# IRS: IRIS RECOGNITION SYSTEM A REVIEW

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## ABSTRACT

*The increasing importance of safety measures in daily life has sparked intense interest in biometric recognition, with biometric detection systems emerging as safer alternatives to various security measures. These systems automatically recognize and authenticate individuals based on unique biometric features. Over the last years, scholars have concentrated on iris recognition, leveraging the distinct the characteristics of the colored muscle within the eye responsible for regulating light intake.*

*The iris contains unique textural information that remains unchanged, making it an ideal trait for biometric systems. Its uniqueness, reliability, universality, and stability make iris patterns invaluable for numerous recognition and authentication applications. However, iris region segmentation and classification pose significant challenges within iris recognition systems. Poor performance in these stages can severely impact effectiveness.*

*Issues such as varying pigmentation levels, brightness, contrast, lashes or eyelid occlusion, and differences in sensor and environmental conditions complicate iris segmentation. Consequently, There is a pressing need to deal with these challenges and develop more efficient algorithms. This paper aims to review various research directions in iris recognition, with the goal of advancing the field and overcoming existing obstacles.*

*Keywords: biometric, recognition, segmentation, authentication, algorithm.*

## I. INTRODUCTION

Advancements in algorithms for artificial intelligence (AI) offer The possibility to enhance human iris identification and recognition systems, providing benefits such as speed, hardware simplicity, accuracy, and learning capability. Biometrics, utilizing various physiological characteristics like iris patterns, retinas, 2D and 3D facial features, facial thermography, fingerprints, and hand geometry, play an a crucial component in public and information security domains. These biometric technologies accurately distinguish individuals based on their unique physiological traits.

There are multiple steps involved in recognition, such as image capture, preprocessing, and recognition. Preprocessing steps encompass iris localization, normalization, and enhancement, each utilizing distinct algorithms. During iris localization, the inner and outer boundaries of the iris, as well as the upper and lower eyelid bounds, are identified. The inner circle lies between the iris and pupil boundaries, while the outer circle lies between the iris and sclera boundaries.

Recent advancements in human iris image processing have focused on identification and recognition tasks, which are challenging due to variations in the presence of outliers and noise. This includes recognizing geometrically transformed iris images, detecting intentional alterations, and handling images with partial or guide information.

Biometric traits possess highly reliable and unique characteristics, making them well-suited for security systems as opposed to conventional techniques. Jain et al. (1999) found seven essential components for evaluating biometric traits: universality, uniqueness, permanence, measurability or collectability, performance, acceptability, and circumvention. Although no single trait satisfies all factors, Iris scores well across most criteria, making it a popular choice for biometric recognition systems.

The iris, a well-protected muscle within the eye, exhibits distinct and immutable patterns such as furrows, rings, freckles, and crypts. Its color remains consistent over time, and even subtle differences exist between iris patterns of the same individual's eyes and between identical twins. Consequently, recognition techniques based on iris patterns are highly effective for identification and authentication purposes, particularly in applications like physical access control, time and attendance tracking, law enforcement, and banking.

| Biometrics | Universality | Uniqueness | Collectability | Performance | Acceptability |
|---|---|---|---|---|---|
| Face | High | Low | High | Low | High |
| Fingerprint | Medium | High | Medium | High | Medium |
| Vascular | Medium | Medium | Medium | Medium | Medium |
| Iris | High | High | Medium | High | Low |
| Voice | Medium | Low | Medium | Low | High |
| DNA | High | High | Low | High | Low |

**Fig. 1:** Comparison of Iris Recognition with other Biometrics

## II. IRIS RECOGNIZE SYSTEM

Figure 1 outlines the general workflow of an identification of the iris. The process begins by capturing an image using specialized hardware equipped with a high-resolution camera. Subsequently, the image undergoes segmentation to isolate the eye region, followed by the extraction of the iris's inner and outer edges using sophisticated image processing techniques. Once the iris within the segmented eye image is located and isolated, it is encoded using mathematical algorithms, resulting in a unique code representing the iris characteristics.

