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A New Feature Extraction Approach in Classification for Improving the Accuracy in Iris Recognition

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***Abstract*— Personal identity is becoming increasingly vital to meet the increasing security standards of today's business society. Iris recognition is one of the most accurate biometric technologies currently in use. Iris recognition is employed in high-security sectors due to its dependability and flawless identification rates. The steps of iris identification, comprising image preparation, extraction of features, and classifier creation, are described thoroughly in the primary portion of this research. The feature extraction stage is the most important in an iris identification system since it extracts the iris's distinctive feature. Several methods have been devised to extract the various characteristics that are unique to everyone. Modern iris identification systems frequently use Gabor filters to identify iris textural characteristics. However, in the application, it is necessary to identify the appropriate Gabor modules and to generate a pattern of iris Gabor characteristics. This research aims to provide a novel multi-channel Gabor filter and Wavelet filter for breaking down and extracting iris data from two different iris datasets. Because wavelet is the most scalable method of image processing, the research investigates using it to create a unique pattern for the iris recognition system. The MATLAB program is used to implement these ideas. CASIA and MMU are the datasets used for this purpose, and their comparative analysis is addressed in the research. To show how well the method performs, experimental results are given. We demonstrate through experiments that the suggested approach results in excellent iris identification performance.**

***Keywords*— Biometric iris recognition; preprocessing; normalization; segmentation; feature extraction; wavelet; gabor filter.**

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I. Introduction

The process of authenticating someone's or something's identity is known as authentication. It uses the information the authenticator provides to determine whether someone or anything is who or what they claim to be. In private and public computing systems, for example, the authentication procedure often involves someone (generally the user) logging on using a password issued by the system administrator. Some essential variables that play a critical role in authentication include that some people utilize their password, secret word, passphrase, and personal identification number for their authentication, which can be easily remembered by the user and authenticator. According to this research, a novel hand gesture authentication password is generated [1]. Instead, graphical passwords are now used for authentication, and researchers make these passwords from hybrid approaches, which provide better results in authentication [2]. Another factor for authentication is that some people use secure IDs, crypto cards, active cards, safe words, and so on instead of passwords. The second factor is biometric systems, which directly impact users. Other criteria for authentication exist, but they depend on users in some way, such as the user's physical or logical location, and the production of a key at a specified time [3].

Biometrics is the process of automatically identifying a person based on physiological or behavioral traits. It is a better option for modern information society has heightened security requirements than traditional identifying methods such as passwords and PINs [4]. As biometric sensors become more affordable and smaller, and as the public recognizes that biometrics is a viable technique for protecting privacy from fraud, this technology is anticipated to be used in practically every transaction that requires personal identification validation. The suggested solution is an affordable iris biometric-based ATM system using a microcontroller, an iris scanner, and a robust database. This prototype, which is appropriate for use in developing nations, is made to prevent ATM fraud [5] efficiently. The article emphasizes the distinctive characteristics and durability of the iris while introducing an iris recognition technology for biometric authentication. In addition to using edge detection and image registration to obtain features, the approach uses a principal component analysis-based method to recognize irises. According to experimental data, the technology considerably shortens computing times and improves accuracy [6]. Authentication and biometrics have emerged as viable components of information security. In identity management systems, biometric recognition provides a dependable solution to the problem of user authentication. With the expanding use of biometric systems in various applications, there is growing concern regarding biometric technology's security and privacy. The capacity of system designers to demonstrate that these systems are resilient, have low mistake rates, and are tamper-proof will determine the public adoption of biometrics technology. The study's goal is to include sophisticated recognition elements in iris authentication.

Iris recognition is a detection technique that employs an exclusive iris pattern based on a high-resolution image class. The iris has a distinct pattern detailed enough to be used as a biometric identification system [7]. The uniqueness of iris recognition is that the chances of two people having similar iris identification systems are as follows: iris picture acquisition, preprocessing (segmentation and normalization); feature extraction, and matching [8]. Fig. 1 depicts these four periods. The following sub-section will describe each of these phases using Fig. 1.

