Hand Geometry

www.recogsys.com

www.panynj.gov/aviation/jfkinspassframe.htm

Applications

- November 18, 2004 Port of Rotterdam Relies on Recognition Systems Biometric HandReaders for Transportation Worker Identity Credential
- October 27, 2004 Prestigious Wisconsin Private School Selects Recognition Systems Biometric HandReader to Secure Campus
- September 14, 2004 IR Recognition Systems HandReaders Verify Transportation Security Administration Employee Identities at San Francisco Airport
- August 31, 2004 Yeager Airport Uses Recognition Systems Biometric HandReaders to Secure Control Tower
- August 17, 2004 With IR Recognition Systems HandReader, German Fuel Terminal Verifies Driver Identities

Applications

- April 29, 2004 David Lawrence Center Swears Off Buddy Punching With IR Recognition Systems HandReaders
- April 13, 2004 IR Recognition Systems HandReaders Secure Assets for Major British Retailer
- March 23, 2004 Washington State Department of Corrections Biometrically Processes Over 300,000 Offender Reports per Year with IR Recognition Systems HandReaders
- March 2, 2004 U.S. Air Force Selects IR Recognition Systems Handreaders to Lend a Hand Securing Their Bases
- February 24, 2004 Simkins Industries Sends Buddy Punching Packing with IR Recognition Systems Biometric HandReaders

Hand Geometry Based Verification

- Anthropologists suggest that humankind survived and evolved due to our large brains and opposing thumbs
- Versatile human hand allows us to grasp, throw, and make tools
- Today, the human hand has another use, a media to verify identity
- A U.S. patent was issued to Robert P. Miller in 1971 for a device that measures hand characteristics and records unique features for comparison and ID verification; highly mechanical device sold under the name Identimation
- Sidlausks received patent for an electronic device in 1988 and established RSI in 1986.

Hand Geometry Based Verification

- Each human hand is unique
- Finger length, width, thickness, curvatures & relative locations of these features distinguish every human being from every other person
- Scanners record no surface details, ignoring fingerprints, lines, scars and color
- Only the silhouette of the hand is recorded
- Orthographic scanning—two distinct images, one from the top and one from the side

Why Hand Geometry?

- It is non-intrusive and simple to use
- Inexpensive acquisition procedure
- Only simple shape/geometric features are used
- Robust to environmental changes
- Has demonstrated excellent performance in verification tasks

http://www.airportnet.org

Prototype System Layout

Hand Image Acquisition

Feedback offered by the GUI

Captured Image

Enrollment

- Scanner prompts the user to place his hand on the scanner platen three consecutive times
- Pins on the platen position the enrollee's fingers to assure accurate image capture
- System "averages" the three templates and stores a single template
- Template is stored as 9 bytes; small enough to be stored in the magnetic stripe of a card; smart card can also receive updated template after verification
- To verify, user inputs his PIN number and places his hand on the platen

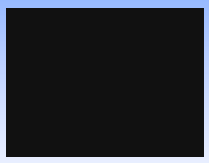
Operational Issues

- Quality of enrollment affects FRR
  - Different platen heights: enrolling at one height and verifying at another can cause enough difference in hand shape to reject the user
  - If enrollment is done while standing (sitting) then verification should also be done standing (sitting)
  - Provide user feedback for correct placement of hand
- Practical systems should "learn" minor hand shape changes and continually update templates as users are verified by the system; refereed to as template averaging
- Systems have worked reliably for children above the age of 8 depending on the size of their hands; children of some ethnic groups are smaller in stature!

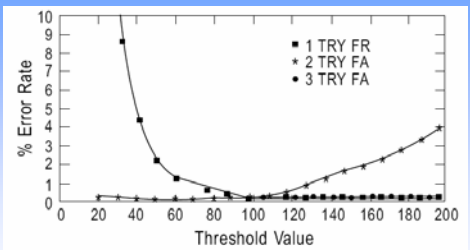
Privacy Issues

Template cannot be "reverse engineered" to identify users. Consequently, hand geometry based authentication protects privacy of the users better than other biometrics, say, fingerprints