However, since no two images captured at different times or under different conditions are exactly alike, the validation process determines whether the iris belongs to the intended individual or not. This comparison ensures the reliability of the identification process despite potential variations in the captured images.

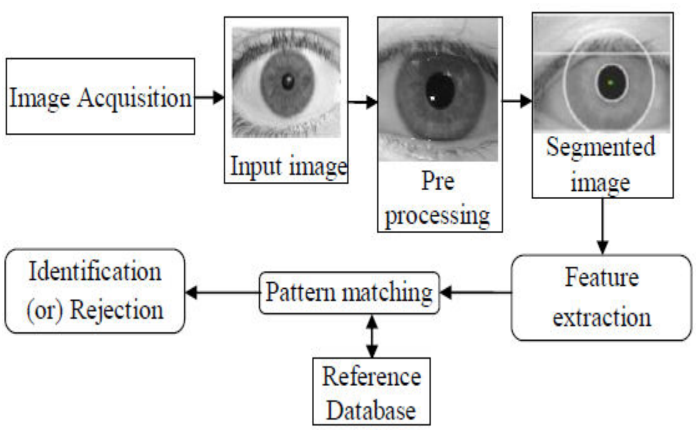


Fig. 1: Flowchart of Iris Recognition

i. **Image Acquisition:** The first and foremost step in the above-mentioned flowchart is Image acquisition. In simple words, it is in which someone get the images of different iris. It may be taken from various datasets that are available in the market. Digital Camera and satellite photographs are also used for acquiring the images.

ii. **Input Image:** Furthermore, the acquired image is input in the system which is created to recognize the iris. In other words, the image is taken from the dataset and other techniques that is used for acquiring the images.

iii. **Preprocessing:** After inputting the image, the next stage is to process the image to remove irregularities present in the image. The technique that is used to remove irregularities are Linear filtering.

iv. **Segmented Image:** Furthermore, the image is divided into various segments in Image segmentation phase. The segmentation is of two types: Region Based Segmentation and Boundary Based Segmentation.

v. **Identification or Rejection:** In this phase, the required region is identified and the extra pixels of the image are rejected.

vi. **Feature Extraction:** In this step, the features of the inputted image are extracted by using various techniques that are used for extracting features.

vii. **Pattern Matching:** In this phase, the image pixels are matched with the pattern available in the reference database. If the pattern of iris of inputted image is matched with the available pattern in the reference database, then that inputted image iris is recognized.

## III. LITERATURE REVIEW

“This section delves into notable research accomplishments within the field of iris recognition.

Nianfeng Liu et al. [5] proposed a novel approach at the code level for heterogeneous iris recognition. They illustrated the nonlinear relationship among binary element codes in heterogeneous iris images using an adapted Markov network. Moreover, their model yielded a weight map indicating the reliability of binary codes within the iris template. Extensive experimental findings, comparing cross-sensor matching, high-resolution versus low-resolution, and clear versus obscured iris images, demonstrated that the code-level approach achieved superior accuracy compared to existing pixel-level, feature-level, and score-level solutions.

Sheng-Hsun Hsieh et al. [6] advocated for a hybrid hardware-software strategy to enhance the standoff distance in iris recognition systems. In the hardware design phase, they employed an enhanced wavefront coding technique to extend the field depth. To address image blurring induced by wavefront coding, the proposed system utilized a local patch-centered super-resolution strategy in the software domain to restore the obscured images to their clear counterparts. This approach expanded the capture volume of a typical iris recognition system threefold while maintaining a high recognition rate. However, due to the hardware implementation, the proposed model incurred higher costs.

Chun-Wei Tan et al. [7] explored a promising method for encoding iris data along with a matching system tailored for noisy iris images captured at a distance under less constrained conditions using both visible and NIR imaging. Their approach in this study simultaneously utilized iris features derived from both local and global feature representations. The effectiveness of the proposed iris encoding and matching methodology was assessed by making contrasts with several competing iris encoding and matching algorithms on three publicly available databases: UBIRIS.v2, CASIA.v4-distance, and FRGC. Their method demonstrated improvements of 36.3%, 32.7%, and 29.6% in equal error rates (EER), respectively, compared to several competing approaches. One limitation of their study is the lack of consideration for multimodal processing.

