Evaluating IRIS Recognition Performance with DTC Wavelet Transform

Anupam chouksey [1], Anoop Chaturvedi [2] Vikas Sakalle [3]

1. Phd Scholar, Computer Science & Engineering, LNCTU Bhopal (M.P)
2. Professor, Computer Science & Engineering, LNCTU Bhopal (M.P)
3. Professor, Computer Science & Engineering, LNCTU Bhopal (M.P

Abstract The dual-tree complex wavelet transform (DTCWT), a subgroup of the discrete wavelet transform, generates complex coefficients using a dual tree of ripple filters to obtain the real and imaginary parts. It provides low redundancy (2 m:1 for m-dimensional signals) while ensuring quasi-shift invariance and directional selectivity, which classical wavelet transforms lack. DTCWT maintains the properties of efficient computing and balanced frequency responses, making it ideal for multidimensional signals such as images. Applications include denoising, sparse coding and registration. In this study, DTCWT is applied to iris recognition, which has higher accuracy than existing methods by combining the features of DTCWT with low-pass and high-pass filters, thereby achieving best detection based on FRR and FAR performance.

Index Terms—DTCWT ; Iris; Image Processing ; Recognition; MATLAB.

1. INTRODUCTION

A complete iris recognition system includes four steps: image capture, preprocessing (localization, normalization, and enhancement), feature extraction, and matching. Traditional systems operate in two stages: registration and authentication. During registration, images of the iris are captured and stored in a data set, often using infrared illumination for clarity. Iris localization identifies the region of the iris, modeling the boundaries as non-concentric circles – the inner (pupillary) and outer (limbic) boundaries. Noise sources, such as occlusion or reflection from the eyelid and eyelashes, are controlled during segmentation. Feature extraction converts the iris features into vector codes and a threshold is set for feature coding to ensure accuracy[1,2].

$$I_{x,y} = \{ 1, \quad If\ value \geq Thresold\ value$$
$$\{ 0, \quad \text{if otherwise} \quad (1)$$

In most set of rules, filters are applied to acquire data about the iris quality. Then the outcomes of the filters are converted into a stream of vector code [3]. The same matching level ccomputes the distance among iris codes and come up to a conclusion whether or not it is a fit or realizes the submitted iris from the subjects inside the data set based on decision threshold level as shown in equation 2.

$$Decision_{template} = \{ Accept, \quad If value \geq Decisionthresoldlevelvalue$$
$$\{\text{Reject}, \quad \text{if otherwise} \quad (2)$$

