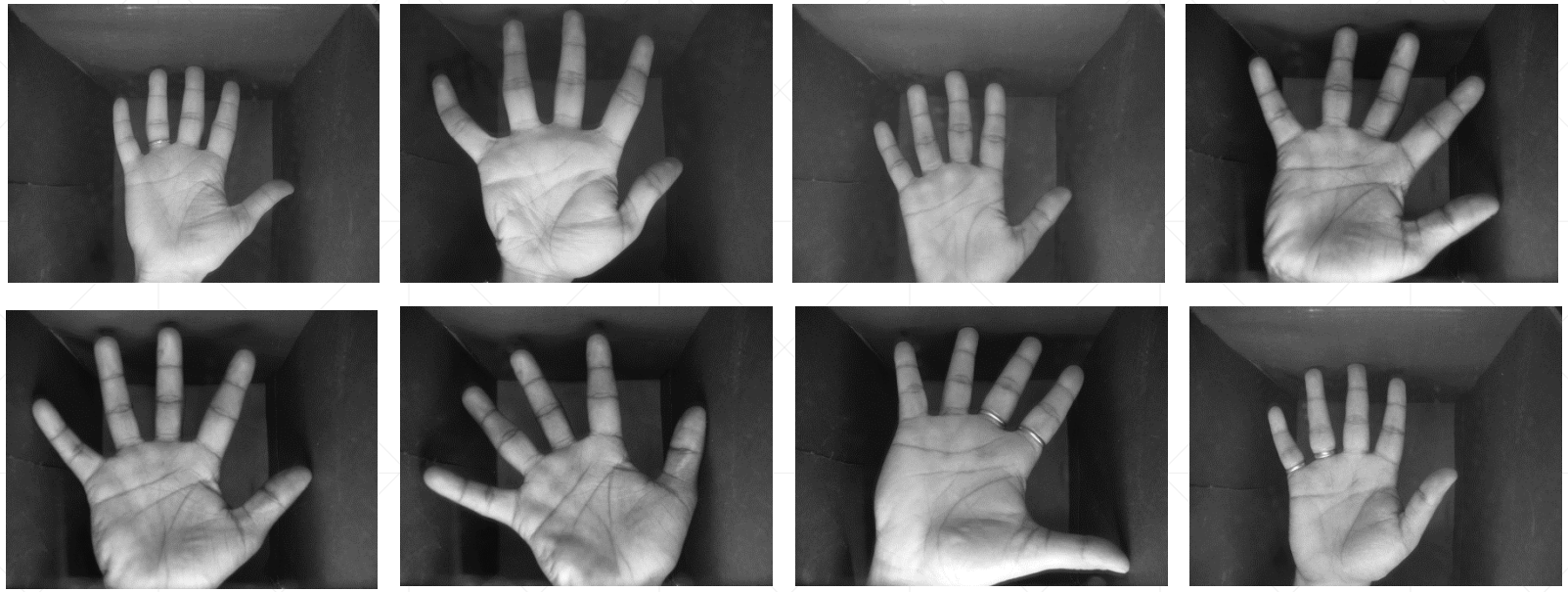


Hand Geometry Based Biometric Recognition

Final Presentation

Abdulkadir Çelikkanat

[DEFINITION & MOTIVATION]

- An approach to biometric recognition based on hand geometry.
- Recognition by hand geometry is considered of low/medium security, but it has a number of advantages compared to other biometrics:
  - Easy to use
  - Low cost, since it only requires an average resolution camera
  - No need for specialized sensors
  - Low computational cost, which allows for faster results.

[RELATED WORKS]

- Image acquisition and datasets
  - Tradional methods require the usage of pegs to correctly position the hands. Ex: Sanchez-Reilo, et-al [1]
  - More recent works study unconstrained and contactless hand geometry biometrics. Ex: Jing-Ming Guo et-al [2]

- Proposed methods differ in features and extraction of features of hand and palm.
  - In the work of Kumar and Zhang [3] combined the hand geometry and palmprints.

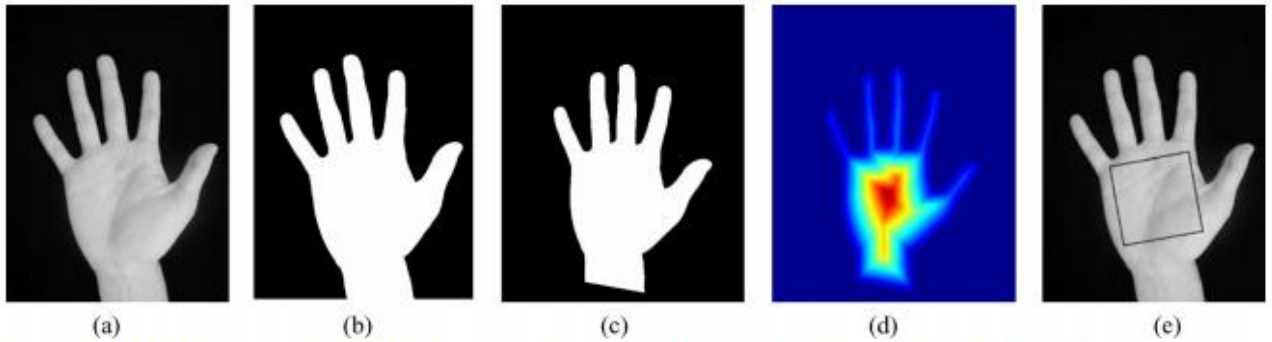
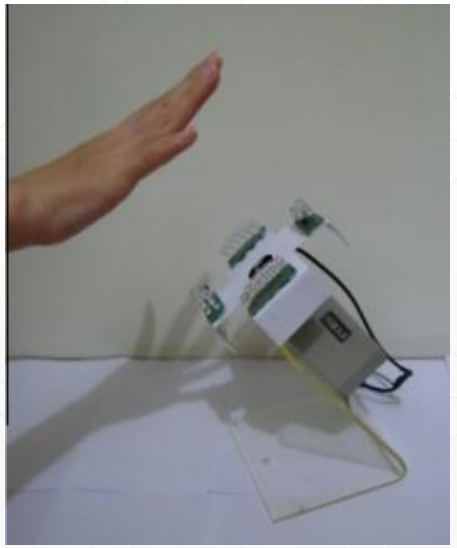


