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Decision Level Fusion of Iris and Signature Biometrics for Personal Identification using Ant Colony Optimization

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Abstract-This research presents the multi –model biometrics system for based iris and signature. This paper presents the decision level fusion for combine two unimodel biometric system. Contourlet transform using to feature extraction for iris while the signatures are used Linear Discriminant Analysis (LDA) to extracted feature. The system applied Ant colony optimization (ACO) technique for classified into genuine (accepted) or impostor (rejected). Finally, apply multi-mode with decision level fusion which the most populating strategy for fusing. The system is for multimodal database comprising of 800 samples. The performance system is tested on a database prepared to find GAR for the three rules (AND, OR, weighted Majority Voting, Bayesian decision fusion) are (96%, 99%, 98%, 96%).

Index Terms; **Multibiometric; Ant colony optimization; Decision level fusion**

I. INTRODUCTION

Biometrics Systems are recently used for person verification build by one or more physiology or behavioral characteristic individual like iris, face, signature, hand-geometry, and retina…etc. The benefit of any biometrics system is to alleviate risks interrelated with lock and key or password authorization. Biometric authentication can be defined as automatic recognition of a person based on his or her physiological or behavioral characteristics. The system required to become reliable demanded applications in terms of universality, uniqueness, permanence, collectability, performance, acceptability and circumvention [1]. Most of currently-used biometric systems employ single biometric trait; these systems are called uni-biometric (biometrics system). Despite their considerable advancement in recent years, there are still challenges that negatively influence their resulting performance, such as noisy data, restricted degree of freedom, intra-class variability, non-universality, spoof attack and unacceptable error rates, these restrictions can be treatment by using multimodal biometric system called "multibiometric system", which utilize more than one physiological or behavioral characteristic for enrollment and verification/ identification, such as multiple samples, multiple biometric traits …etc. [2]. Multibiometric systems used to overcome the limitations in uni-biometric systems such as Non-universality (insufficient population coverage, Noisy data, Spoof-attacks, Inter-class similarities, Intra-user variation…etc. [3]. This paper present multibiometrics system that combines iris and signature traits. These two traits are widely acceptable by users. The Iris is an internal organ of the eye, physically protected from external environment by the cornea. This makes it more consistent than fingerprints which are more susceptible to worn out due to age or manual labor. The agglomeration of pigment is formed during the first year of life, and pigmentation of the stromal occurs in the first few years. The highly randomized appearance of the iris makes its use as a biometric well recognized. Its suitability as an exceptionally accurate biometric derives. The difficulty of forging and using as an imposter person, stability, it is intrinsic isolation and protection from the external environment, it's extremely data-rich physical structure, its genetic properties—no two eyes are the same [4]. The characteristic that is dependent on genetics is the pigmentation of the iris, which determines its color and determines the gross anatomy. Details of development, that are unique to each case, determine the detailed morphology [5]. Historical, the Signature is basic legal transactions identity authentication in most of applications. Signatures have played role in authenticate documents. Signature based verification is commented as a consistent non-invasive authentication procedure by the majority of the users, therefore, it can help in overcoming some of the privacy difficulties. Signature is strong to fake access attempts. In theory, there is no person signed exactly same each time. Theory, there are many dynamic data (such as speed, pen-up movement, pressure, etc.). They affected to forge signature for every digitized signature point [6]. A multibiometrics system designed in this paper, could indeed be improved by decision level fusion this type of fusion is regarding accepted or rejected of a genuine user are obtained by independently processing each modality. Each source represents in binary data thus subsequently fused to make a global decision. Significant reduction in system complexity can be obtained. However, this is at the reduce for cost of high information loss due to the binary quantization of individual features [6]. The rules of decision level cases of multiple biometrics integration are studied in this paper and show that the integration of multiple biometric is acceptable. The reset of paper is section(2)discuss the related work ,section (3) explain the models of the multibiometrics system and why choice the multibiometric model in the paper, section(4) discuss the proposed system called Iris and Signature Multibiometric System(ISMS), and algorithms for authentication ,section (5) performance evaluation for (ISMS) system is explained and finally section(6) are conclusion and future work.