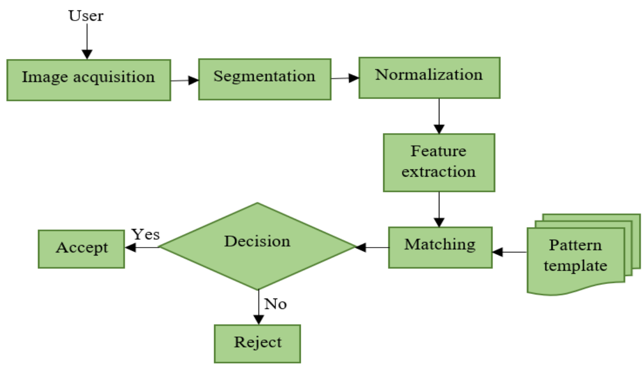


Fig. 1 Four phases of the Iris Recognition System [9]

A. Image Acquisition

This phase is carefully thought out as the first step in iris identification. At this level, a user must capture his or her iris image with a specific class using a powerful high-resolution camera. At this point, he or she must pay close attention so that the camera may record the complete iris portion [9].

B. Preprocessing (Segmentation)

The image must be precisely localized at this level to model an iris's inner and outer margins as a circle [10]. The two circles, however, are not always concentric. As a result, the iris was localized in two stages. The first stage is to approximate the iris region by projecting an image of the iris with a certain class in horizontal and vertical directions. The two circle parameters were produced in the second stage using the Hough transform and edge detection [11]. The segmentation methods include the localization operator, the Hough transform along a hybrid algorithm, the fuzzy clustering approach, and a canny edge detector.

C. Preprocessing (Normalization)

If the image is not appropriately improved, subsequent processes, such as feature extraction and matching, will not successfully extract significant features and improve recognition performance. The goal of the normalization stage is to improve low-contrast images. After successfully segmenting the iris areas, the segmented iris region converted to a fixed dimension. This technique normalizes iris areas to a fixed dimension to compare collected images to image databases [12]. Any discrepancy between iris class photos taken due to inadequate illumination and low contrast photographs is because this situation influences iris identification accuracy [7]. As a result, to attain improved accuracy, Daughman's [13] "Homogenous Rubber Sheet Model" compensates for the iris size mismatch.

D. Feature Extraction

After appropriately normalizing the iris region, the next step is to extract relevant information from the iris pattern, which may be extracted from the normalized iris image. The retrieved features have been encoded to be useful. The bands pass the decomposition of iris pictures used by a few iris identification systems [10]. Some feature extraction methods include the Wavelets Transform, Gabor Filter, Laplacian of Gaussian Filter, Key Local Variations of Hilbert Transform, and Discrete Cosine Transform. Human iris patterns and Gabor filters are used to examine human iris patterns and collect feature points from iris images [13]. Daubechies, bi-orthogonal, Haar, Mexican Hat, and other wavelets are frequently used [9]. The capacity to resolve space and frequency is the most significant advantage of the wavelet transform.

E. Matching

The result generated at the feature extraction step is used to measure the similarity of two irises at the matching stage. This stage compares the similarities and differences between the two codes to make an acceptance or rejection judgment. Serial algorithms are available for matching, but the Hamming Distance [7] is the most widely employed. Evaluation and testing are carried out using the False Acceptance Rate (FAR) and False Rejection Rate (FRR).

