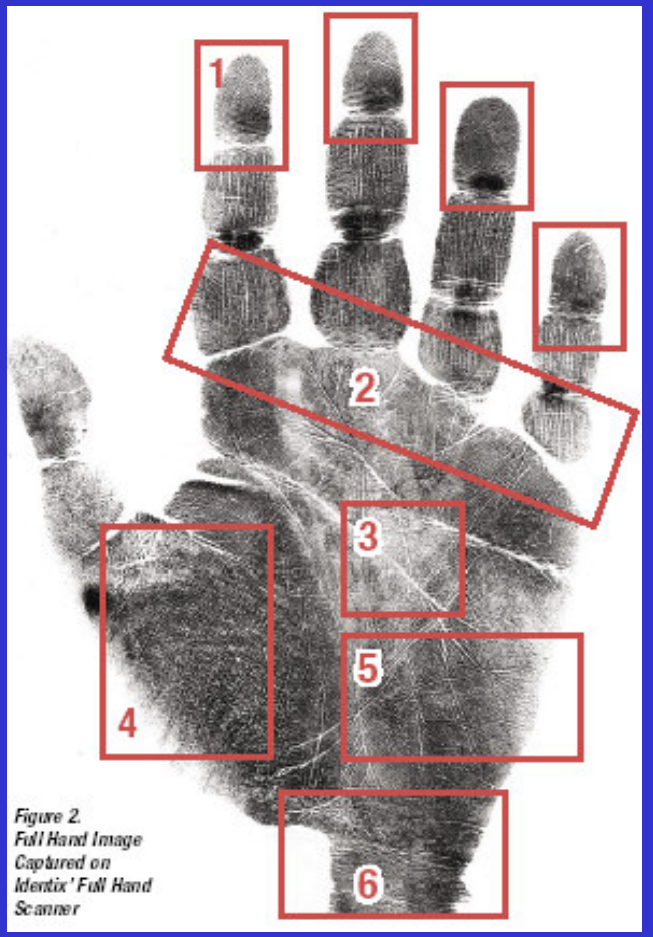


Figure 2. Full Hand Image Captured on Identix' Full Hand Scanner

End of presentation

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Comparison of the human and technical factors of seven popular unimodal biometric systems

H, M, and L denote high, medium, and low, respectively.

	Fingerprint	Face	Hand geometry	Palmprint	Iris	Voice	Signature
Universality	M	H	M	M	H	M	L
Uniqueness	H	L	M	H	H	L	L
Permanence	H	M	M	M	H	L	L
Collectability	M	H	H	H	M	M	H
Performance	H	L	M	H	H	L	L
Acceptability	M	H	M	M	L	H	H
Circumvention	M	H	M	L	L	H	H
Scalability	H	M	L	H	H	L	H
Maturity	H	M	H	L	M	M	M
Cost	M	L	H	M	H	L	M