II. RELATED WORK

Many researches for person verification using multi biometric with decision fusion traits are done; table (1) summarized most important researches

Researcher	Year	Multibiometrictraits	Algorithm
Arun R., et al	2004	Information fusion in biometrics	The research used score level fusion multibiometrics system by combining three traits(face, fingerprint and hand geometry) are presented, using compare for the feature extraction in each single traits [4]
KrawczykS.	2005	User Authentication Using On-line Signature and Speech	Signature verified using thedynamicprogramming technique of string matching. Voice is verified using a commercial, off the shelf, software development kit. In order to improve the authentication performance, theresearch combines information from both on-line signature and voice biometrics. fusion is performed at the matching score level[7]
Rajiv.J, et al	2006	Multimodal Biometric using Face, Iris, Palmprint and Signature Features	Multimodal biometric system of iris, palm print, face and signature based on wavelet packet analysis is described. The fused image is thenextracted by using Inverse Discrete WaveletPacket transform[8]
Connaughton K., et al	2007	Fusion of Face and Iris Biometrics	The multi-biometrics system exploits the face information , a sensor that is intended for iris recognition purposes, with no modifications to the sensor and no increase in probe data acquisition time. The resulting system is less likely to experience failures to acquire, and the use of multiple modalities could allow the system to identify subjects with incomplete gallery data. This approach could be extended to operate on other stand-off iris sensors, which often detect the face as a preliminary step to iris image acquisition [9].
Kumar, A, et al.	2008	Fusion of Hand Based Biometrics using Particle Swarm optimization	The researchers applied palmprint and hand geometry over other biometric modalities. It implementedparticle swarm based optimization technique for selecting optimal parameters through decision level fusion of two modalities: palmprint and hand geometry [10].
KarthikN.r, et al	2009	Fusion in Multibiometric Identification Systems	This research applied likelihood ratio-based score fusion and Bayesian approach for consolidating ranks and a hybrid scheme that utilizes both ranks and scores to perform fusion in identification systems[11].
Giot R., et al	2010	Fast Learning For Multibiometrics Systems Using Genetic Algorithms	This research use algorithm to learn the parameters of differentmultibiometrics fusion functions. It interested in biometric systems usable on any computer (they do not require specific material). In order to improve the speed of the learning, we defined a fitness function based on a fast ERR, FAR and GAR also, the search calculate the time that required to recognition the person [12].
Vanaja R. E. , at el	2011	Iris Biometric Recognition for Person Identification in Security Systems	This research applied another project in biometrics, It used multibiometrics for security. Security systems having realized the value of biometrics for two basic purposes: to identify users. It focuses on an efficient methodology foridentification and verification for iris detection. [13]
Maya V. , et al	2013	Multimodal Biometrics at Feature Level Fusion using Texture Features	It presents a feature level fusion algorithm based on texture features. The system combines fingerprint, face and off-line signature. Texture features are extracted from Curvelet transform. The Curvelet feature dimension is selected based on d-prime number [14].

III. MODAL OF MULTIBIOMETRICS

To establish system for multibiometricsmodel most fused multiplebiometric data for a person's identity. It could be based on the one of following modalities:

a. **Multiplesamples:** used more than one sample for same physicals or behaviors trait. (e.g. fingerprints of the same finger – rolled or flat).
b. **Multiple instances:** used left and right for the samebody traits such as left and right retina.

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c. **Multiple sensors**: single biometric trait is imaged or captured using multiple sensors in order to extract diverse information.
d. **Multiple model**: used two or more different for body traits such as fingerprint, gait and DNA. In this research applied this type of multiple systems.
e. **Multi-algorithm systems**: In this type applied more algorithm fort the same traits.

Each of these modalities (see figure. 1) when used could pose various issues with regard to fusion of the multiple biometric data [15].In this paper a multiple model is applied by different traits (iris and off line signature).