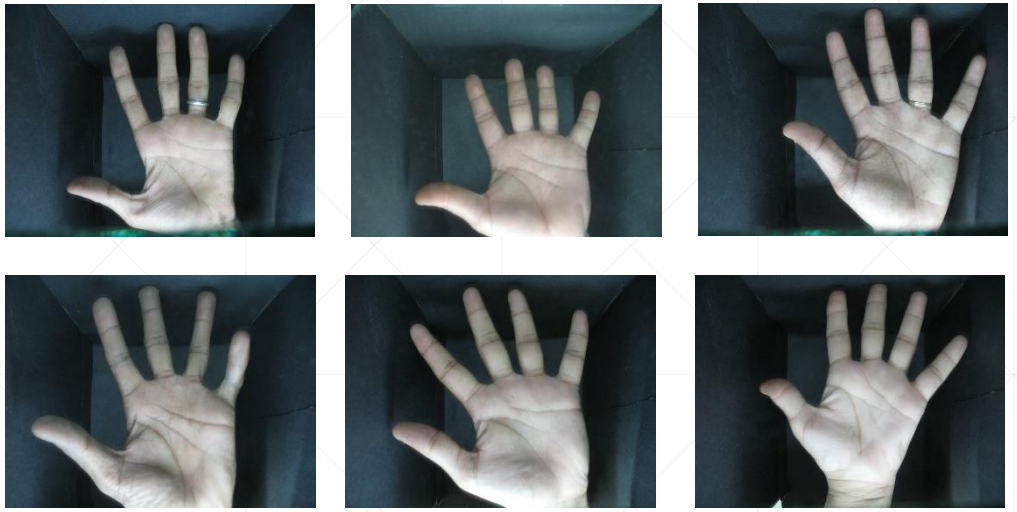
Fig. 3. (a) Acquired hand image. (b) Binarized hand-shape image used to extract the parameters of best-fitting ellipse. (c) Hand-shape image after rotation. (d) Distance transform of image. (e) Estimation of palmprint region using located center and orientation from (d) and (b), respectively. (Color version available online at http://ieeexplore.ieee.org.)



[DATASETS]

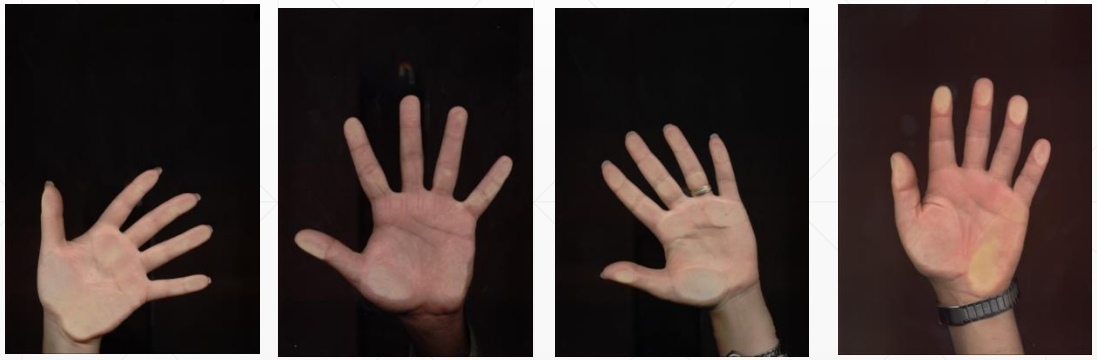
IIT Delhi Touchless Palmprint Database

- The dataset was collected by using a simple and touchless imaging setup
- The resolution of these images is 800 x 600 pixels
- The database contains images of 235 users
- 4-6 images from each subject, from each of the left and right hand, in varying hand pose variations



Bosphorus Hand Database

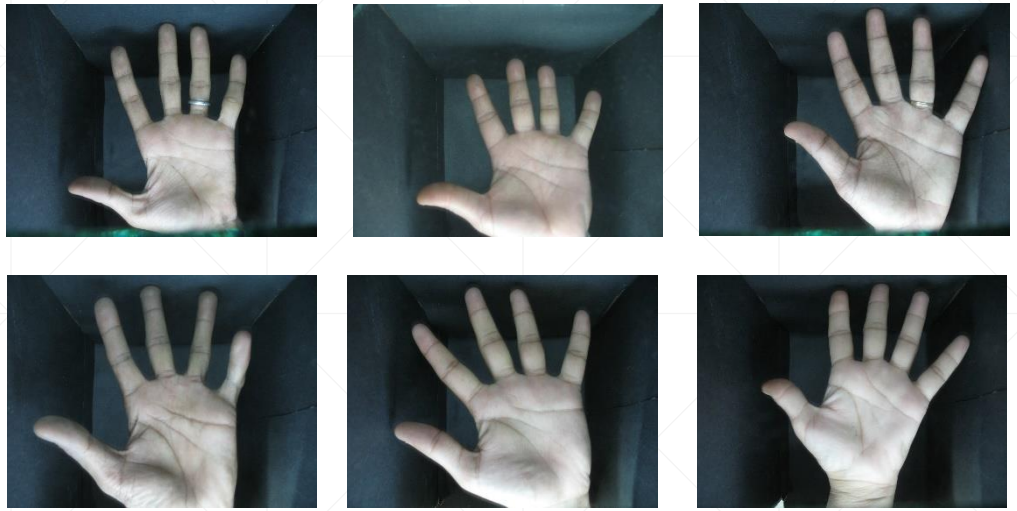
- 642 subjects with 6 images/person, that is, three right-hand images and three left-hand images
- 276 subjects with three only left-hand images (These subjects are different than above mentioned 642 ones)
- 160 among 918 subjects have hand images with time lapses of several months

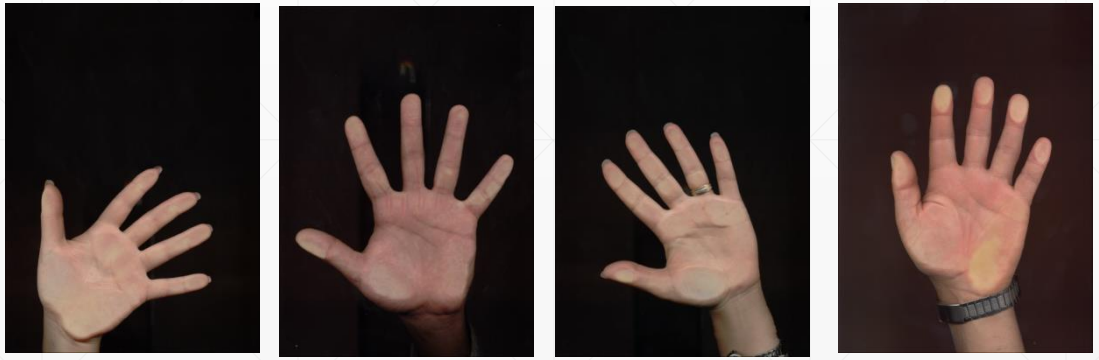


[HAND SEGMENTATION]

Details For Bosphorus Hand Database

- To extract the hand region from the background, the following steps are appied
- Firstly, color images are converted into grayscale.
- To improve the contrast of the image, imadjust is applied.
- The grayscale image is converted into a binary image using a certain threshold value.
- 2D median filter of size 5x5 is applied to get rid of possible noises
- Erosion operation is performed using a disk structuring element (SE) of size 3px
- Dilation operation followed with a disk SE of size 3px





[HAND SEGMENTATION]

