A STUDY ON IRIS RECOGNITION CHALLENGES AND MACHINE LEARNING ALGORITHMS FOR UNIMODAL BIOMETRIC SECURITY SYSTEMS

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ABSTRACT

Iris Recognition is one of the most challenging and fastest growing areas in the field of biometrics. This study focuses about the brief summary of iris recognition system for identification and verification of iris images. The fusion of biometrics leads to security systems that exhibit higher recognition rates and lower false alarms compared to unimodal biometric security systems. Supervised learning was carried out using a number of patterns from a well-known benchmark biometrics database, and the validation/testing took place with patterns from the same database which was not included in the training dataset. Furthermore, this research might explore the adaptability of these systems to real-world scenarios, addressing challenges such as variations in lighting conditions, occlusions, and robustness against spoof attacks. Subsequently, machine learning algorithms such as Convolution Neural Networks (CNNs), Support Vector Machines (SVMs), or Deep Learning models are applied to classify and identify individual irises. We comprehensively evaluated our algorithm on three publicly available iris databases for which the results proved satisfactory for real-time iris recognition. The fusion of biometrics leads to security systems that exhibit higher recognition rates and lower false alarms compared to unimodal biometric security systems.

Keywords: *Machine learning algorithms, benchmark biometrics database, Support Vector Machines (SVMs), iris databases, Convolution Neural Networks (CNNs).*

INTRODUCTION

The technology of biometric recognition is becoming increasingly crucial for individual identification, with a wide range of applications that include authentication of mobile devices, as well as security and surveillance. Iris recognition (IR) is considered to be a highly dependable biometric technology that utilizes distinct iris patterns to accurately authenticate individuals. The precision of IR is contingent upon the precision of iris segmentation, which involves the isolation of the iris area from the remaining portion of the ocular image. The discipline of biometrics pertains to the process of verifying and validating the identity of individuals by means of their distinct biological and behavioral traits. Numerous studies concentrate on contemporary developments in identifying the most essential biometric features, with particular attention to techniques for iris segmentation and recognition processing. Biometric systems are assessed based on their design, operational procedures, and performance metrics, as stated in the study of Nachar and Inaty.

Iris recognition is a biometric verification or identification technique that authenticates a person by using an image of a human eye, i.e., more precisely – by analyzing highly entropic iris patterns. The iris is a circular membrane that lies between the cornea and the lens of the human eye. Its function is to control the amount of light passing through the pupil by contracting and relaxing the pupillary sphincter and dilator muscles. The pioneering papers and patents on iris recognition are written by John Daugman. The main idea underlying his approach is that pattern recognition can be based on the failure of statistical independence tests, in the case of sufficiently high entropy among inter-class samples. However, one should also note that F. H. Adler wrote already in 1953 that the "markings of the iris are so distinctive that it has been proposed to use photographs as a means of identification, instead of fingerprints". The traditional iris recognition systems based on the Daugman's approach operate as follows. In the iris localization step, the edges of the iris and pupil are detected by applying the Hough transform and Canny edge detector.

LITERATURE REVIEW

Moamin A. Mahmoud (2023) Biometric recognition is essential for identifying people in security, surveillance, and mobile device authentication. Iris recognition (IR) biometrics is exact because it uses unique iris patterns to identify individuals. Iris segmentation, which isolates the iris from the rest of the ocular image, determines iris identification accuracy. The main problem is concerned with selecting the best deep learning (DL) algorithm to classify and estimate biometric iris biometric iris. This study proposed a comprehensive review of DL-based methods to improve biometric iris segmentation and recognition. It also evaluates reliability, specificity, memory, and F-score. It was reviewed with iris image analysis, edge detection, and classification literature.