Fusion issues at the time of enrolment, identification and verification of multimodal biometric data. The fusion method could be adopted the following

- **Fusion before matching**: combine information from multiple biometric sources can happen either at the sensor level or at the feature level.
- **Fusion after matching**: combine information after the classification/matcher stage can be further divided into three categories: fusion at the decision level, fusion at the rank level, and fusion at the match score level [16].

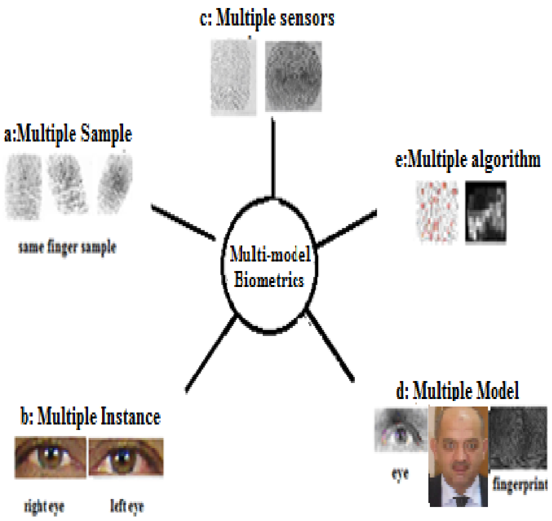

Fig (1): Multibiometrics modal [15]

In this paper decision fusion level comes into action when individual matcher presents its decisions based on its input patterns. The system applied fuse under three rules, first (AND rule) that the genuine when all matcher agree input sample with the template. Second, (OR rule) the system is genuine when only one matcher agree input sample with the template. Third, (Weighted Majority Voting) when the matchers used in a multibiometric system do not have similar recognition accuracy, it is reasonable to assign higher weights to the decisions made by the more accurate matchers. Fourth, Bayesian decision fusion relies on transforming the discrete decision labels output by the individual matchers into continuous probability values calculated according to the Bayes rule illustrate in equation 1[16].

$$p(w_j|u) = \frac{p(u|w_j)p(w_j)}{p(u)} \dots\dots\dots\dots\dots\dots (1)$$

Where: j=0,1 ; *p(u)* probability of matcher; *p(u|w)*can be treated as an estimate of the prior probability of class; *p(w)* probability of all matcher testing .

IV. IRIS AND SIGNATURE MULTIBIOMETRICS SYSTEM (ISMS)

Iris and Signature Multibiometric SystemISMSapplied to authentication person used two phasesverification and identification .Both phases involve image captured for iris and signatureof person separately in data acquisition, pre-processing, feature extracted for eye invariant in contourlet transformation while the signature feature extracted using personal compound analysis (LDA), making decision using Ant colony optimization (ACO) and fusing at decision level as shown in figure 2.

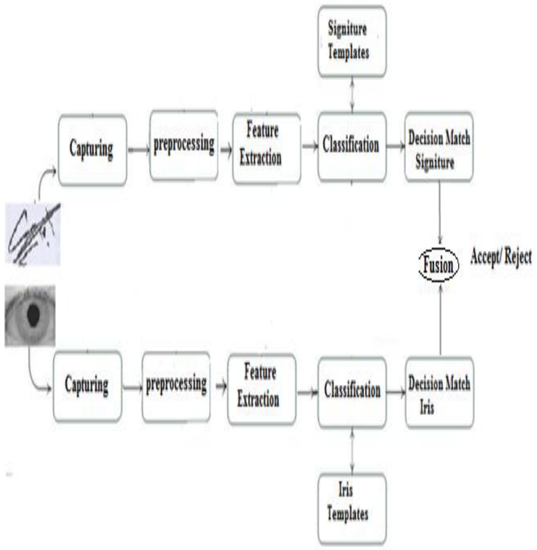

Fig (2): Iris and Signature MultibiometricsSystem (ISMS)

A. *Iris and Signature database*

A multi biometrics system needed database including samples for iris and signature, andit isnecessary to test theperformance of the proposed system. There is no standard database generously available tomeet the requirement of thealgorithm that lead to create database. The database is collected fromforty persons. Each person has seven images for eyes (four to train and three to test) and signed seven signatures also (four to train and three to test). Collection of these uni-modal traits are described below.