Video

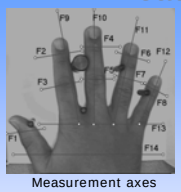


Verification Accuracy

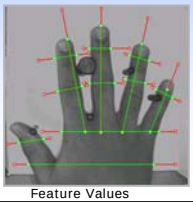


Sandia Labs evaluation results (1991) for ID3D System for authenticating identity based on hand geometry. EER = 0.1% based on 2-try false reject rate. One-try FAR is 0.2%

Feature Extraction

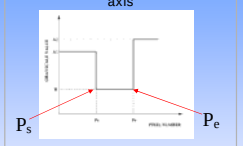


Measurement axes

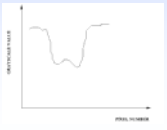


Feature Values

Ideal grayscale profile along an axis



Observed grayscale profile along axis F3



Feature Extraction

G(x) is the grayscale profile along the x-axis, 0 ≤ x < Len. Goal is to compute P_s and P_e from this profile.

- Slide a window across the profile starting from the leftmost pixel.
- The window is moved to it's right one pixel at a time.
- Compute the following parameters for each window position W_i:

$$Maxval(i) = \max_{j \in W_i} G(j)$$
$$Maxindex(i) = \arg\max_{j \in W_i} G(j)$$
$$Minval(i) = \min_{j \in W_i} G(j)$$
$$Minindex(i) = \arg\min_{j \in W_i} G(j)$$

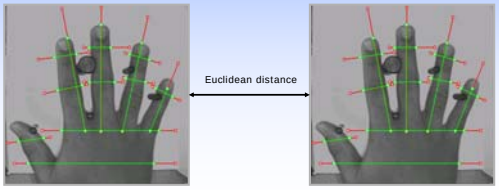
- Compute P_s and P_e as follows:

$$P_s = Maxindex(k)$$
$$s.t. Minindex(k) > Maxindex(k),$$
$$(Maxval(k) - Minval(k)) > (Maxval(i) - Minval(i)),$$
$$\forall i \neq k, 0 \leq i, k \leq N$$

$$P_e = Maxindex(k)$$
$$s.t. Maxindex(k) > Minindex(k),$$
$$(Maxval(k) - Minval(k)) > (Maxval(i) - Minval(i)),$$
$$\forall i \neq k, 0 \leq i, k \leq N$$

Matching

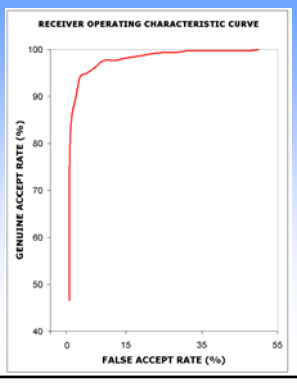
- Template feature vector: $(x_1, x_2, \ldots x_{14})$
- Input feature vector: $(y_1, y_2, \ldots y_{14})$
- Matching score: Euclidean distance $\sum_{i=1}^{14} (x_i - y_i)^2$



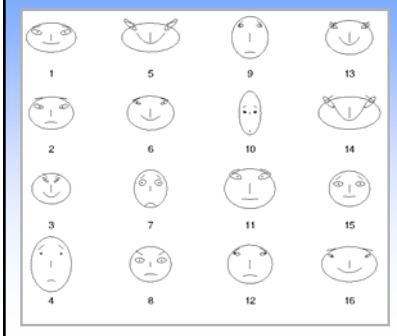
System Performance

Test database consists of 400 hand images of 55 users.

Threshold (T)	Genuine Accept Rate (%)	False Accept Rate (%)
20	46.61	0.00
25	66.67	0.01
30	72.27	0.04
35	81.42	0.28
40	86.14	0.72
45	89.68	1.76
50	94.10	2.81
60	96.17	6.69
65	97.64	9.11
75	98.23	15.09
85	99.12	21.81
135	100.00	50.09

