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Multi-wavelet based Feature Extraction Algorithm for Iris Recognition

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Abstract*— In today's world, the highly stable and distinct biometric characteristics to identify and/or to verify any person are the human iris. It got attention from the researcher in recent years. Iris biometry is used to recognize any individual in a natural and intuitive way. The success of iris recognition system depends on the basic two factors: image acquisition and iris recognition algorithm. Multi-wavelet is extremely effective to analyze mutational signals and singular signals. It selects spatial directions and the energy is basically concentrated in low frequency section. In this paper, we propose a system which aims to find out most efficient multi-wavelet family and its coefficients for encoding the iris template of experiment samples. This algorithm performs segmentation, normalization, feature encoding and matching. By using GHM, DD2, and IGHM Multiwavelet families, the feature encoding is performed by decomposing the normalized iris image. The feature vectors are stored into the database and the performance of the system is evaluated. The experimental data indicate that this system achieves higher recognition efficiency and stronger robustness.

***Index Terms*— Iris Localization, Iris Recognition, Normalization, Multiwavelet, Wavelet.**

I. INTRODUCTION

Iris recognition has been a popular area of research to avoid computer-based frauds and thefts which are very common now a day. It plays a very important role in identifying and verifying a person automatically from the given database [2]. Among all the biometrics reported such as finger print, palm print, retina, face, vein, signature, voice, gait etc., iris is the unique organ in human being. Iris recognition offers the highest accuracy in identifying individuals of any method available. This is only because no two irises are alike- not between the identical twins, or even between the left and right eye of the same person. Unlike other identifying characteristics that can change with age, the pattern of one's iris is fully formed by ten months of age and remains stable throughout their life-time [1]. Iris recognition relies on unique patterns of the human iris to identify or verify an individual which remains stable throughout life. Thus iris recognition has received extensive attention and is reputed to be most reliable and accurate person identification system in last decade [3] [4].

An iris has various features such as pigment frill, collarette, crypts, concentric area etc. This is shown in figure 1.

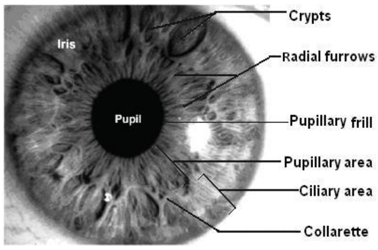

Fig.1: Structure of Iris [Source: [5]]

This paper consists of six sections. Section II describes the literature survey. Section III explains iris localization and normalization. Section IV depicts feature extraction and section V explains classification. Section VI shows experimental results and Section VII shows conclusion and future work respectively.

II. RELATED LITERATURE

Different methods have been proposed for iris image feature extraction, iris recognition and for improving the recognition rate. K. Masood et al (2007) [6] has extracted iris image features by using 2D Haar, Symlet, Bi-orthogonal and Mexican hat at level 1 and calculated average absolute matching difference for iris recognition on MMU database. Yongjun et al (2011) [7] has used DB4 wavelet on ACTA AUTOMATA database. And they had specified that the reconstruction is similar to the original iris image. But there is an error in numeric precision. R. Sundaran et al (2011) [8] used 2D Haar wavelet for feature extraction and various statistical features such as energy, contrast, variance, co-relation etc on UBIRIS database and has achieved good results. Lin et al (2009) [9] used Marr wavelet transform for feature extraction with very good recognition rate but time complexity is not superior in this algorithm. Guesmi et al [10] used Curvelet transform on CASIA 1 database and achieved higher iris recognition rate. Arivazhagun et al (2011) [11] proposed Ridgelet transform on CASIA 3 (interval) and achieved good recognition rate.

In general, the process of iris recognition system consists of image acquisition, preprocessing the iris image which includes localization, normalization and polar transformations, feature extractions and iris matching; this is depicted in figure 2.

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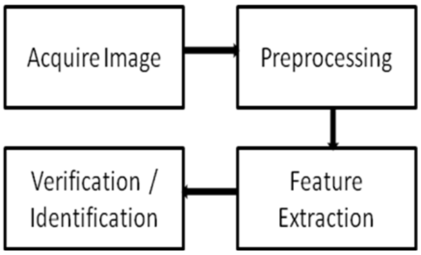

Fig.2: Iris Recognition System

III. NORMALIZATION

In this work CASIA V 1 database and KVKIris Database is used for testing and result generation. CASIA V 1 [12] has 756 images of 108 subjects at resolution of 380 X 230, out of which only 13 classes were used as training and testing dataset. Similarly from KVKIris database having about 1760 images of 88 subjects from which only 5 classes were used for training and testing to prove our results.