Chun-Wei Tan et al. [8] devised a nonlinear approach aimed at concurrently representing both the local consistency of iris bits and the overall characteristics of the weight map to balance and prioritize the encoded iris bits. Their method effectively penalizes fragile bits while rewarding more stable ones, aiming to achieve more robust local iris features. They proposed a Zernike moment-centered phase encoding of iris features. Employing a joint methodology, they simultaneously extracted and integrated global and localized iris features. Their experimental findings indicated significant advancements in iris matching accuracy compared to competing approaches, with an average improvement of 54.3%, 32.7%, and 42.6% in Equal Error Rates (EER), respectively, across UBIRIS.v2, FRGC, and CASIA.v4-distance datasets.

Jianxu Chen et al. [9] implemented an iris recognition technique designed to identify corresponding iris crypts reliably. Their proposed matching scheme aimed to address potential topological variations in locating the same crypt across different images. Their approach outperformed the prominent visible-feature-based iris recognition strategy across three distinct datasets. Specifically, their method achieved over a 22% greater identification rank-one hit rate and more than a Reduced Equal Error Rate by 51%) in verification. Additionally, they tentatively demonstrated the advantages of their approach in multi-enrollment scenarios. However, their method is more susceptible to significant occlusion and poor illumination compared to traditional iris codes. Poor illumination conditions may lead to lower contrast, resulting in fewer detectable features compared to normal illumination conditions.

Zhiyong Peng et al. [10] have introduced an enhanced Daugman iris recognition algorithm that focuses on two key aspects: improving iris localization and refining iris encoding and matching algorithms. In the first step, they determine the localization and shape of the pupil in the iris image. Then, in the second step, they further refine the process by isolating possible noise from residual eyelashes, selecting a "pure" iris portion as a reference, and making pixel-wise validation judgments. This proposed algorithm significantly enhances processing speed while reducing rejection rates."

Imran Naseem et al. [11] introduced the concept of class-specific dictionaries for iris recognition. Essentially, they represent the query image as a linear combination of training images from each class. They solve the well-conditioned inverse problem using least squares regression and make decisions based on the class with the most accurate estimation. They also propose an augmented modular approach to combat noise resulting from imperfect segmentation of the iris region. Comparing their algorithm with the novel Representation Classification with Bayesian fusion across multiple sectors, their complexity analysis demonstrates the superiority of the proposed approach.

Daugman [5] introduced the pioneering methodology in iris biometrics. Daugman employed this is an integral differential operator that can be used to find the inner ring of the iris and the pupil area , as well as the curves of the upper and lower lids. This operator seeks the circular path exhibiting the maximum change in pixel values by adjusting the radius and center coordinates of the circular contour. Iteratively applied, the operator gradually reduces smoothing to achieve precise localization, while eyelids are localized concurrently. The integro-differential approach resembles a variant of the Hough transform, utilizing first derivatives of the image and conducting a search for geometric parameters. By working with raw derivative data, it circumvents the thresholding challenges of the Hough transform. Nonetheless, the algorithm may falter in the presence of noise in eye images, such as reflections, as it operates primarily at a local scale.

In order to define the iris borders in Daouk et al.'s [14] suggested iris recognition systems, a fusion process of Canny Edge Detection and Circular Hough Transform was integrated.

Digital pictures of the eyes. Then, deterministic iris patterns were extracted and turned into a feature vector with the help of Haar wavelet analysis. A wavelet tree facilitated mapping of image coefficients, achieving an average correct recognition rate of 93% across a database of 60 images. However, this methodology struggles in scenarios of poor lighting, eyelid occlusion, noise, or improper eye positioning.

Noh et al. [12] introduced a novel feature extraction technique wherein an adaptive method replaced the traditional wavelet transform. This method extracted both global and local features from wavelet coefficients. Utilizing a polar coordinate system for mathematical modeling, global features remained invariant to eye image rotation and imprecise iris localization. Customized geometric moments represented global iris features, while local features offered precise iris information. This approach was motivated by the absence of shift-invariant property in Discrete Wavelet Transform (DWT), as methods lacking this property fail to provide accurate texture analysis.