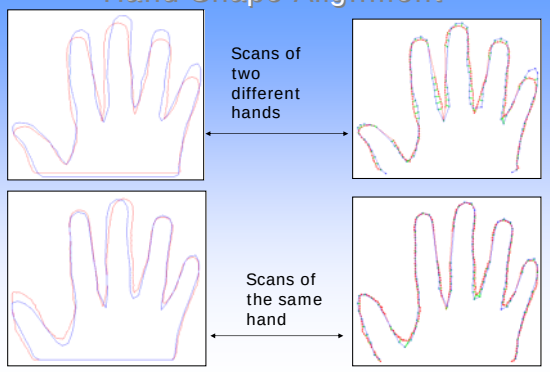


Visualizing Feature Vectors from 16 Different Hands using Chernoff Faces



Feature value along axis:	Attribute
F1	Area of face
F2	Shape of face
F3	Length of nose
F4	Location of mouth
F5	Curve of smile
F6	Width of mouth
F7	Location of eyes
F8	Separation of eyes
F9	Angle of eyes
F10	Shape of eyes
F11	Width of eyes
F12	Location and width of pupil
F13	Location of eyebrow
F14	Angle of eyebrow

Hand Shape Alignment

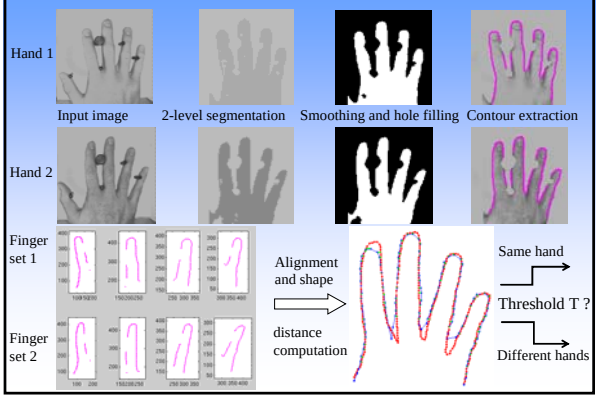


Jain, Duta, "Deformable matching of hand shapes for verification", ICIP 1999.

Alignment-based Verification

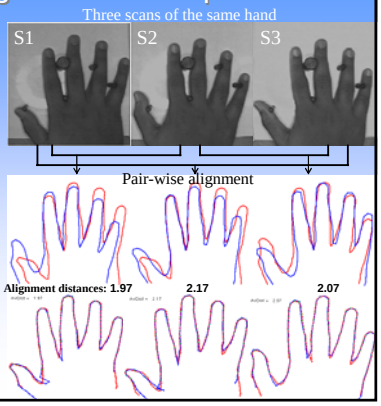
- Peg removal - a mask containing the known positions of the five pegs is used to replace the pegs with a color that closely matches the background
- Contour extraction - an adaptive thresholding is applied to each image and a contour following algorithm is used to compute the shape of the hand
- Finger extraction and alignment – the five pairs of corresponding fingers are aligned separately with respect to the rigid transformations group
- Pairwise distance computation - each alignment in Step 3 produces a set of point correspondences. The Mean Alignment Error (MAE) between the two hand shapes is defined as the average distance between the corresponding points
- Verification - the pair of hand shapes are said to belong to the same hand if their MAE is smaller than a threshold *T*

Alignment-based Verification



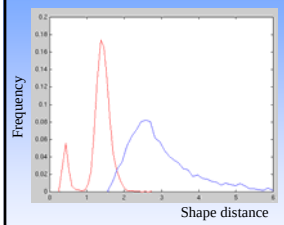
Learning a Hand Template

- One hand template per person can be selected from the enrollment set based on its average alignment distance to the remaining enrollment shapes
- Here S2 is closest to S1 and S3 is S2 with an average alignment distance of 2.02 so S2 is selected as the template

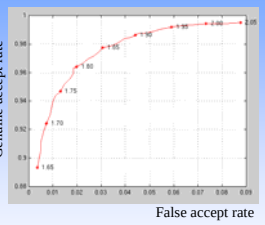


System Performance

Shape distance distributions for genuine (red) and imposter (blue) classes



ROC curve



- Based on 353 images of 53 persons
  - Genuine distribution: 3021 pairs, Imposter distribution: 2809 pairs
- By learning a shape template for each user, the system performance is 96.5% GAR at 1.5% FAR

Limitations of Hand Geometry

- Hand geometry is not unique to an individual; hence application in large-scale identification is limited
- Information not invariant over the lifespan of an individual, especially during childhood
- An individual's jewelry or limitations in dexterity (e.g., arthritis) may pose challenges in extracting correct features
- Physical size of a hand geometry-based system is large; cannot be used in applications like laptop computers

http://www.tinyplace.org/tinyblog/fotographia/prettyring.php