- Data acquisition: This step gathered all eyes images for the persons in system and stores them in database using digital cameratype (I SCAN 2), see figure 3.
- Off line signature can captured by scanned a signature on white paper and using an 8-bit, 300dpi resolution scanner and store the sample in separate data base.

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Fig (3): I-SCAN 2 cameras

B.Preprocessing

The purpose of the pre-processing is to reduce or eliminate some of the image variations for the illumination of the image, the preprocessing step divided into two phase one for iris and the other for signature preprocessing :

Iris an excellent recognition performance when used as a biometric. Iris patterns are supposed to be unique due to the complexity of the underlying the environmental and genetic processes. Segmenting area is a challenging task since the Eye image can be occluded by eyelids or eyelashes. This will cause a significant difference between the intra- and inter-class comparisons. The major modules of preprocessing are explained in the following steps, see figure 4:

- Localizing the iris area between the inner (pupillary) and outer (limbic) boundaries, with prior assumption that each border is either circular or elliptical. This process also obliges detection and removing any specular reflection, eyelash or eyelids noise from the image prior to segmentation.
- Data enhancement for iris to remove all the noise in imagesusing medium filterwhich is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges [16].
- Image cropping step to determine the part that used to classification applying Hough transform, see appendix (A) [17] that detect circle and crop the iris boundary .

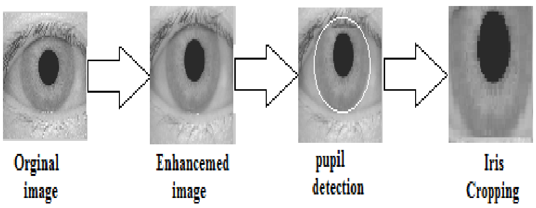

Fig (4): Iris preprocessing phase

To preprocessing the signature do the following steps:

- Enhanced the signatures using median filter to remove some noise compound like background noise pixels, the filter reducing the amount of intensity variation between neighboring pixels. The average filter works by moving through the image pixel by pixel, replacing each value with the average value of neighboring pixels, illustrate in equation(2)[18].

$$I_{new(x,y)} = \sum_{j=1}^{n} \sum_{i=1}^{m} l_{i,j} * I_{old(x+i,y+j)} \dots\dots\dots\dots (2)$$

- Normalize the size of image 128*256 to avoid inter-personal and intra-personal size variations of signatures samples.
- Sobel filter is applied to detect the edges of signature. The weights of kernels apply to pixels in the 3 × 3 region are depicted below [19]

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} \qquad G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

To detect the edges for signature applied Sobel filter, figure 5 shown a signature preprocessing phase:

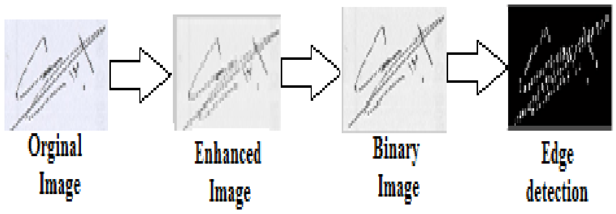

Fig (5) signature preprocessing phase

C. Feature Extraction

The discriminative power of the features in the reference set plays a major role in the entire process. The eye has fascinating texture information. Therefore, it is attractive to search representation methods which can capture the local crucial information in eyes image. There have been many techniques suggested in the literature for extracting unique and invariant features from image. In this papercontourlet used to extract local crucial information. Contourletis discrete transform, can efficiently handle the intrinsic geometrical structure containing contours. It more a flexible multiresolution and directional decomposition by allowing different number of directions at each scale with flexible aspect ratio is offered. Contourlet transform uses a structure similar to that of wavelet. Figure6 shows a double filter bank structure comprising the Laplacian pyramid capturing the point discontinuities followed by a directional filter bank to link point discontinuities into linear structure. The contourlet transform satisfies the anisotropy scaling relation for curves by doubling the number of directions at every finer scale of the pyramid. The reconstruction is perfect, almost critically sampled with a small redundancy factor of up to 4 [20].