Results

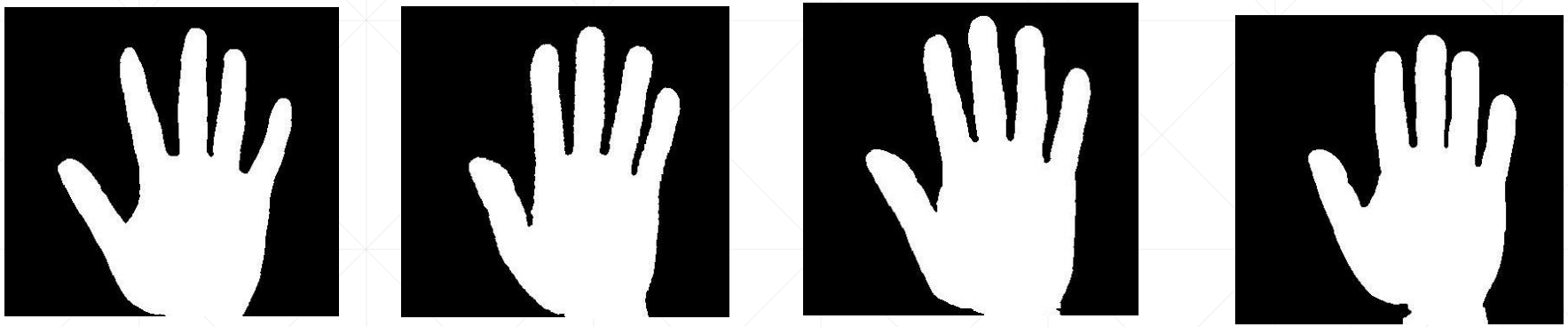
Better samples

Samples having problems

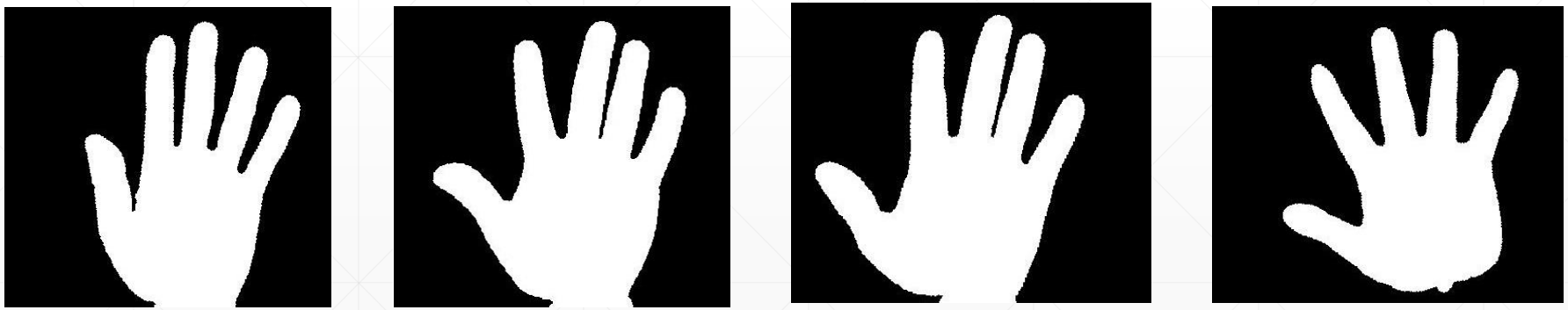
* 24 of 1300 images for IITD dataset, and 21 of 600 hand images for Bosphorus dataset were thrown out.

[HAND REGISTRATION]

Aim : Translation and rotation of the hands to put them in certain alignment



Better rotated samples



Samples having problems

[HAND REGISTRATION]

Details

The moments of a binary image is defined as $$m_{i,j} = \sum_{(x,y)\in object} x^i y^i$$

and the centroid is $$\hat{x} = \frac{m_{1,0}}{m_{0,0}}, \quad \hat{y} = \frac{m_{0,1}}{m_{0,0}}$$

Therefore, the central moments can be written as $$\mu_{i,j} = \sum_{(x,y)\in object} (x-\hat{x})^i (y-\hat{y})^j$$

Then the orientation of the hand mask can be found with

$$\theta = 0.5 * tan^{-1}\left(\frac{2\mu_{1,1}}{\mu_{2,0} - \mu_{0,2}}\right)$$

The hand is rotated by ϕ in counterclockwise direction

$$\phi = \begin{cases} 90 - \theta & 90 \geq \theta \geq 0 \\ 90 - \theta & -90 \leq \theta < 0 \end{cases}$$

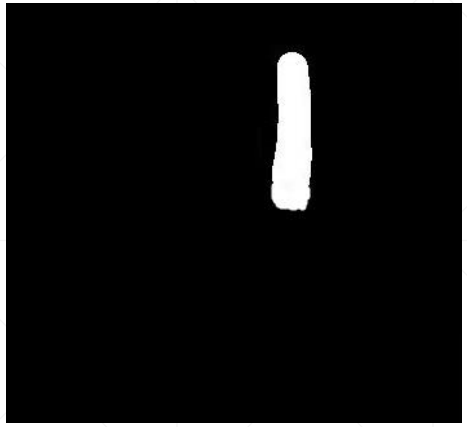
*The regionprops() function of Matlab returns measurements with specified property.

[RING ARTIFACT REMOVAL]

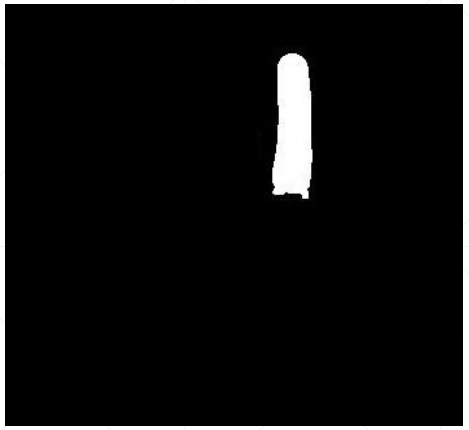
Aim : Detection of the disconnected finger if exists and connect it to the hand.