II. Materials and Methods

In order to improve the performance of iris recognition systems, an effective combination of feature extraction techniques is found through a binary genetic algorithm with a novel fitness criterion. Many filters and transformers that are often used to extract iris features are used in the proposed method. After several rounds of the suggested algorithm, the optimal combination of these methods is discovered. The final combination is made up of several wavelet transformations. The results using a single filter on the CASIA-v1 dataset demonstrate the experimental superiority of the performance [14]. In 2012, a researcher enhanced Daughman’s algorithm for iris authentication on the CASIA database. According to the enhanced version, the researcher reduced the dimensional inconsistencies between iris regions and normalized its region with the help of the Gabor filter [15]. In 2021, a novel approach to iris recognition by decomposition was put out. Initially, the steerable pyramid method and Gabor filter are used to segment, normalize, and deconstruct the iris image. The input image is subjected to a steerable pyramid to produce many sub-bands. The high-frequency sub-band is disregarded to reduce noise and improve CASIA-V4 accuracy. Improvements have also been made to the equal error, genuine, and false acceptance rates[16]. For securing of iris, the singular value decomposition method is integrated with discrete wavelet transform along the high strength of its system [17]. A novel iris recognition system was developed and tested over UBIRIS.v1 dataset. Gabor filter hybrid with discrete cosine transform method and that hybrid approach used to extract the features from iris due to feature vector requirements while grey level co-occurrence matrix is a statistical method that gives largest recognition accuracy [18]. The main goal of the principal component analysis in this system, which combines discrete wavelet transformation with sub-band coding to minimize computation time and resource requirements, is to lower the iris pattern's resolution for feature extraction in iris recognition. The proposed system operates efficiently, as supported by the experimental calculation [19].

The researchers present a multi-biometric framework based on score level (multi-algorithm) fusion that uses a bin-based classifier to improve recognition and decrease error rates. In this work, a bin-based classifier is a combination rule that merges the matching scores from two different modalities, the iris and the face. Then, the feature sets are combined, and the particle swarm optimization approach is used to reduce unnecessary information. The test results show that compared to previous fusion rules, the multi-biometric system performs better as a bin-based classifier using multi-algorithm score-level fusion [20].

The iris recognition uses an exclusive prototype based on the high-resolution image class for identification, and its accuracy strongly depends on a good quality image [21] [22] [23]. Preprocessing steps for the iris image class are hindered by low peculiarity and deprived illumination caused by light position. Therefore, the recognition accuracy only depends on the preprocessing steps. For instance, successful feature extraction cannot be achieved properly [24].

Iris image class with low contrast is a big defy for iris recognition as the acceptance or rejection rates of the verified user depend exclusively on the image quality. Consequently, this research investigates the problem of low-contrast iris image class preprocessing with feature extraction [25].

The feature extraction process based on preprocessing steps plays a vital role. The existing extraction of significant features from the iris image class addresses the problems of erosion and dilation with low intensity [26]. This piece of work has a negative effect on iris recognition accuracy, and the low contrast iris image class needs to be remunerated along with improvement. Based on the previously presented, this study looks for an effective approach to address the low contrast image class in preprocessing steps and, by this means for iris recognition, designing a new algorithm for extracting significant features with high contrast.

A. Methodology

To design a hybrid approach (WAVE-G) for feature extraction based on wavelet transform and Gabor filter to develop WAVE-G for getting optimal results of feature extraction level based on wavelet transform and Gabor filter. To evaluate the accuracy of the proposed approach based on FAR and FRR. This research focuses only on the feature extraction approach for iris recognition based on CASIA and MMU datasets. To check the accuracy of FAR and FRR based on empirical results. Approaches that utilize Gabor filters are frequently employed in image processing, particularly for image assessment. Primitive Gabor functions are sinusoidally adjusted Gaussians. It is demonstrated that Gabor filtering is a successful method for representing images and that the functional shape of Gabor filters very much resembles the sensory characteristics of basic cortical cells. The more accurate and less computational cost of using wavelet transform with Gabor filter to recognize iris in different available iris datasets is based on the proposed hybrid feature extraction approach.