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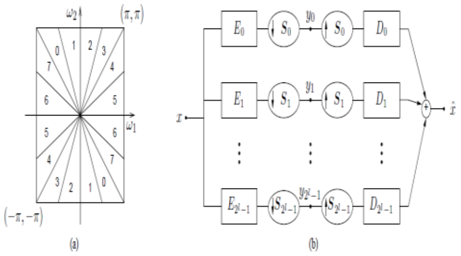

Fig (6): The contourlettransform datagram [20]

Since the contourlet transform has used to extract features to recognize images. In a 3 level decomposition, 16 sub bands are generated. The large number of coefficients generated from this need not be involved in the classification step to reduce the computation time. I n this paper, feature dimension is reduced by calculating energy features from each subband. As shown in figure 7.

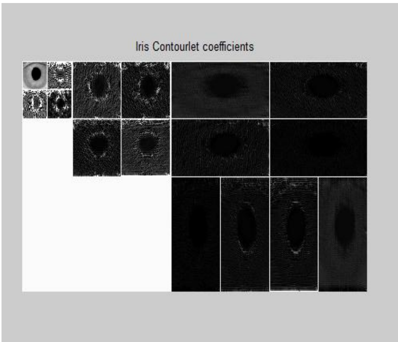

Fig (7) composed the iris in contourlet transform

To extract the feature for signature Linear Discriminant Analysis (LDA) is used the result is represented by two sets are shown below:

$$set1 = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \\ \cdots & \cdots \\ \cdots & \cdots \\ a_{m1} & a_{m2} \end{bmatrix} \qquad set2 = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \\ \cdots & \cdots \\ \cdots & \cdots \\ b_{m1} & b_{m2} \end{bmatrix}$$

After that compute the mean of each data set(µ1) and mean of entire data set(µ2), which is obtained by merging set 1 and set 2, is given by Equation(3):

$$\mu_3 = p_1 * \mu_1 + p_2 * \mu_2 \ldots\ldots\ldots\ldots\ldots(3)$$

*

Where: $p_1$and $p_2$are the apriori probabilities of the classes.

The probability factor is assumed to be 0.5.

In LDA, Thescatter measures are computed using Equations4and 5, within class scatter is the expected covariance of each of the classes [21].

$$S_w = \sum_i p_j * (cov_j) \ldots\ldots\ldots\ldots(4)$$

Where:*cov*is covariance of sets

Therefore, to calculate summation for the two-class problem, *p*=0.5

$$S_w = 0.5 * cov_1 + 0.5 * cov_2 \ldots\ldots\ldots\ldots\ldots(5)$$

Covariance matrix is computed using the following equation.

$$cov_j = (x_j - \mu_j)(x_j - \mu_j)^T \ldots\ldots\ldots\ldots\ldots(6)$$

The between-class scatter is computes using the following equation [20]

$$S_b = \sum_j (\mu_j - \mu_3) * (\mu_j - \mu_3)^T \ldots\ldots\ldots\ldots\ldots(7)$$

S_b: the covariance of data set whose members are the mean vectors for each class.