Original Image

Detection of Disconnected Finger



Rotation of Disconnected Finger



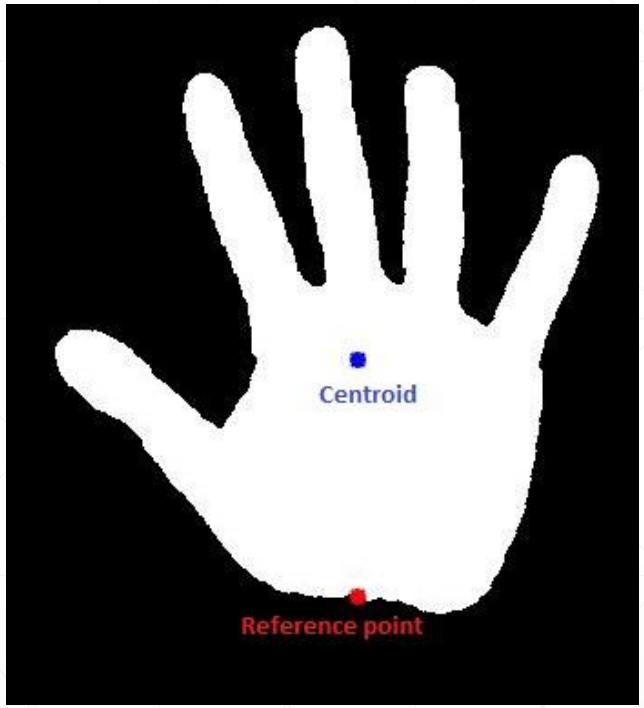
Extended Finger

Rotate the finger back

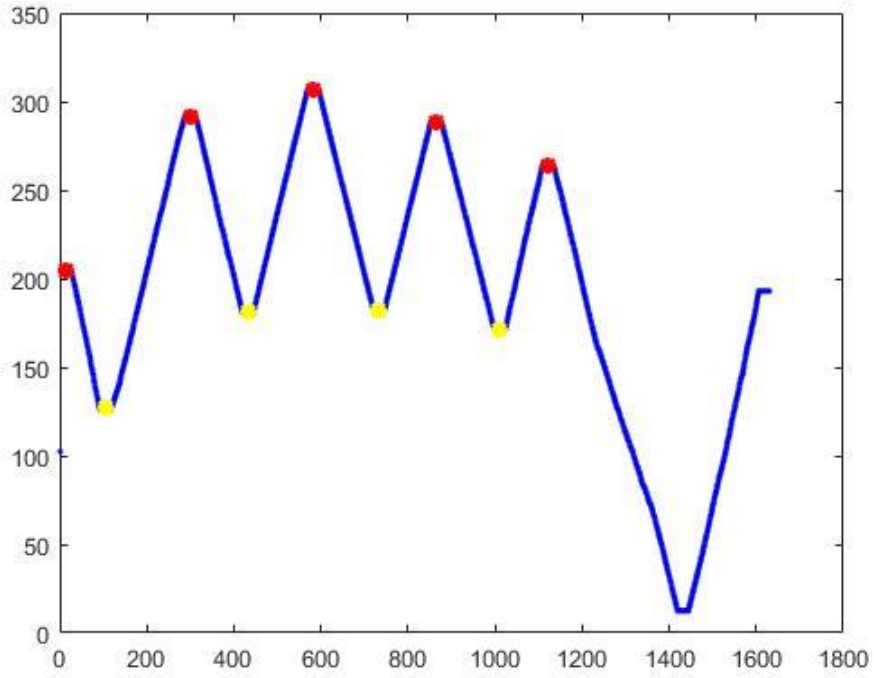
*The bwpropfilt() extracts all connected components (objects) from a binary image

[EXTRACTING HAND EXTREMITIES]

Aim : Detection and localization the peaks and valleys of the fingers



- The point of intersection of hand's major axis passing through the centroid ***c*** of the hand with the wrist boundary line is considered as the stable reference point ***r***.



- After finding the reference point ***r***, finger feature points are extracted by computing the euclidean distance map between the reference point and the contour points

*The bwboundaries() function extracts the contours of the hands.

[EXTRACTING HAND EXTREMITIES]

Aim : Detection and localization the peaks and valleys of the fingers

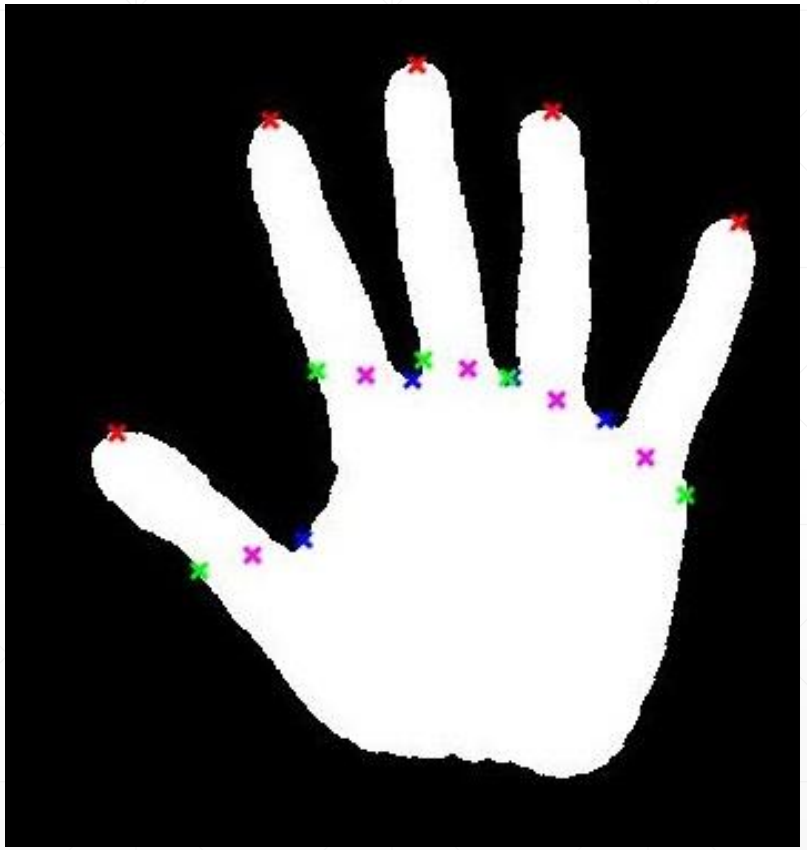
- The peak and valley points of the distance map are found, which correspond to the finger extremities, thumb, index, middle,
- In order to complete to find the finger extremities, one more valley point is needed

$$\Gamma_{c_j} = \begin{cases} \Gamma_{p_j} - (\Gamma_{v_j} - \Gamma_{p_j}), & \Gamma_{p_j} < \Gamma_{v_j} \\ \Gamma_{p_j} + (\Gamma_{p_j} - \Gamma_{v_j}), & \Gamma_{p_j} > \Gamma_{v_j} \end{cases} \quad for\ j \in [1,5]$$

$where\ \Gamma_{p_j}$ and Γ_{v_j} denote the index of peaks p_j and valleys v_j

- Finally, the middle points in the finger are defined as

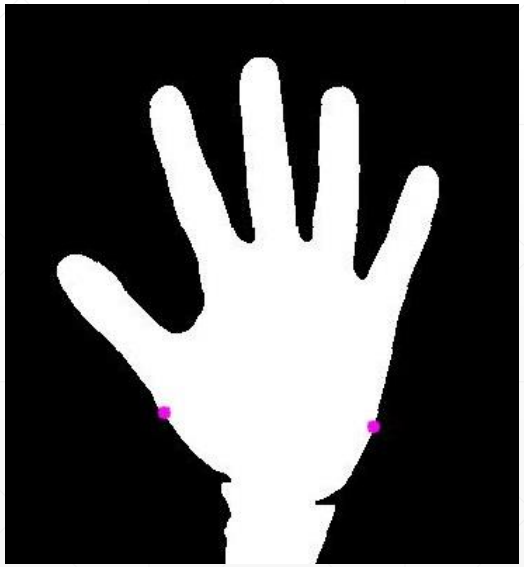
$$x_{m_j} = (x_{\Gamma_{v_j}} + x_{\Gamma_{c_j}})/2\ and$$
$$y_{m_j} = (y_{\Gamma_{v_j}} + y_{\Gamma_{c_j}})/2\ for\ j \in [1,5]$$