This shows that the proposed model for iris recognition with significant feature extraction is better. The second portion of the proposed approach is wavelet transform, the famous wavelet series. Wavelet transform coefficients are used to be the vector of features in the proposed system. To derive the wavelet coefficient from standardized iris images, the wavelet, a potent mathematical tool for feature extraction, was applied. Wavelets are scaled and shifted variations of predefined parental wavelets with regional fundamental functions. Wavelets' principal benefit is their concentrated frequency details about a signal's function, making them especially valuable for categorization. This model is divided into three main levels. The first level is having preprocessing steps necessary for the desired tasks. Level one is further divided into two sub-steps. We get the iris image and start performing the processing steps with segmentation. This step consists of edge detection and locating the inner and outer boundaries of the iris. In the second level, select parameters for feature extraction, then apply the Gabor filter and wavelet transform and combine these two methods' results according to the Haralick features scheme.

Our proposed approach deploys on two datasets, CASIA and MMU, and gets optimal results for performing the activity. Finally, perform a matching process with a decision-based classifier for iris recognition with acceptance or rejection rates. Experimental-based results provide for analysis according to the FAR and FRR. In the third level, the error rate will be checked along with some statistical measures for final optimal results. All these measurements are presented in Fig. 2. The orthogonal wavelet transforms in terms of MRA can decompose the input image into the low-frequency component that represents the optimal approximation and the high-frequency component that represents the detailed information. To obtain the next coarse level of wavelet decomposition, the first number sub-band is further decomposed, and so on. Repeatedly, this process is iterated until some final scale is reached.

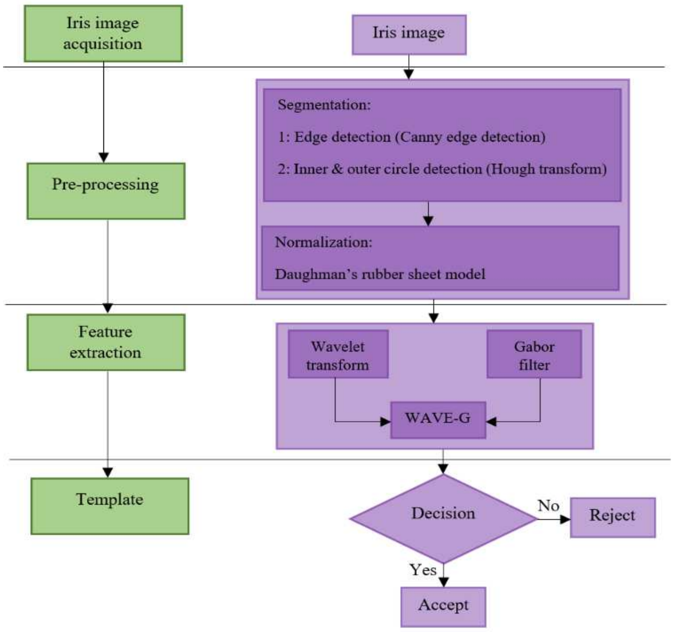


Fig. 2 The proposed framework for iris recognition

After this, apply the grayscale morphological process, select the maxima and minima points of the scaled image, and then apply the 2D Gabor filter on the full-decomposed scaled image and extract the global features with the help of the Gabor filter. In the end, the inverse wavelet transform operates reconstruction with projection. Concerning thresholding, this gives the optimal results for feature extraction. In Fig. 3, the proposed approach works according to the integrated methods shown.