From the above depicted databases, the outer and inner boundary of iris is selected by using Daugman's integro-differential operator [1], [3], [14]-[17] and our localization technique [18] named KKLOCAL. Both databases support gray scale iris images. That is why extra colour processing is not required. Some of the images were not localized correctly from CASIA databases; these are shown in figure 3. The classification is not done on these un-localized classes.

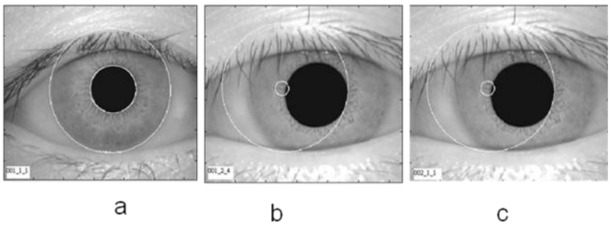

Fig. 3: (a) Localized (b, c) Not Localized Iris Image [12]

IV. FEATURE EXTRACTION

A. *Wavelet Transform*

For good identification system better feature vector is needed. This makes a classifier simple and fast. This also improves the process of feature extraction. Wavelet analysis allows researcher to isolate and manipulate specific patterns in any image. Wavelets are based upon spatial and spectral domains. They indicate location of the edges in an image with sharp variation and edge points. Wavelet transform is used to detect singularities of image and extract features from the iris image [20]. Wavelet decomposition provides a very good approximation of images and natural settings for the multi-level analysis. It's application is extremely fast and simple. It uses less computation time [19].

The different wavelets such as Haar, Db2, Sym4, Coif 1 and Bior1.1 were used for the experimental work. Haar, Db2, Sym4 and coif1 are of wavelet type 1 that is orthogonal wavelets whereas Bior1.1 is of type 2 that is bi-orthogonal wavelet.

B. *Multi-wavelet Transform*

Symmetry, short supporting, orthogonal and high-order vanishing moments are very important characteristics in signal processing. Wavelet does not support all these characteristics. Multi-wavelet is constructed with more than one scaling function and mother wavelet and it has all the above characteristics.

GHM is a name of multi-wavelet which represents the name of three researchers namely Geronimo, Hardin and Messopust.

GHM is a single-level discrete 2-D multi-wavelet transform and it performs a single-level 2-D multi-wavelet decomposition with four multi-filters. GHM computes the approximation coefficients matrix LL and details coefficients matrices LH, HL, HH, obtained by a multi-wavelet decomposition of the input matrix and puts the result in [LL,LH;HL,HH]. LL, LH, HL, and HH will have the size NxN. The size of output is double that of input matrix which should be a square matrix of size N x N where N is power of 2. That is only because input is vectorized by a repeated row preprocessing.

The coefficients of GHM and initialized values are as follows:

$$H_0=\begin{bmatrix}\frac{3}{5\sqrt{2}} & \frac{4}{5}\\ -\frac{1}{20} & -\frac{3}{10\sqrt{2}}\end{bmatrix}\qquad H_1=\begin{bmatrix}\frac{3}{5\sqrt{2}} & 0\\ \frac{9}{20} & \frac{1}{\sqrt{2}}\end{bmatrix}$$

$$H_2=\begin{bmatrix}0 & 0\\ \frac{9}{20} & -\frac{3}{10\sqrt{2}}\end{bmatrix}\qquad H_3=\begin{bmatrix}0 & 0\\ -\frac{1}{20} & 0\end{bmatrix}$$

$$G_0=\begin{bmatrix}-\frac{1}{20} & -\frac{3}{10\sqrt{2}}\\ \frac{1}{10\sqrt{2}} & \frac{3}{10}\end{bmatrix}\qquad G_1=\begin{bmatrix}-\frac{9}{20} & \frac{1}{\sqrt{2}}\\ \frac{9}{10\sqrt{2}} & 0\end{bmatrix}$$

$$G_2=\begin{bmatrix}\frac{9}{20} & -\frac{3}{10\sqrt{2}}\\ \frac{9}{10\sqrt{2}} & -\frac{3}{10}\end{bmatrix}\qquad G_3=\begin{bmatrix}-\frac{1}{20} & 0\\ -\frac{1}{10\sqrt{2}} & 0\end{bmatrix}$$

We have used GHM multi-wavelets for our work [13]. GHM multi-wavelets are combined with above wavelets to get the better results. The CASIA and KVKIris images are segmented first and then normalized with rubber-sheet model of 64X64 matrixes. The output of GHM applied images of CASIA and KVKIris databases are shown in figure 4 and figure 5 respectively.