Dr. M. SIVAJOTHI (2021) Iris Recognition has been one of the most robust means of biometric recognition. In recent years, there are so many researches in iris recognition using deep learning. In this paper, three recent researches on iris recognition are compared and analyzed for the in-depth study on iris recognition. All the three researches use deep learning for its method which are VGGNet, Residual Convolutional Neural Network (Residual CNN) and Dense Fully Convolutional Neural Network (DFCN). Experiments results are compared on CASIA 1000 and IITD databases for all the three models. The DFCN architecture achieves good accuracy when compared to other methods.

Khalid Saeed (2021) One of the most important modules of computer systems is the one that is responsible for user safety. It was proven that simple passwords and logins cannot guarantee high efficiency and are easy to obtain by the hackers. The well-known alternative is identity recognition based on biometrics. In recent years, more interest was observed in iris as a biometrics trait. It was caused due to high efficiency and accuracy guaranteed by this measurable feature. The consequences of such interest are observable in the literature. There are multiple, diversified approaches proposed by different authors. However, neither of them uses discrete fast Fourier transform (DFFT) components to describe iris sample. In this work, the authors present their own approach to iris-based human identity recognition with DFFT components selected with principal component analysis algorithm.

Vladislav Miškovic (2020) This study presents a novel iris recognition system based on machine learning methods. The motivation behind this research resides in the interrelatedness of biometric systems and stylometry, as shown in our previous research. The main goal of the proposed model is to reach virtually perfect classification accuracy, eliminate false acceptance rates, and cancel the possibility of recreating an iris image from a generated template. To achieve this, we omit Gabor wavelets and other filter banks typically employed in iris recognition systems based on the pioneering work of John Daugman. The biometric templates are generated by converting a normalized iris image into a one-dimensional set of fixed-length codes, which then undergoes stylometric feature extraction. The extracted features are further used for classification. A new recognition method is developed using the CASIA iris database, and its generalizability is demonstrated on the MMU and IITD iris databases separately, and also on their unification with the CASIA database, by applying oversampling before and during the cross-validation procedure.

Sapiee Jamel (2017) With the prominent needs for security and reliable mode of identification in biometric system. Iris recognition has become reliable method for personal identification nowadays. The system has been used for years in many commercial and government applications that allow access control in places such as office, laboratory, armoury, automated teller machines (ATMs), and border control in airport. The aim of the study is to review iris recognition algorithms. Iris recognition system consists of four main stages which are segmentation, normalization, feature extraction and matching. Based on the findings, the Hough transform, rubber sheet model, wavelet, Gabor filter, and hamming distance are the most common used algorithms in iris recognition stages.

Iris recognition

Iris recognition is an automated method of biometric identification that uses mathematical pattern-recognition techniques on video images of one or both of the irises of an individual's eyes, whose complex patterns are unique, stable, and can be seen from some distance. The discriminating powers of all biometric technologies depend on the amount of entropy they are able to encode and use in matching. Iris recognition is exceptional in this regard, enabling the avoidance of "collisions" (False Matches) even in cross-comparisons across massive populations. Its major limitation is that image acquisition from distances greater than a meter or two, or without cooperation, can be very difficult. However, the technology is in development and iris recognition can be accomplished from even up to 10 meters away or in a live camera feed. Retinal scanning is a different, ocular-based biometric technology that uses the unique patterns on a person's retina blood vessels and is often confused with iris recognition. Iris recognition uses video camera technology with subtle near infrared illumination to acquire images of the detail-rich, intricate structures of the iris which are visible externally. Digital templates encoded from these patterns by mathematical and statistical algorithms allow the identification of an individual or someone pretending to be that individual. Databases of enrolled templates are searched by matcher engines at speeds measured in the millions of templates per second per (single-core) CPU, and with remarkably low false match rates.