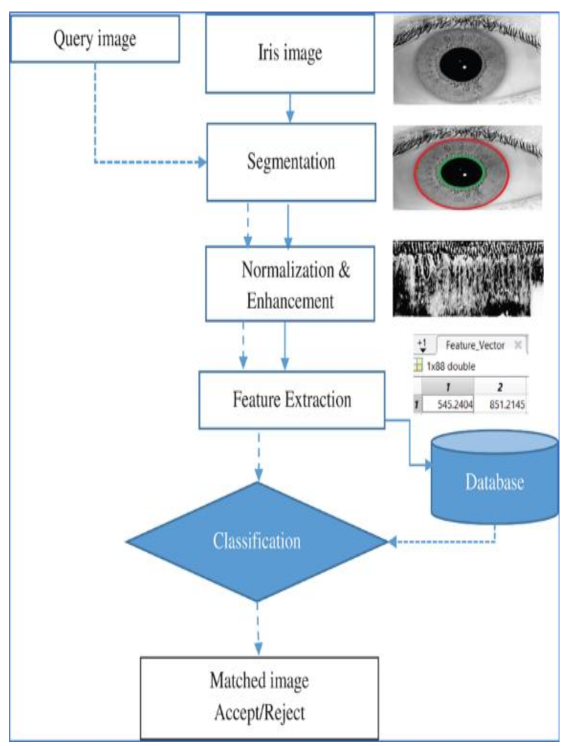

Fig.1 Iris Recognition System

2. PROBLEM IDENTIFICATION

Biometric systems offer significant advantages over traditional authentication methods, are user-friendly and ensure proximity to the user. Among them, iris recognition is one of the most reliable technologies as its unique and stable pattern remains unchanged throughout a person's lifetime. The iris, the circular septum between the cornea and lens, varies widely between individuals. Previous methods, such as Dougman's 2D Gabor filter, extracted the iris texture into a 256-byte code that was analyzed using Hamming distance. To address the limitations of the discrete wavelet transform (DWT), the complex wavelet transform (CWT) was introduced, which provides translation invariance, increased directional selectivity, and reduced redundancy. The Dual-Tree Complex Wavelet Transform (DT-CWT) further refines these features, making it ideal for image processing and iris recognition [4,5].

3. IRIS RECOGNITION

This segment is totally associated with the usage of the iris for biometric purposes. We begin via an overall explanation of the eye's anatomy followed by the identification of the most essential regions of the iris. Further, we preserve the identification of the most classical phases of common iris identification motives and explain the most relevant strategies to each of those phases.

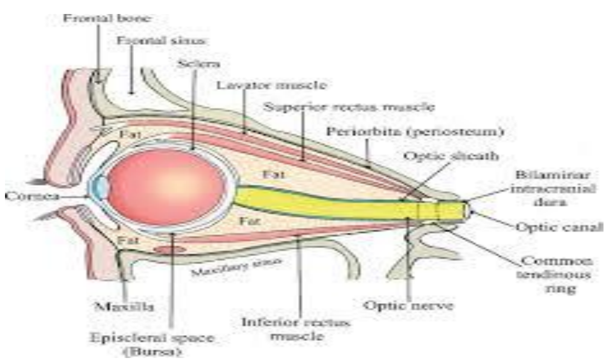

Fig. 2 Anatomy of human iris

Figure 3 shows the typical steps of an iris recognition system, following the general structure. The first step involves segmenting the iris, identifying the inner (pupil) and outer (sclera) boundaries, which are usually modeled as circles or ovals. To account for variations in pupil size and image capture distance, the Dogman method is typically used to convert the segmented region of the iris into a dimensionless polar coordinate system of fixed size [5,6].

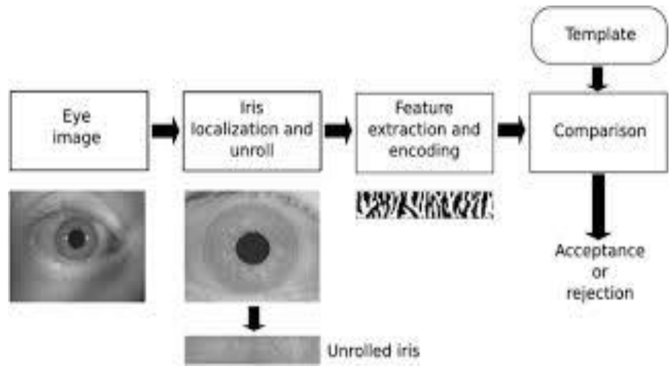

Fig. 3 Stages of Iris Recognition

4. DUAL TREE COMPLEX WAVELET TRANSFORMS

Shift invariance can be achieved using undirected binary filter trees, efficiently implemented via "Three Algorithm". However, this approach requires extensive calculations and produces redundant output, increasing processing costs. To solve these problems, a double-tree complex wavelet transform (DT-CWT) is introduced, which provides computational efficiency and improves the direction selectivity of multidimensional signals. Its main features include offset invariance, better directional filtering and low redundancy[7-8].

Approximate shift invariance;

• Right directional selectivity in 2-dimensions (2-D) with Gabor-like filters (also authentic for better dimensionality, m-D);

• Ideal reconstruction (PR) the usage of short linear-section filters;

• Confined redundancy, impartial of the wide variety of scales, 2 : 1 for 1-D (2m : 1for m-D);

• Efficient order-N computation—most effective two times the simple DWT for 1-D (2m instances for m-D).