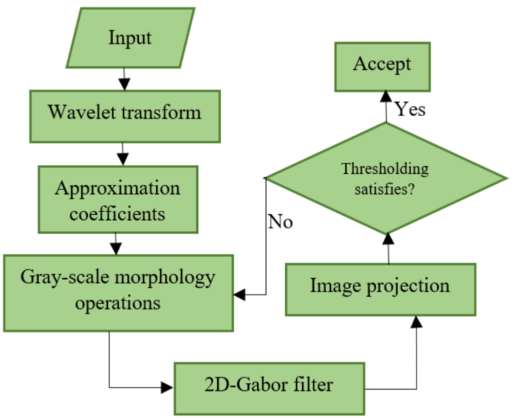
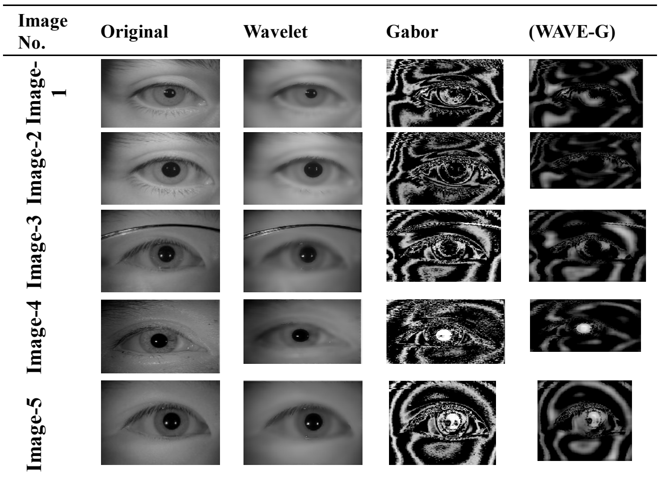


Fig. 3 The proposed WAVE-G approach

III. Results and Discussion

These experiments represent the analysis of the proposed WAVE-G method. The experiments were done on MATLAB software and tested with the CASIA and MMU datasets. To extract the clean features is the main objective. In this experimental analysis, the results of the five images from the CASIA dataset are obtained in Table 1. The results of the proposed method WAVE-G on the original image were analyzed. After this experimental analysis, it was found that the WAVE-G method is working well in any manner. In the experiment, it can be seen clearly that Wavelet and Gabor separately do not produce good results. Wavelet is not very accurate in this regard, as it blurs the image and does not give appropriate results.

TABLE I
THE RESULTS OF THE CASIA DATASET ALONG WAVE-G



Analysis shows that the WAVE-G starts extracting image features without affecting and altering the feature. It observed that the WAVE-G method is a better method of forming the features for inner as well as outer lines. Hence, it is experimentally proved that this proposed method is the most efficient and optimal feature extraction method.

TABLE II
THE RESULTS OF THE MMU DATASET ALONG WAVE-G

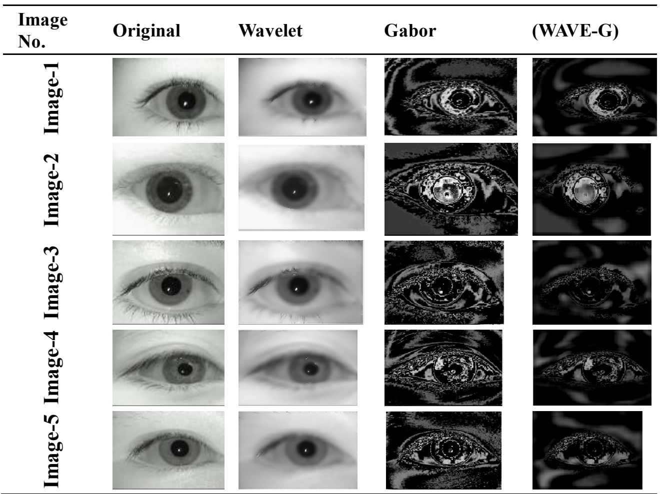


Table 2 shows the results of five images from the MMU dataset used in this experiment. After experimental examination, Wavelet and Gabor are simple in evaluation separately, but when it comes to combining the properties or functions of these selected filters, it improves the image results in the form of feature extraction. The FAR and FRR measurements are used as assessment metrics to gauge how well the proposed approach performs. The FAR ratio is calculated by dividing the number of identification attempts by the number of erroneous approvals. FRR is another term for the system's proportion of false rejects.