The optimizing criterion in LDA is the ratio of between-class scatter to the within-class scatter. The solution obtained by maximizing this criterion defines the axes of the transformed space. However for the class dependent transform the optimizing criterion is computed using equation (8)

$$criterion = inv(S_w) * S_b \ldots\ldots\ldots\ldots\ldots(8)$$

When apply the LDA on the signature invariant subspace of the vector space in which the transformation is applied. A set of these eigen vectors whose corresponding eigen values are non-zero are all linearly independent and are invariant under the transformation the following:

[1.9374 1.0652 0.17810.1467 0.0500 0.0329 0.0250 0.0167 0.013 7 0.0097 0.0064 0.0040 0.0035 0.0030
0.0025 0.0021 0.0014 0.00090.0006 0.0005 0.0004 0.0003 0.0002 0.0002 0.0001 0.0001 0.0001]

D. Classification

The system relays on the classification operation for granting the authentication operation. The "one to many" matching isused to match the person with all persons that enroll in the database. Ant colony optimization (ACO) was used as a metric for measure the similarity between the test image and the reference image in the gallery. Ant colony optimization one of artificial intelligence for solving complex optimization problem. It based on the study of collective behavior in decentralized and self-organized systems. The idea comes from systems found in nature, including ant colonies, bird flocking and animal herding that can be effectively applied to computationally intelligent system. It used for clustering the feature extraction that used in last step and find the centroid for each cluster to matching.The ACO approach attempts to solve anoptimization problem by iterating the following two steps:

• Candidate solutions are constructed using a pheromone model, that is, a parameterized probability distribution over the solution space;

• The candidate solutions are used to modify the pheromone values in a way that is deemed to bias future sampling toward high quality solutions.

E. ACO algorithm [10]

a. Choose a number of clusters k
b. Initialize cluster centers $\mu_1 \ldots \mu_k$ based on mode.
c. For each data point, compute the cluster center it is closest to (using some distance measure) and assign the data point to this cluster.
d. Re-compute cluster centers (mean of data points in cluster)
e. Stop when there are no new re-assignments.
f. Ant based refinement
i. Input the clusters from improved k-means.
ii. For i = 1 to N do
  a. Let the ant go for a random walk to pick an item
  b. Calculate the pick and drop probability
  c. Decide to drop the item.
  d. Re-calculate the entropy value to check whether the quality is improving or not.
iii. Repeat

To authentication the system consists of two classes recognition assignment, where the sample is classified either genuine or not. The result with predefined allies between two values for threshold (minimum, maximum threshold) and classifies the claimer. The system accepts the claimer if and only if the value less than or equal the maximum threshold and greater than minimum threshold. ID is validated and matched with one of the images stored in the database. The different biometrics systems can be integrated at multi-classifier and multi-modality level to improve the performance of the verification system. However, it can be thought as a conventional fusion problem i.e. can be thought to combine evidence provided by different biometrics to improve the overall decision accuracy. Let M_{eye} and Msign denote the decision of the eye and signature respectively. The parallel can be obtained after training each classifier independency to take the final decision of the individual classifiers in order to find M_{eye}, M_{sign} the estimated by equation (9)

$$M = (M_{eye} \; // M_{sign}) \ldots\ldots\ldots \ldots(9)$$

Where // mean combine rule.

The summarized of the algorithm applied in this research

Step 1: Read and normalize the images to become more suitable for processing, and crop these images to remove unused part of image.

Step 2: Extractv the feature for all eyes images using contourlet transform, while the signature used LDA transformation on the extract images.

Step 3: Extract the global features from iris and signature to obtain eigenvalues.

Step 4: Apply ACO to the values those obtain in step 2 to obtain the optimized values for irises and signatures separately.

Step 5: Apply the ACO clustering to centroid of each cluster and save it with ID number.

Step 6: verify the image choosing any ID number belong any person in database set and train it in the same method.

Step 7: compare the output for matching with dataset of step five, and then decide if accepted or rejected

Step 8: Fuse the decision for step 7 and then apply weighed Majority voting for acceptable or rejection.

Step 9: Return step 8, apply AND rule and OR rule for acceptance or rejection

V. PERFORMANCE EVALUATION

In this paper is performed in order to evaluate the performance used the following measurements [16]:

- The false rejection rate (FRR): is the probability that an authorized individual is inappropriate rejected.
- FalseAcceptance Rate (FAR): which represents the ratio of impostors accepted by the system?
- Equal Error Rate (EER): It is the value is the rate when FAR equals the FRR of the biometric system.Common threshold used to evaluate the performance.
- Genuine Accept Rate (GAR): It is measured as the fraction of genuine score exceeding the predefined threshold
- Recognition Rate (RR): The estimation of recognition rates (or error rates) for a classifier [1]. This inside-test result is usually overly optimistically since all data is used for training and the test is also based on the same data [6].