[WRIST COMPLETION]

- The hand contours obtained after segmentation have irregularities in the wrist regions due to clothing or the difference in the angle of the forearm and the pressure.
- Hence, the hand is guillotined at the index points Γ_{u_1} and Γ_{u_5} where

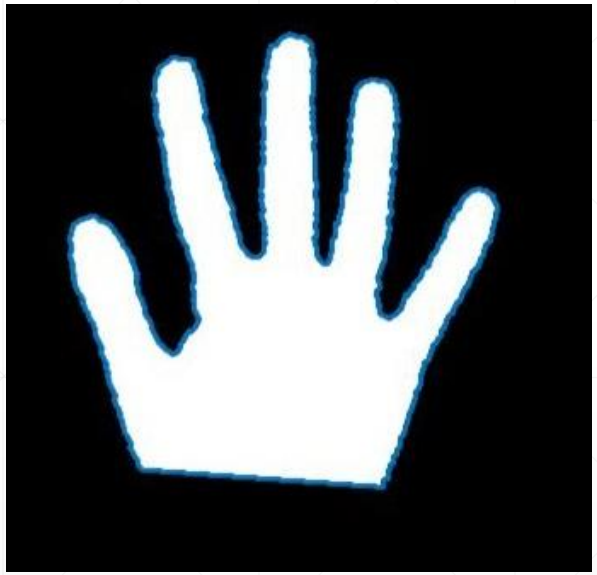
$$\Gamma_{u_1} = \Gamma_{p_1} - (\Gamma_{p_1} - \Gamma_{c_1}) * 1.75$$
$$\Gamma_{u_5} = \Gamma_{p_5} + (\Gamma_{p_5} - \Gamma_{c_5}) * 1.75$$

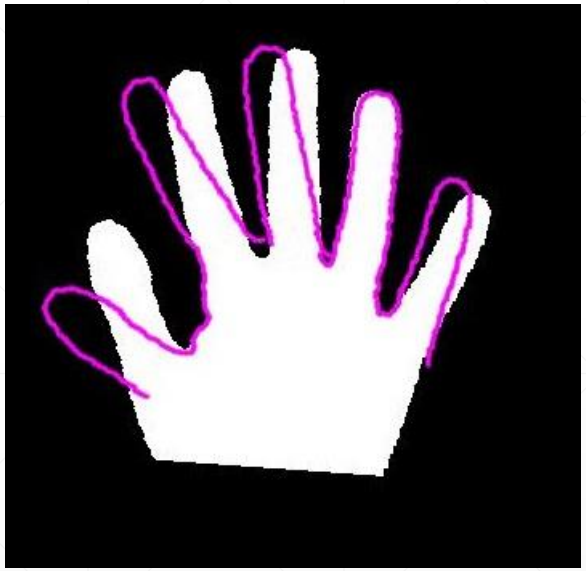


[FINGER REGISTRATION]

Aim : Allignment of the finger contours in order to decrease possible errors, since the images were obtained the peg-free environments

- The angle of the finger i can be obtained with, $$\phi_i = tan^{-1} \frac{y_{p_i} - y_{m_i}}{x_{p_i} - x_{m_i}}$$



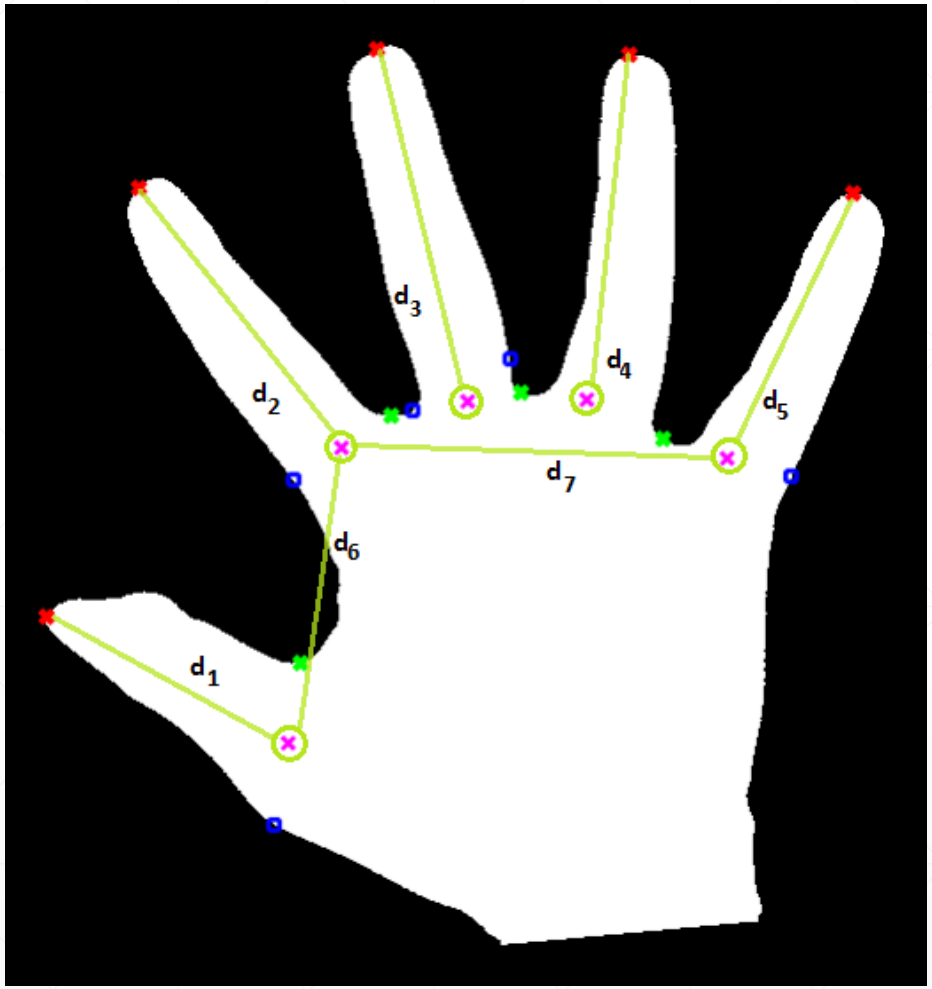


finger angles after registration				
i=1	i=2	i=3	i=4	i=5
60˚	30˚	10˚	-10˚	-20˚

- The new coordinates of the finger contours can be computed with,

$$x_{i_{new}} = x_{m_i} + (x_{o_i} - x_{m_i}) * cos\phi_i - (y_{o_i} - y_{m_i}) * sin\phi_i$$
$$y_{i_{new}} = y_{m_i} + (x_{o_i} - x_{m_i}) * sin\phi_i - (y_{o_i} - y_{m_i}) * cos\phi_i$$

[FEATURE EXTRACTION]