HH represents diagonal features. HL represents horizontal features. LH represents vertical features whereas LL represents the coefficients which can be further decomposed in the next level if needed. Otherwise it represents the approximation order.

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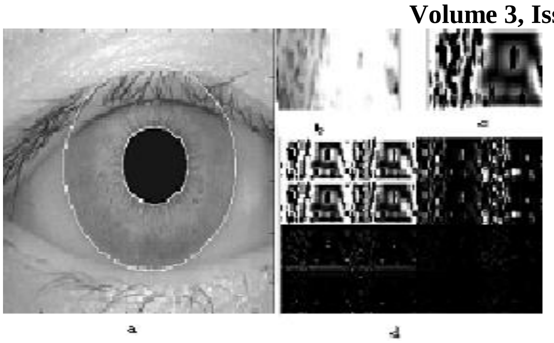

Fig. 4: CASIA 1 image (Daugman's method)

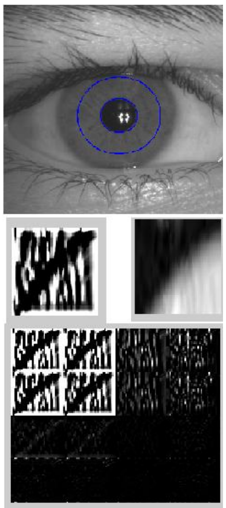

Fig. 5: GHM on KVKIris DB (KKLOCAL method)

V. CLASSIFICATION

The classification is done on the basis of Euclidean distance calculated on training and testing dataset of CASIA 1 and KVKIris database. The CASIA 1 has 756 iris images of 108 subjects at different illumination conditions. They are considered as subclass 1 and subclass 2. Similarly KVKIris database has 1000 iris images of 50 subjects, 10 of right eye and 10 images of left eye. The classification is on the basis of subclasses and left and right eye. Statistical features such as mean, variance, entropy and energy etc were used to encode the iris image. The combination of wavelet and multi-wavelet are also used to get the better results. Euclidean distance is a squared distance between two vectors and calculated between training and testing datasets.

VI. EXPERIMENTAL WORK AND RESULTS

The experiment is performed on CASIA 1 and KVKIris database with Matlab R2012a on core 2 Duo Processor. The GHM multi-wavelet is applied [13] on both of these databases. The different wavelets are applied on the result of GHM multi-wavelets separately such as Sym4, Coif1, Db2, Bior1.1 and Haar wavelet. Then we have applied Sym4 on the result of GHM+Sym4. The result is not so good so again we have applied Bior1.1 on the resultant matrix. The workflow of a system is as shown in figure 6.

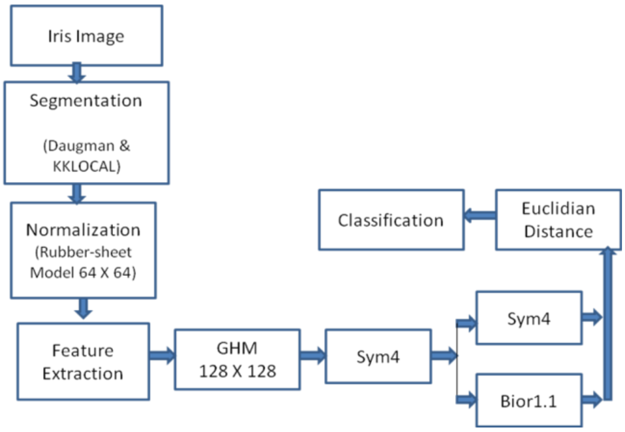

Fig.6: Workflow of Our System

The results are encouraging with this approach of GHM with sym4, sym4 and bior1.1. [see Table I].