Table (2) is shown the result for the system for decision level fusion.

Table (2): Measurement of decision fusion with hybrid technique

Decision rule	GAR (%)	FAR (%)	FFR (%)	RR (%)
AND rule	96	4	0	95
OR rule	99	1	5	96
Weighted Majority Voting	98	2	4	94
Bayesian decision fusion	96	4	4	93

As seen in table (2) the OR rule is best for genuine accept rate because it accepted only one true of traits , while the AND rule is best for false rejected rate because it measured all traits is accepted. Also note that for recognition rate, OR rule is best and Bayesian decision fusion is worst one. Figure (8) illustrate the performance measurement to the decision level type

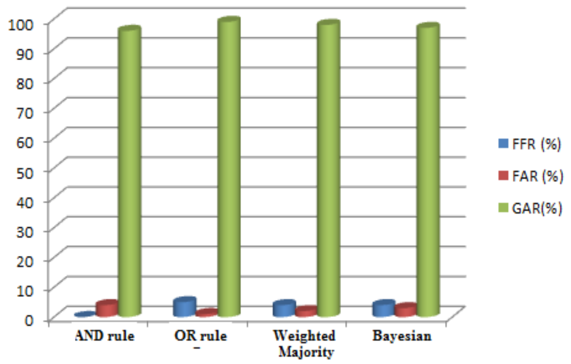

Fig (8): illustrate the measurement's rules

VI. CONCLUSION

The outline for this paper applied multibiometric system with multi-mode applied decision level fusion with three rules (AND, OR, weightedMajority voting and Bayesian decision). The authors have presented a novel approach in which multiple modes (signature and iris) were processed withcontourlet and LCD transform to obtain comparable features and classified with technique applied ant colony optimization (ACO) to classification. The reported experimental results have a remarkable improvement in the accuracy level achieved from the proper fusion of decision sets the AND rule is lease value from GAR but it is best values from FRR that not allow any impostor to entire system otherwise the OR rule is greater value form GAR while FRR is worse one. GAR in weighed majority voting rule and in between best AND rule and OR rules. FRR in weighted majority voting best than OR rule lease than AND rules. The recognition rate values from OR rules best from values of (99%).also the Bayesian fusion is equation AND rule in GAR and FAR values,while it less than AND rule from measured the FRR which allow more imposters in system. It is also noted thatenable fusing information fromtwo independent/ uncorrelated traits (signature and iris) at the decision level fusion

REFERENCES

[1] Anil K. Jain and Arun R." Multimodal Biometrics an Overview". Appeared in Proc. of 12th European Signal Processing Conference (EUSIPCO), (Vienna, Austria), pp. 1221-1224, 2004.

[2] Tran Binh L. and Le Hoang T."Multi-Biometric Person Authentication System "Proceedings of the World Congress on Engineering and Computer Science Vol I WCECS 2012, October 24-26, 2012, San Francisco, USA, 2012.

[3] Singhal R.and Jain P." Multi-Biometric Systems: Secure Security Systems" IJREAS, Volume 2, Issue 2, ISSN: 2249-3905, 2012.

[4] G. L. Marcialis and F. Roli, "Experimental results on fusion of multiple fingerprint matchers," in Proc. of 4th Int'l Conf. on Audio and Video-based Biometric Person Authentication (AVBPA), (Guildford, UK), pp. 814–820,2003.

[5] WaghmareL.M. NaroteS. P. and Narote A.S."Biometric Personal Identification Using IRIS‖", Proceedings of International Conference on Systemic", Cybernetics and Informatics, ICSCI -, Pentagram Research Centre Hyderabad, pp. 679-682, 2006.