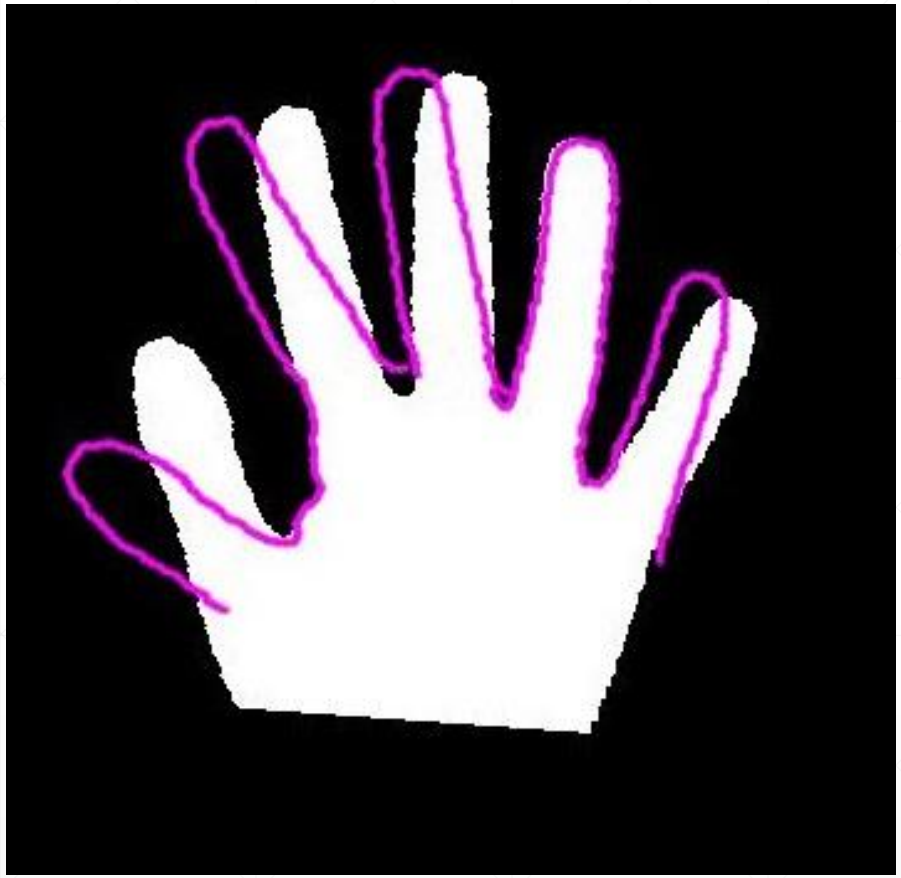


Geometric features*

- 7 distances from 5 fingers
- Consider the ratios from these 7 distances
- The geometrical feature description g($\frac{n(n-1)}{2}$) is the ratios of $\frac{d_i}{d_j}$ where i<j and i,j≤n.
- Finally, use g(6), g(10) and g(21) as geometric feature vectors

*The proposed method of S.Sharma et al

[FEATURE EXTRACTION]



Distance and Orientation Map*

Compute

$$d\mu(i) = \sqrt{(x_r - x_i)^2 + (y_r - y_i)^2}$$

and

$$o\mu(i) = 90 + tan^{-1}\left(\frac{y_r - y_i}{x_r - x_i + \sigma}\right)$$

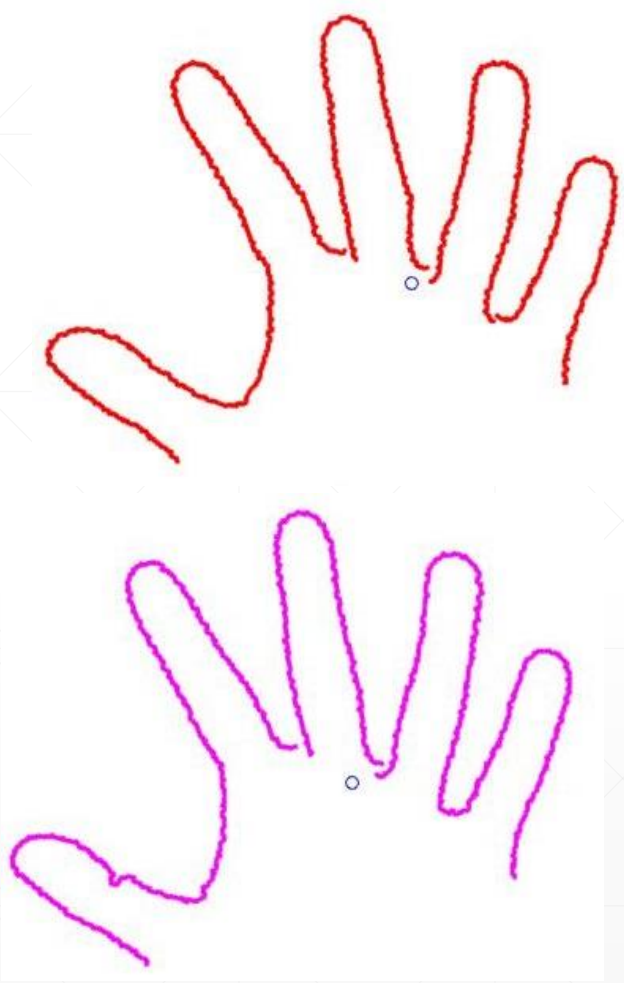
where (x_i, y_i) the coordinates of contour points and (x_r, y_r) is the location of the reference point.

To transform the higher dimension feature into low dimension feature vector and to choose the most discriminative features, the 1-D wavelet decomposition at level 5 using Daubechies-1 decomposition over distance and orientation map.

The wavelet toolbox of Matlab is used for wavelet decomposition.

*The proposed method of S.Sharma et al

[FEATURE EXTRACTION]



Hand Contour Based Comparison*

- To compare two hand contours, modified Hausdorff distance is used
- The Hausdorff distance is an efective method since the distance measures proximity rather than exact superposition so it is more tolerant to perturbations in the locations of points.
- The modified Hausdorff distance is defined as

$$h(F,G) = \frac{1}{N_f} \sum_{f \in F} \min_{g \in G} \| f - g \|$$

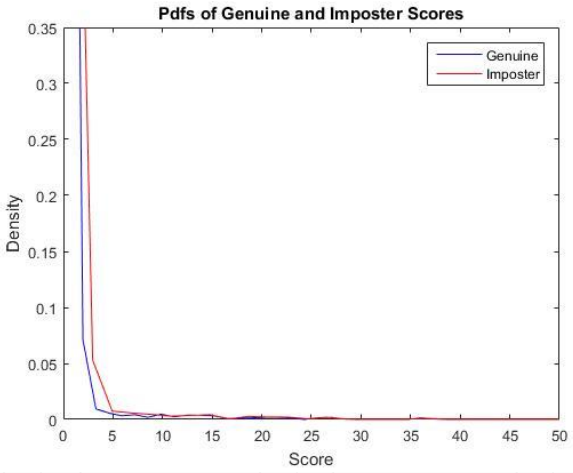
$$h(G,F) = \frac{1}{N_g} \sum_{g \in G} \min_{f \in F} \| f - g \|$$