Iris scanning process

There are four main steps involved in iris recognition enrollment for use as a form of biometric authentication:

1. Image capture

A high-quality image of the individual's left and right iris must be captured using a specialized iris camera. These cameras use near-infrared (NIR) sensors to capture the minute and intricate details of the iris with much greater accuracy than visible light (VIS), which can pollute the sample. Research from Michigan State has determined that iris recognition accuracy drops significantly when VIS is used instead of NIR. Visible light is also more at risk of causing discomfort and pupil contraction when shined into a subject's eyes. By comparison, near IR causes neither pupil contraction nor discomfort during an iris scan.

2. Compliance check and image enhancement

The next step is to perform quality and compliance checks to ensure that the captured image is suitable as a biometric template for future iris scanning. This requires specialized software that analyzes each image for key characteristics that indicate quality, including, but not limited to:

- Sharpness.
- Gray-level spread.
- Margin.
- Iris sclera contrast.
- Iris pupil contrast and pupillary dilation.
- Eyelash presence.
- Eyelid occlusion.

Once the iris has been segmented from the rest of the eye and evaluated for quality, the sample can be saved for future use as a biometric template.

3. Image compression

Each iris-scan template should be compressed using the JPEG 2000 format. This format preserves image quality and minimizes the occurrence of artifacts (image distortions) that result from other compression methods.

4. Biometric template creation for matching

Finally, the high-quality sample is put to use as a template for iris scanning.

In one-to-one authentication, each live scan of an individual's iris is compared to the existing template for identification and authentication. In one-to-many authentication, a live scan is analyzed and compared against an existing gallery to identify a match or lack thereof.

RESEARCH METHODOLOGY

The performance parameters of proposed method are analyzed using available standard ORL, JAFFE, L-SPECK and CMU-PIE face databases.

(i) ORL databas: The database consists of totally forty persons with each person having ten different face images captured during different instance of time with variations in facial expressions pose and illumination conditions, which includes face images with/without glass, open/close eye, left and right orientations. The database is created for testing proposed method by considering nine images of first twenty persons leading to one eighty images inside the database and tenth image of each twenty persons is considered as query image to compute False Rejection Rate (FRR) and True Success Rate (TSR). The False Acceptance Rate (FAR) is computed with remaining twenty persons who are considered for outside database.

(ii) JAFFE database: The database has ten female members with twenty images of different angle, expression and illumination per member. The database is created to compute performance parameters of proposed method by considering five persons with ten images per person ie., fifty images in total. The remaining five persons with one image per person are considered as query image to compute FAR.

RESULTS AND DISCUSSION

Performance Evaluation for different Combinations of PID: POD.

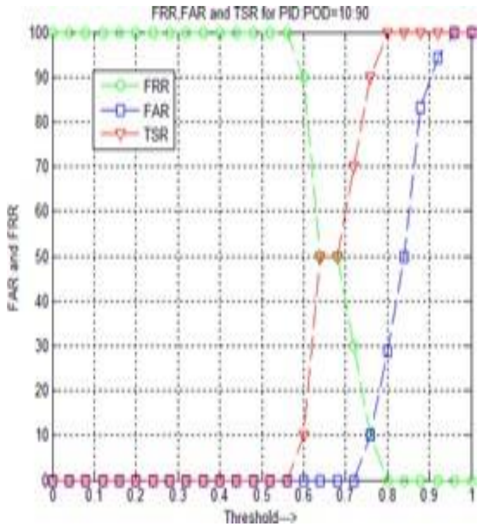
The performance parameters such as FRR, FAR and TSR are computed for variations of threshold values with different combinations of PID and PODs

(i) Performance Evaluation for Combination of PID and POD of 10:90

The Percentage variations of FRR, FAR and TSR values with the threshold for PID: POD of 10:90 are shown in Table 1 and graph 1. The maximum success rate TSR of 100 and Optimum TSR value of 90 are obtained with an EER value of 10 at a threshold value of 0.76.