[6] LejtmanD. and GeorgeS."On-line Handwritten Signature Verification Using Wavelets and Back-Propagation Neural Networks "Proceedings of the 6th International Conference on Document Analysis and Recognition, pp.596-598, 2001.

[7] Krawczyk S."User Authentication Using On-Line Signature and Speech", Mc.S thesis, Department of Computer Science and Engineering, Michigan State University, 2005.

[8] Rajiv.J, Suresh.S. and Ranjith. P.K. "Multimodal Biometric using Face, Iris, Palm print and Signature Features",share.pdfonline.com.ICACIT2013_TEMPLAT E.htm, 2006.

[9] ConnaughtonK.W. R. and Flynn P." Fusion of Face and Iris Biometrics" University of Notre Dame, IN 46637, 2007. e-mail: rconnaug,kwb,flynn@nd.edu

[10] Kumar, A.; Hanmandlu, M.; Sanghvi, H. and Gupta, H.M. "Decision level biometric fusion using Ant Colony Optimization", Image Processing (ICIP), IEEE International Conference on, on page(s): 3105 – 3108, 2010.

[11] Karthik Nandakumar1, Anil K. Jain and Arun R." Fusion in Multibiometrics Identification Systems: What about the Missing Data?" Proc. of ICB, Alghero, 2009.

[12] Giot, R, and Rosenberger, C."Fast learning for multibiometrics systems using genetic algorithms", High Performance Computing and Simulation (HPCS), International Conference on Caen, France,2010.

[13] VanajaR.E., Dr.L.M. and Waghmare, E.R.Ch." Iris Biometric Recognition for Person Identification in Security Systems" International Journal of Computer Applications (0975 – 8887) Volume 24– No.9, 2011.

[14] Maya V. K. and Sethu S., " Multimodal Biometrics at Feature Level Fusion using Texture Features", International Journal of Biometrics and Bioinformatics (IJBB), Volume (7), 2013.

[15] NandakumarK.,"Multibiometric Systems: Fusion Strategies and Template Security" Mc.S thesis Submitted to Michigan State University, Department of Computer Science and Engineering,2008.

[16] Poh N. and Bengio N." How Do Correlation and Variance of Base-Experts Affect Fusion in Biometric Authentication Tasks? " . IEEE Transactions on Signal Processing, 53(11):4384– 4396, 2005.

[17] Simon J."Circular Hough Transform "Kjeldgaard Pedersen Aalborg University, Vision, Graphics, and Interactive Systems, 2007.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 11, May 2014

[18] Chaunssot J." Filter with Progressively Decimated Filtering Windiw: Application to Color, Image Enhancement "IEEE vol7803-8554, 2004.

[19] MaiF., HungY.,ZhongH., and SzeW." A hierarchical approach for fast and robust ellipse extraction. Pattern Recognition", 41(8):2512–2524, 2008.

[20] LuY. and DoM. N. "RISP-contourlet: a critically sampled directional multiresolution image representation," in Proc. SPIE Conf. on Wavelet Applications in Signal and Image Processing, San Diego, 2003.

[21] Zhu Jie, **"**Implementation of Modified KL Transform for LPR Systems" European Journal of Scientific Research ISSN 1450-216X Vol.67 No.4 (2012), pp. 521-531, Euro Journals Publishing, Inc. 2011.http://www.europeanjournalofscientificresearch.com

Appendix A

Hough transform algorithm for circle detection

1. Any circle in xy-plane is given by the circle equation

$$(x-a)^2+(y-b)^2=c^2$$

Use a 3-dimensioal accumulated array with indexes x_c,y_c,r

(Length in each direction depends on resolution you choose)

2. For i=1,..N
{For each possible (x_c,y_c) find r using equation

$$x_c = x_i - r\cos\theta_i ------(A1)$$
$$y_c = y_i - r\sin\theta_i ------(A2)$$

3. Increment the cell (x_c,y_c,r) once.

The cell (x_c',y_c',r') with the highest score in the accumulated array after all edges are handled is the result.

x_c',y_c' is the center,

r'=radius of the circle.