Introduced a technique for shift invariance and directional selectivity based on Laplacian pyramids and steerable filters designed in the frequency domain. Originally proposed by Burt and Adelson, Laplacian pyramids offered limited redundancy (2:1 for 1-D and 1.33:1 for 2-D signals) and moderate shift invariance with narrowband low-pass filters[8-10]. Simoncelli's steerable filters enhanced directional

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 11 | Nov - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

selectivity in 2-D, increasing redundancy to 5.33:1.

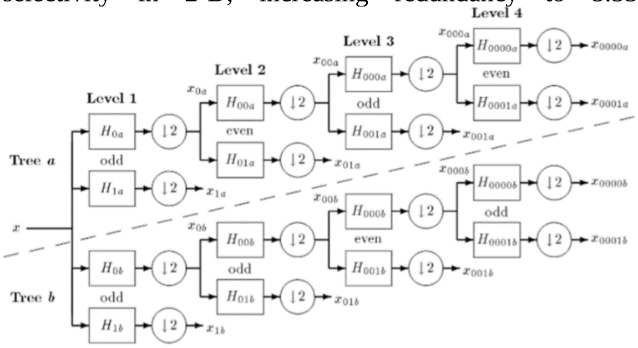

Fig. 4 The complex wavelet dual tree structure

Algorithm Iris Recognition Algorithm

Input: New Image (for Testing) or Database Image (for Training) **Output:** Recognition Result or Personal Information Displayed

Step 1: Pre-processing

- Input either a **new image** or **database image**.
- Perform **image preprocessing** to remove noise and standardize the input.

Step 2: Segmentation

- Segment the preprocessed image to isolate the region of interest (e.g., facial features, fingerprints).

Step 3: Normalization

- Normalize the segmented region for size, orientation, and lighting consistency.

Step 4: Enhancement

- Enhance the normalized image to improve clarity and feature visibility.

Step 5: Template Generation

- Generate a unique biometric template from the enhanced image.

Step 6: Feature Extraction

- Apply the Dual-Tree Complex Wavelet Transform and extract features to create a compact representation of the template.

Step 7: Feature Matching

- Compare the features from the **new image** (testing) against the features from the **database image** (training).

Step 8: Decision Making

- If a match is found: **Display Personal Information.**
- If no match is found: **Display Not Recognized** and terminate the process.

Step 9: Stop

- Stop the algorithm and output the result.

Fig.5 Flow chart of proposed model

5. RESULT AND DISCUSSION

In this section describes the result and discussion associated with feature extraction, comparison and selection in the classification of iris pictures. To defeat these problems associated with earlier strategies, DTCWT method that contribute for the recognition robustness and accuracy. The results obtained is then compared with other similar strategies based on FAR and FRR having threshold values [11-17].

Table 1-Actual datasets

Type of Colour data set	No. of images
Children	60
Young	90
Old	30
Men	40
Women	30
Left iris	25
Right iris	25

Table-2 Features for training database

S.No.	X_{CP}	Y_{CP}	R_P	X_{CL}	Y_{CL}	R_L	DTCWT feature Mean	DTCWT feature (SD)
1	127	93	11	132	94	88	120.7937	8.7981
2	137	152	34	142	157	88	119.4631	7.6204
3	147	152	9	142	156	62	148.0302	7.2092
4	110	137	10	115	134	62	89.6076	2.6442
5	126	188	7	130	188	65	151.7769	9.5038
6	126	88	12	125	92	71	110.2126	10.1274
7	150	108	33	150	103	89	59.8012	4.3515
8	146	159	16	141	155	62	147.6717	701669
9	130	184	7	130	188	65	151.5221	9.5326
10	121	154	32	117	152	69	149.2989	7.5103
11	121	149	10	119	153	64	110.9506	16.8020
12	134	128	12	139	132	70	77.5467	8.4069
13	139	111	29	143	114	69	139.8358	13.1769
14	120	139	39	121	135	99	90.1237	6.2830
15	113	101	25	115	100	71	129.6005	8.9126
16	130	126	7	130	126	63	115.7657	5.4859
17	102	156	33	106	159	63	220.9914	17.4093
18	133	130	47	138	125	94	107.5038	7.8901
19	89	105	15	86	110	66	102.5378	12.2651
20	163	123	21	165	126	65	129.1872	12.7071