Features	GHM (Daugman's method) (percentage)		GHM (KKLOCAL) (percentage)	
	CASIA1	KVKIris	CASIA1	KVKIris
Mean	19.23	-	21.15	-
Variance	21.15	-	25.00	-
Entropy	17.30	12.50	11.53	-
Sym4	17.30	25.00	05.75	37.50
Bior1.1	17.30	-	15.38	37.50
Coif1	15.38	25.00	09.61	37.50
Db2	25.00	25.00	07.69	37.50
Haar	17.30	12.50	15.39	37.50
Sym4 + Sym4	92.31	95.83	65.34	37.50
Sym4 +Bior1.1	Subclass 1 92.31 Subclass 2 92.31	75.00	Subclass 1 69.23 Subclass 2 92.31	Left Iris 50.00 Right Iris 37.50

Table I: Experimental Results

The hard threshold of 1 to 15 is applied on the distance scores to verify our results. The false rejection rate and false acceptance rate is given in percentages. [See Table II & Table III]

Euclidean Distance	**FAR**	**FRR**
1	0	0.13
2	0	0.13
3	0	0.12
4	0	0.08
5	**0.01**	**0.06**
6	0.02	0.03
7	**0.04**	**0.02**
8	0.05	0.02
9	0.09	0
10	0.16	0
11	0.29	0
12	0.4	0
13	0.49	0
14	0.64	0
15	0.75	0

Table II: Euclidean Distance, FAR, FRR of CASIA Subclass 1

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Euclidean Distance	FAR	FRR
1	0.000	1.000
2	0.000	0.994
3	0.000	0.981
4	0.000	0.981
5	0.006	0.948
6	0.058	0.897
7	0.103	0.845
8	0.148	0.787
9	0.194	0.742
10	0.265	0.671
11	0.284	0.652
12	**0.368**	**0.568**
13	0.406	0.523
14	0.465	0.465
15	0.548	0.381

Table III: Euclidean Distance, FAR, FRR of CASIA Subclass 2

The threshold values are applied on CASIA 1, subclass 1 and subclass 2. Only 13 subjects were considered for the ROC curve of the above FAR and FRR value. But this has to be validated for the larger dataset. From the ROC curve it has been observed that the EER i.e. equal error rate of the system is 0.368% at threshold 12 determines the accuracy of the system. The ROC curve is shown in figure 7 for subclass 1 and in figure 8 for subclass 2.

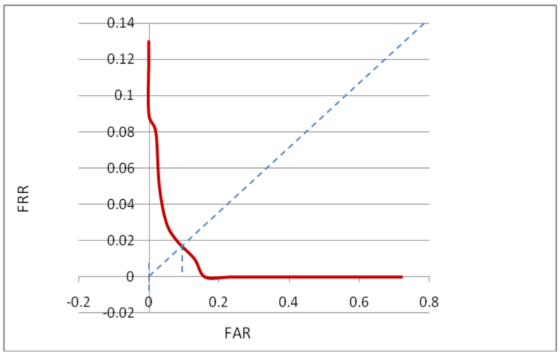

Fig. 7: ROC Curve of CASIA Subclass 1

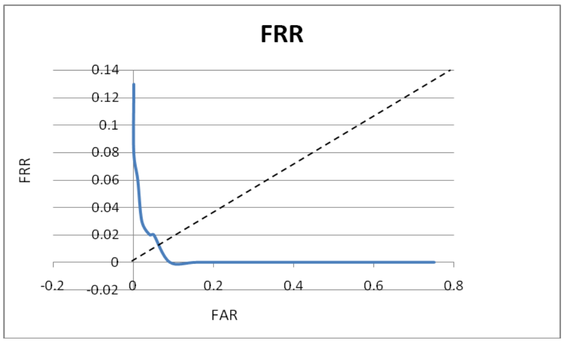

Fig. 8: ROC Curve of CASIA Subclass 2

The results were compared with the existing system and from the comparison it has been observed that our results are much better than the existing system. [see Table IV]

Recognition Methods	Database Name	CRR
Peng Zou et al [10]	-	44.51 %
Proposed Approach	CASIA 1	92.31 %
		92.31 %
	KVKIris	75.00 %

Table IV: Comparison od Proposed approach with Existing System

VII. CONCLUSION AND FUTURE WORK

This paper proposes a combination of wavelet and multi-wavelet for iris feature extraction. GHM multi-wavelet is first applied on an iris image and then various wavelets are applied on the resultant matrix. Finally a Euclidean distance has been calculated for the matching process.

From the above work we conclude that the combination of symlet4, symlet4 and bior1.1 on GHM multi-wavelet gives better results than individual wavelets applied on GHM. The proposed model gives the accuracy of about 92.31% for CASIA database and 75.00% for KVKIris database in which a Daugman' segmentation method was used to segment an iris. Similarly the accuracy of about 92.31% for CASIA subclass 2 and 50.00% with KVKIris database is achieved with KKLOCAL method. Our further research is on the way and more results will be presented in future with more vision and multiple databases. Our aim is to improve the recognition rate and use different combinations of wavelets and Multiwavelets.