Table 1: Performance parameters variations with threshold for PID: POD of 10:90

PID:POD 10: 90			
THRESHOLD	FAR	FRR	TSR
0.56	0	100	0
0.60	0	90	10
0.64	0	50	50
0.68	0	50	50
0.72	0	30	70
0.76	10	10	90
0.80	29	0	100
0.84	50	0	100



Graph 1: Plot of FRR, FAR, and TSR for PID: POD=10:90

(ii) Performance Evaluation for Combination of PID and POD of 20:80

The Percentage variations of FRR, FAR and TSR values with the threshold for PID: POD of 20:80 are shown in Table 2. The maximum TSR of 100 and Optimum TSR value of 85 are obtained with an EER value of 15 at a threshold value of 0.75.

Table 2: The Performance parameters variations with threshold for PID: POD of 20:80

PID:POD 20: 80			
THRESHOLD	FAR	FRR	TSR
0.52	0	100	0
0.56	0	95	5
0.60	0	85	15
0.64	0	55	45
0.68	0	40	60
0.72	5	25	75
0.76	15	15	85
0.80	39	10	90
0.84	66	5	95
0.88	91	0	100
0.92	98	0	100

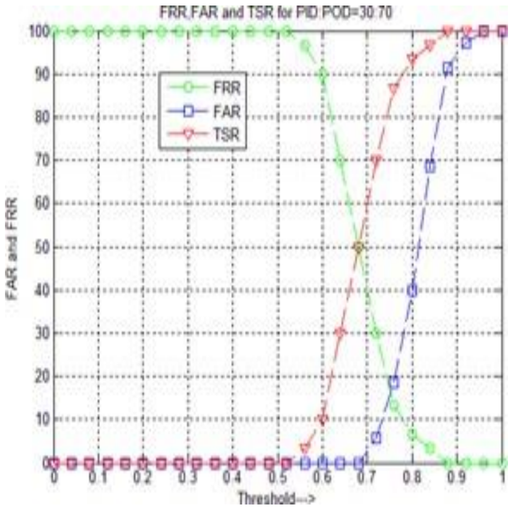
0.96	100	0	100

(iii) Performance Evaluation for Combination of PID and POD of 30:70

The Percentage variations of FRR, FAR and TSR values with threshold for PID: POD of 30:70 are shown in Table 3 and graph 2. The maximum TSR of 100 and Optimum TSR value of 86 are obtained with an EER value of 14 at a threshold value of 0.76.

Table 3: The Performance parameters variations with threshold for PID: POD of 30:70

PID:POD		30: 70	
THRESHOLD	FAR	FRR	TSR
0.52	0	100	0
0.56	0	97	3
0.60	0	90	10
0.64	0	70	30
0.68	0	50	50
0.72	6	30	70
0.76	19	13	87
0.80	40	7	93
0.84	69	3	97
0.92	97	0	100
0.96	100	0	100



Graph 2: Plot of FRR, FAR, and TSR for PID: POD=30:70

CONCLUSION

The face recognition based on transforms domain techniques. The DTCWT and FFT are used to extract transform domain features. The final features ore obtained by fusing DTCWT and FFT features based on arithmetic addition. The ED is used to compare features of data base and test images to compute performance parameters. The face recognition based on combinations of spatial domain features and transform domain futures is presented. The DWT features are extracted from pre-processed face images. The disadvantages of the traditional iris recognition systems based on the Daugman's pioneering work include the existence of the FAR, which is unacceptable in most of authentication scenarios, the existence of a threshold in the authentication phase, the need to find a balance between the FAR and FRR, the fine-tuning of filter parameters, and large template sizes which are not suitable for some applications. The iris recognition based on translation of iris templates using AHE, HE and Gabor Wavelet filter is proposed. The number of iris templates per person is converted into one template per person to save computational time. AHE and HE are used to enhance quality of iris template. The performance parameters are computed by comparing data base and teat iris template features. The proposed method is evaluated on three publicly available databases. The experimental results indicate that our method has outstanding efficiency and performance over previous studies utilizing deep learning-based methods and handcrafted feature-based methods.

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