Table 3 Testing table recognition and accuracy for 50 images

No.of data subject in training dataset	FAR	FRR	Accuracy(%)
50	0.00	0.004	99.8
100	0.00	0.006	99.7
150	0.00	0.0053	99.735
200	0.00	0.025	99.75

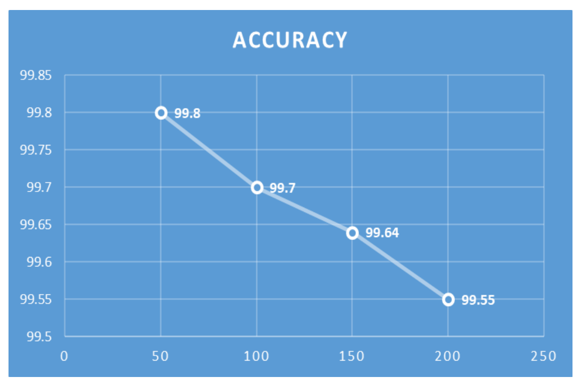

Fig 6-Overall accuracy by graph

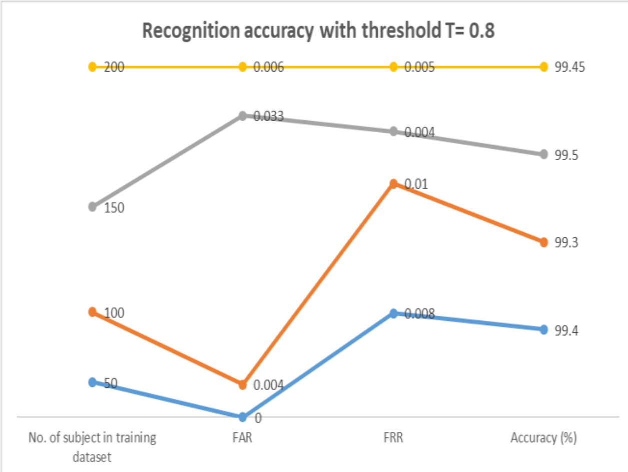

Fig 7- Recognition accuracy, FAR and FRR with threshold T= 0.8

In previous case discussed we have considerabaly reduce FRR with FAR remaining zero. To further reduce FRR. In this case we have used DT-DWT for feature extraction tempelet is generated and store rest parameter remaining same that is threshold is reduced from 0.4. In all three cases the performance parameter are evaluated the best accuracy is got when threshold T = 0.4 with FAR = 0.00.

Table 4 Recognition accuracy with DT-DWT feature extraction technique.

Testing for 50 images for 5 times	FAR	FRR
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.02

CONCLUSION

This paper proposes an innovative method for translation-invariant image retrieval using dual-tree discrete wavelet transform (DT-DWT) and dual-tree complex wavelet transform (DT-CWT) to evaluate the performance of content-based image processing systems. Retrieve. . The database used contains 100 images divided into 5 categories. Filter design challenges are addressed and a filter bank suitable for DT-CWT is proposed. The method utilizes FFT for efficient computation and uses a dual-tree filter bank when extracting features for classification tasks. The proposed technique improves iris recognition by incorporating improved DT-CWT texture extraction, effectively handling occlusions such as eyelashes and eyelids, even for partially visible iris areas.