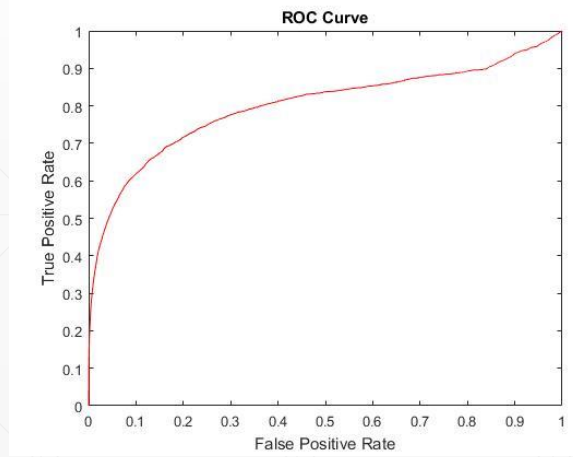
where (N_f, N_g) is the number of points in the sets F and G.

*The proposed method of Erdem Yoruk et al

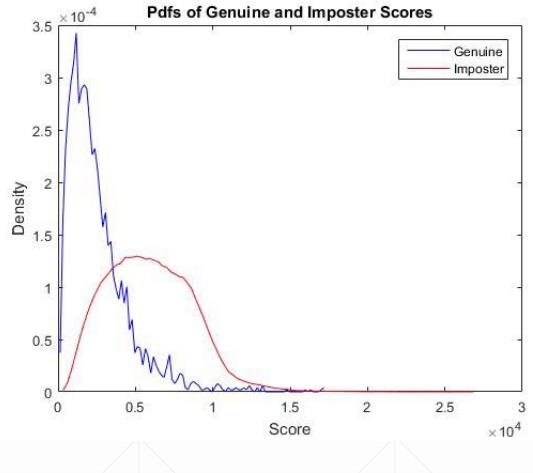
[RESULTS]

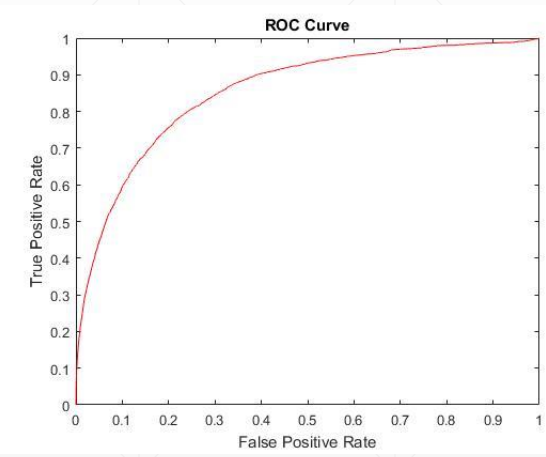
	EER for IITD dataset						
	g(6)	*g(10)*	*g(21)*	*'d'*	*'o'*	*fused*	*contour*
My Score	31.4014	30.7347	25.1195	21.9936	21.9973	22.1580 (min-max)	18.7350
S.Sharma et al			38.46	26.83	34.06	0.52	



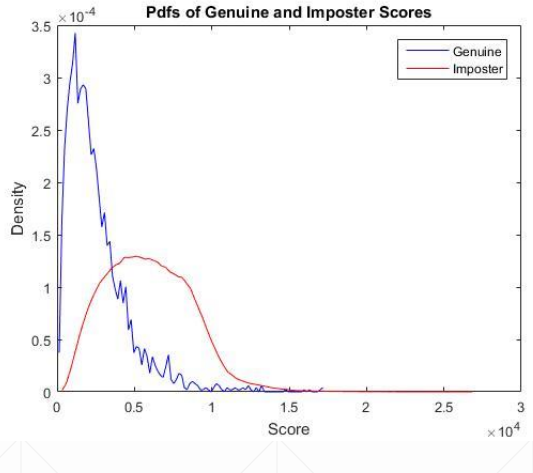


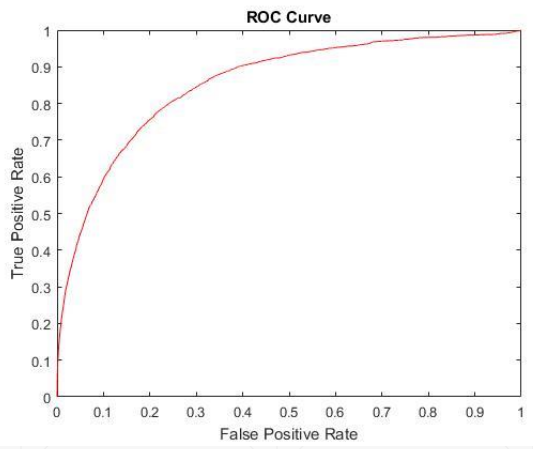
Geometric g(21)