APPENDIX

Table V is added in appendix to show the distance scores on CASIA database subclass 1 and Table VI shows the distance scores of CASIA database subclass 2.

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APPENDIX

	1	8	14	16	24	45	65	66	74	75	83	87	93		Minimum
1	4.23	11.06	11.94	11.89	15.16	14.97	15.82	20.85	12.13	15.95	19.35	24.23	24.37		4.23
8	11.65	2.72	15.88	14.70	17.51	14.79	17.01	20.01	13.45	18.77	22.01	25.20	25.45		2.72
14	20.28	22.48	9.84	15.91	24.97	24.09	18.51	19.82	18.46	21.22	24.31	27.27	25.54		9.84
16	13.62	10.26	8.93	9.74	18.32	14.73	12.19	14.25	11.04	15.98	20.00	23.38	22.82		8.93
24	21.24	23.20	23.91	23.23	9.82	18.21	21.24	28.38	23.08	23.16	22.40	26.29	25.48		9.82
45	12.54	12.73	16.58	12.13	6.63	5.81	10.23	18.93	12.76	12.89	14.94	20.89	21.06		5.81
65	15.14	15.99	15.87	9.13	13.88	7.65	6.53	17.07	13.05	8.54	13.06	20.82	20.88		6.53
66	17.15	16.99	13.99	11.16	20.19	15.67	10.45	7.59	8.44	11.24	13.12	15.54	15.38		7.59
74	12.50	13.39	12.79	10.23	17.87	14.23	11.12	9.99	3.55	8.87	10.54	13.55	13.81		3.55
75	13.92	16.06	14.31	9.39	16.95	12.51	8.50	10.76	6.08	5.16	7.47	13.32	13.79		5.16
83	18.37	20.37	19.76	14.12	18.46	13.98	11.51	14.92	12.13	5.86	5.06	12.90	13.69		5.06
87	21.86	23.04	22.03	19.31	21.24	19.59	16.74	13.37	12.94	12.80	7.12	3.84	4.73		3.84
93	26.04	26.99	25.31	23.95	25.51	24.73	21.67	16.08	17.11	17.84	12.13	4.30	3.52		3.52
			Total=13	classified=12		Misclassified=1		92.31							

Table V: Distance scores on CASIA database subclass 1 Daugman's method

	1	8	14	16	24	45	65	66	74	75	83	87	93		Minimum
1	3.66	4.12	12.03	11.79	13.42	16.50	15.72	22.29	11.76	16.70	20.02	26.89	22.41		3.66
8	8.76	6.56	12.06	11.01	12.10	16.10	12.52	21.14	10.00	16.99	19.05	26.43	21.50		6.56
14	11.21	10.78	5.31	9.13	13.62	15.93	9.46	18.20	7.91	14.97	17.15	25.06	18.93		5.31
16	15.36	14.35	14.60	11.66	13.52	8.38	9.01	18.84	9.40	10.33	15.54	25.56	19.84		8.38
24	15.86	15.11	16.30	15.15	8.19	11.48	10.93	22.39	11.39	14.32	15.50	25.63	19.46		8.19
45	19.42	18.88	19.38	15.67	14.68	5.03	13.40	20.50	13.87	9.38	15.51	25.43	19.76		5.03
65	19.54	18.17	13.51	11.78	16.55	16.73	6.17	14.60	9.26	14.20	13.65	21.25	15.40		6.17
66	27.04	25.99	21.40	16.32	26.48	24.66	16.95	6.83	17.20	16.79	13.76	10.52	10.97		6.83
74	14.57	14.01	10.65	8.48	13.13	13.28	5.03	14.13	4.30	9.60	10.53	19.45	13.58		4.30
75	19.28	19.42	18.01	13.73	16.16	10.48	12.63	15.79	11.86	3.52	8.93	18.15	13.54		3.52
83	21.55	21.16	18.09	14.19	17.08	17.84	11.85	12.82	11.88	10.80	3.55	10.49	6.11		3.55
87	29.59	29.18	26.12	21.65	27.20	27.87	22.18	15.18	21.51	19.78	13.61	3.20	10.14		3.20
93	22.36	21.76	17.33	13.93	17.52	18.67	12.49	11.35	12.88	12.45	6.71	10.11	2.76		2.76
			Total=13	classified=12		Misclassified=1		92.31							

Table VI: Distance scores on CASIA database subclass 2 Daugman's method