Two separate databases are employed as benchmark iris images for estimating those characteristics, and several iris images are collected for the proposed testing process. Each database's image was assessed in relation to the complete strength of all the other images in the database to determine FAR. Like FRR, one image was chosen and treated as an imposter before being assessed against the other images. The acquired values are shown in Table 3 and Table 4, respectively.

TABLE III
ESTIMATED VALUES OF FAR AND FRR FOR CASIA DATASET

Assessment metrics	I-1	I-2	I-3	I-4	I-5
FAR	0.03	0.04	0.06	0.03	0.04
FRR	0.05	0.03	0.05	0.04	0.07

TABLE IV
ESTIMATED VALUES OF FAR AND FRR FOR THE MMU DATASET

Assessment metrics	I-1	I-2	I-3	I-4	I-5
FAR	0.03	0.05	0.013	0.04	0.06
FRR	0.04	0.07	0.06	0.05	0.04

The receiver operating characteristic (ROC) curve for their datasets is shown in Fig. 4 and Fig. 5 as a plot of FAR against FRR.

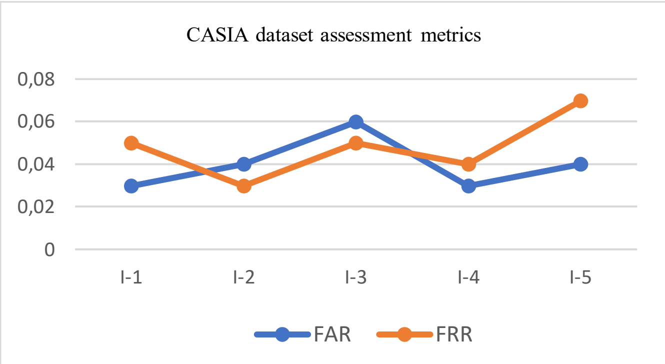


Fig. 4 CASIA dataset evaluation metrics

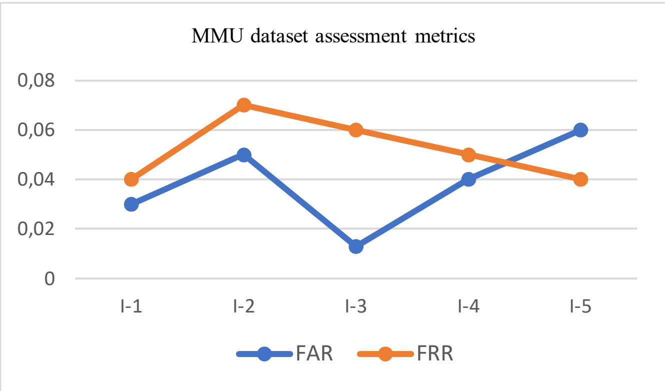


Fig. 5 MMU dataset evaluation metrics

These curve points represent every potential system running state in various considerations. It displays a system's performance in general. At zero FAR, the ideal ROC curve is a step value. The results of this evaluation depict that the proposed approach works effectively in recognition mode.

IV. CONCLUSION

An iris is the most reliable biometric trait among other biometric traits. In this paper concept is used to generate iris unique features to identify persons effectively. The proposed approach is highly accurate and can efficiently be used as an iris recognition system. Iris localization and normalization, in this paper, efficient approach for iris feature extraction and recognition method WAVE–G can achieve high performance and high efficiency in iris recognition. Iris recognition is based on combined feature extraction methods WAVE–G by considering both the Wavelet and Gabor filter. The feature extractor involves a unique combination named WAVE–G.

The proposed method is highly accurate and can efficiently be used as an iris recognition system. The proposed approach derives from the iris simultaneously global and local data. A fixed-length feature vector is produced after applying Gabor filters to each iris image. According to experimental findings, our method may successfully discriminate between several people by identifying their irises. Additionally, it has good computing performance and is unaffected by interference and light. Our next research will concentrate on iris recognition from image sequences and more reliable iris features. This approach can be used for other biometric security systems and provide better outcomes for future directions.

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