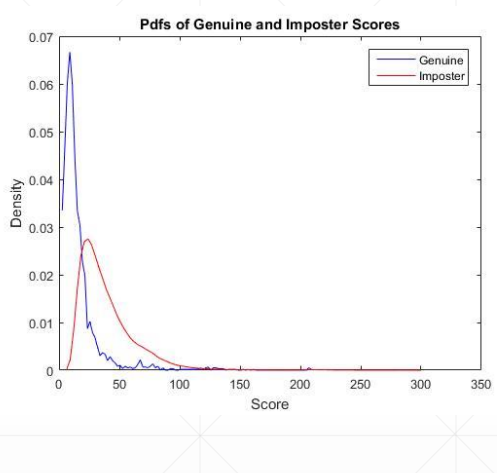


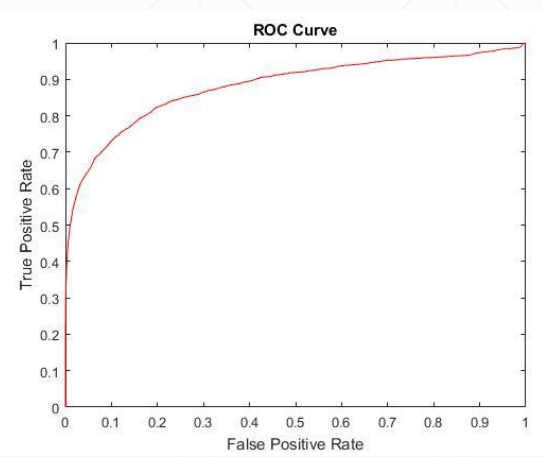
Distance Map





Orientation Map

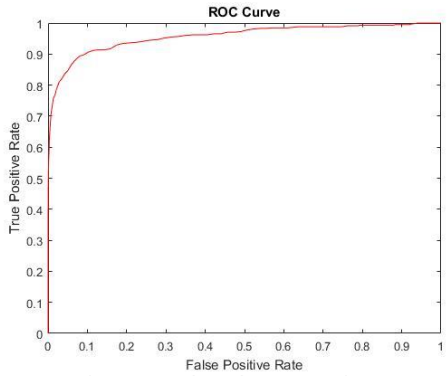


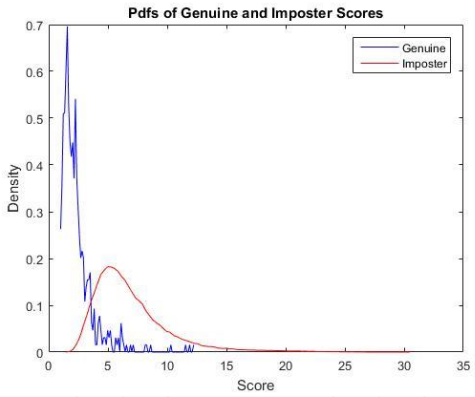


Contour-based

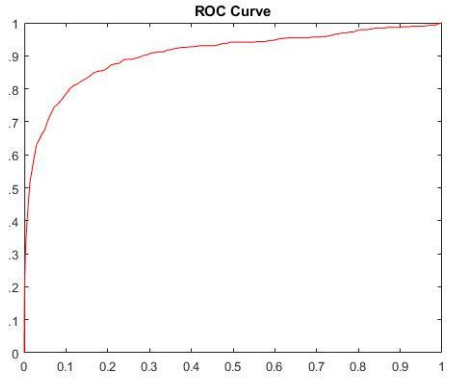
[RESULTS]

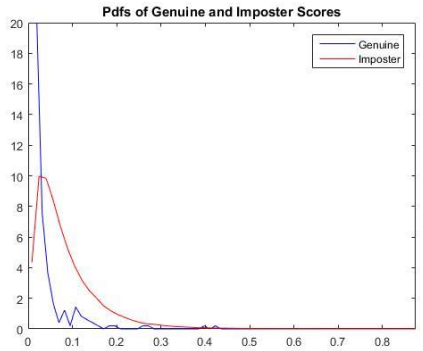
Contour



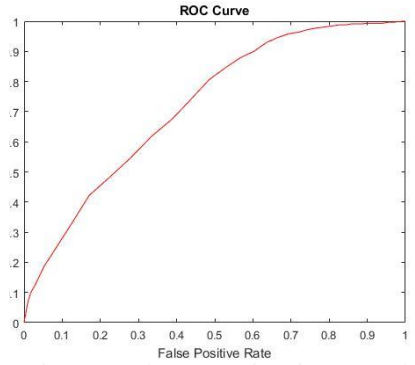


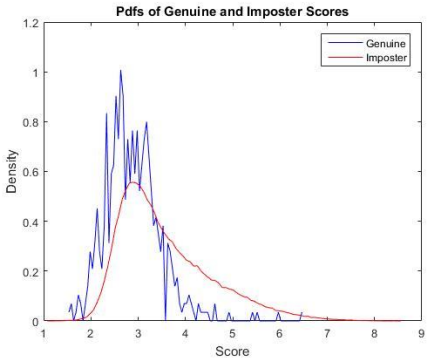
Geometric g21



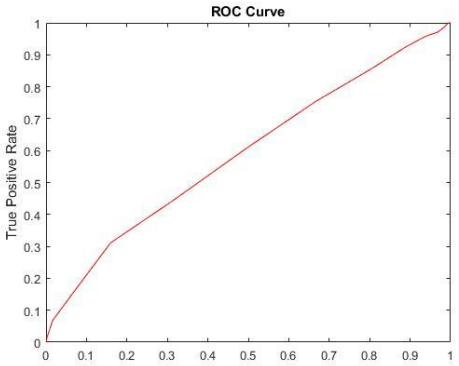


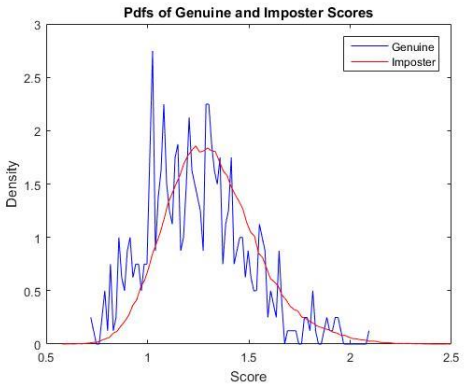
Distance Map





Orientation Map





EER for Bosphorus dataset							
	g(6)	*g(10)*	*g(21)*	*'d'*	*'o'*	*fused*	*contour*
My Score	24.5751	19.7363	15.8795	36.2267	45.0265	16.6858 (min-max)	10.0063

EER for private JUET dataset							
	g(6)	*g(10)*	*g(21)*	*'d'*	*'o'*	*fused*	*contour*
S.Sharma et al	23.60	22.40	21.80	17.80	0.208	0.4 (min-max)	

[RESULTS]

Correct Identification Percentage (Double Training Set)					
Set size	20	35	50	100	All (193/458)
My scores	81.66±5.77	80.00±5.71	84.00±5.29	80.66±2.08	79.62±1.82
Erdem Y. et al	98.75	98.14	97.97	97.21	93.51

Correct Identification Percentage (Single Training Set)					
Set size	20	35	50	100	All (193/458)
My scores	40.83±9.17	40.00±8.28	42.00±8.76	40.33±4.32	39.81±10.41
Erdem Y. et al	2.67	3.23	4.23	4.38	3.61

Correct Identification Percentage for different feature vectors (Double Training Set)					
Method name	g6	g10	g21	distance	orientation
My score	15.72±1.81	24.01±1.65	45.25±2.99	1.72±0.299	1.38±0.299

References

- [1] R. Sanchez-Reillo, C. Sanchez-Avilla and A. Gonzalez-Marcos, "Biometric Identification through Hand Geometry Measurements," *IEEE Trans. Pattern Analysis and Machine Intelligence,* vol. 22, no. 10, pp. 1168-1171, 2000.
- [2] Jing-Ming Guo, Chih-Hsien Hsia, Yun-Fu Liu, Jie-Cyun Yu, Mei-Hui Chu, Thanh-Nam Le «Contact-free hand geometry-based identification system», Expert Systems with Applications, Volume 39, Issue 14, 15 October 2012, Pages 11728–11736
- [3] A. Kumar, D. Zhang «Personal recognition using hand shape and texture» IEEE Transactions On Image Processing, Vol. 15, No. 8, August 2006
- [4] Márcia V. P. do Nascimento, Leonardo V. Batista, N. L. Cavalcanti, Jr. «A new approach to biometric recognition based on hand geometry» Proceeding, SAC '15 Proceedings of the 30th Annual ACM Symposium on Applied Computing, Pages 59-65
- [5] Yoruk, E., Konukoglu, E., Sankur, B., \& Darbon, J. (2006). Shape-based hand recognition. IEEE Transactions on Image Processing, 15(7), 1803–1815.
- [6] Shefali Sharma, Shiv Ram Dubey, Satish Kumar Singh, Rajiv Saxena, Rajat Kumar Singh «Identity verification using shape and geometry of human hands», Expert Systems with Applications 42 (2015) 821–832