REFERENCES

[1] A.M.,A Smart Framework for Enhancing Automated Teller Machines (ATMs) Fraud Prevention International Journal of Advanced Computer Science and Applications15,2,pp153-162,(2024), 10.14569/IJACSA.2024.0150217

[2] Thepade S.D.; Wagh L.R.,Iris Liveness Detection using Fusion of The pade SBTC and Triangle Thresh holding Features with Machine Learning Algorithms International Research Journal of Multidisciplinary Technovation6,1,pp128-139,(2024), 10.54392/irjmt24110

[3] Jan F.; Alrashed S.; Min-Allah N.,Iris segmentation for non-ideal Iris biometric systems Multimedia Tools and Applications83,5,pp15223-15251,(2024), 10.1007/s11042-021-11075-9

[4] Kakani V.; Jin C.-B.; Kim H.,Segmentation-based ID preserving iris synthesis using generative adversarial networks Multimedia Tools and Applications83,9,pp27589-27617,(2024), 10.1007/s11042-023-16508-1

[5] Liu Y.; Xu J.; Yee A.L.,The analysis of Iris image acquisition and real-time detection system using convolutional neural network Journal of Supercomputing80,4,pp4500-4532,(2024), 10.1007/s11227-023-05629-x

[6] Hattab A.; Behloul A.,A Robust Iris Recognition Approach Based on Transfer Learning International Journal of Computing and Digital Systems13,1,pp1065-1080,(2023), 10.12785/ijcds/130186

[7] Dang T.-V.; Tran H.-L.,A Secured, Multilevel Face Recognition based on Head Pose Estimation, MTCNN and Face Net Journal of Robotics and Control (JRC)4,4,pp431-437,(2023), 10.18196/jrc.v4i4.18780

[8] Bethu S.; Neelakantappa M.; Goud A.S.; Krishna B.H.; Rao M P.N.V.S.,An Approach for Person Detection along with Object Using Machine Learning Journal of Advances in Information Technology14,3,pp411-417,(2023), 10.12720/jait.14.3.411-417

[9] Balashanmugam T.; Sengottaiyan K.; Kulandairaj M.S.; Dang H.,An effective model for the iris regional characteristics and classification using deep learning alex network IET Image Processing17,1,pp227-238,(2023), 10.1049/ipr2.12630

[10] Minh H.T.; Van Hau B.; Hoang N.N.,An Integrated Two-Factor Authentication Scheme for Smart Communications and Control SystemsMendel29,2,pp181-190,(2023), 10.13164/mendel.2023.2.181

[11] Meenakshi K.; Maragatham G.,An Optimised Defensive Technique to Recognize Adversarial Iris Images Using Curve let Transform Intelligent

Automation and Soft Computing35,1,pp627-643,(2023), 10.32604/iasc.2023.026961

[12] Purohit H.; Dadhich M.; Ajmera P.K.,Analytical study on users' awareness and acceptability towards adoption of multimodal biometrics (MMB) mechanism in online transactions: a two-stage SEM-ANN approach Multimedia Tools and Applications82,9,pp14239-14263,(2023), 10.1007/s11042-022-13786-z

[13] Mohzary M.; Almalki K.J.; Choi B.-Y.; Song S.,Apple in My Eyes (AIME): Liveness Detection for Mobile Security Using Corneal Specular Reflections IEEE Internet of Things Journal10,4,pp3356-3367,(2023), 10.1109/JIOT.2022.3215916

[14] Zhou T.; Chen D.; Liu W.; Yang X.,Attacks and Improvement of Unlinkability of Biometric Template Protection Scheme Based on Bloom Filters IEEE Transactions on Cloud Computing11,3,pp3251-3261,(2023), 10.1109/TCC.2023.3276971

[15] Nalini M.K.; Preetha S.; Samanta S.; Tejaswini V.; Yashasvi M.,Iris Recognition Approach for Preserving Privacy in Cloud Computing International journal of online and biomedical engineering19,17,pp33-50,(2023), 10.3991/ijoe.v19i17.42635

[16] Ibrahim Y.I.; Sultan E.A.-J.,Iris recognition based on 2D Gabor filter International Journal of Electrical and Computer Engineering13,1,pp325-334,(2023), 10.11591/ijece.v13i1.pp325-334

[17] Sallam A.A.; Al Amery H.; Saeed A.Y.A.,Iris recognition system using deep learning techniques International Journal of Biometrics15,6,pp705-725,(2023), 10.1504/IJBM.2023.133959