"Xu et al. [13] proposed an enhanced system for recognizing iris images addressing the identification of eyelids and eyelashes, along with an alternative image enhancement technique. Recognizing the impact of eyelids and eyelashes on iris images and their potential to introduce noise, the study compared sub-block models for detecting these elements. Image enhancement involved background subtraction, followed by filtering through histogram equalization and Weiner filtering. Eyelid/eyelash detection employed summary derivative analysis. The iris location finding rate achieved an impressive 98.42% within the CASIA database.

A work on feature extraction and subset selection for iris identification was presented by AZizi et al. [15]. They extracted iris characteristics using contourlet transform, capturing the iris image's inherent geometrical structures. The iris image underwent additional breakdown into sub-blocks holding texture data. Iris template matching was done using Support Vector Machines (SVM). For coding, the Gabor filter and Haar wavelet were applied. Principal Component Analysis (PCA) was used to create iris vectors. The CASIA picture database was used to assess the suggested system's performance. Gupta and Saini [17] conducted an assessment of the performance of existing iris recognition systems using the Matlab Image Processing Toolbox. Their proposed technique comprised several fundamental steps, including image acquisition, segmentation (detecting circles of pupil and iris boundary using Daugman's filter), normalization (creating rectangular blocks of fixed size via a rubber sheet model), image enhancement (converting low-contrast images to high-contrast ones and mitigating non-uniform illumination with Gabor filter), and image matching (performing template matching where Various iris images are displayed. using Hamming distance). A key advantage of their proposed technique is its ability to achieve promising accuracy and performance even when pictures are taken from a distance."

## IV. APPLICATIONS

The applications of Iris Recognition System span various fields, such as:

i. **Finance and Banking:** Iris recognition technology is revolutionizing banking and financial organizations by replacing cumbersome and time-consuming pin-based and password-based systems. By implementing iris recognition, these institutions can elevate the standards of financial services, freeing bankers from laborious document processing for identity proofs. This, in turn, allows them to focus on vital areas like customer service. Given the substantial volume of financial data handled by banks and the high footfall they experience, data security becomes paramount. Iris recognition systems emerge as the most reliable and secure security solutions for banks, ensuring enhanced protection for sensitive financial information.

ii. **National ID:** In every nation, including developing countries, citizens are issued National IDs. Alongside fingerprint technology, iris recognition is increasingly being employed for the most accurate identification of citizens. This approach helps prevent duplicate registrations, ensures swift and precise voting identification, establishes easily accessible audit trails, and fosters interoperability between government agencies for seamless data integration, verification, and maintenance [19].

iii. **Law Enforcement**: In Law enforcement, various agencies using biometric authentication since 1891, and numerous forms of identification based on biometric features have been developed since then. Recently, iris biometric authentication has been integrated into law enforcement practices to identify and track criminals, ensuring public safety. This technique is not just beneficial in detecting criminals but also aids in preventing crimes by addressing the shortcomings of traditional security systems [19].

iv. **Immigration and the Border-Control:** With rising traveler numbers and concerns over international crimes, security checkpoints are under pressure to modernize their measures by adopting automated identification systems. Consequently, international borders are increasingly deploying iris biometric authentication systems to streamline immigration processes while ensuring safety measures are met. Several international airports in the USA, Canada, Netherlands, and the UK have already integrated iris biometric authentication for immigration procedures. Furthermore, airline companies are also utilizing iris-authenticated boarding systems to enhance travel security [19].

v. **Healthcare Services:** One of the successful biometric authentication system called the iris authentication system has been found applications in healthcare services, enabling the accurate identification of patients, access to their medical history and treatment plans, and the provision of health policy benefits while safeguarding personal information. Additionally, its non-contact nature ensures hygiene standards are maintained.

Proven to be highly reliable and convenient, the iris biometric authentication system is favored for its intricate patterns and ease of use. Many government sectors and businesses in developed nations have already adopted this technology, while developing countries are working towards implementing this advanced authentication system [19].

## V. CONCLUSION

Iris recognition stands at the forefront of biometrics, showcasing remarkable potential across a wide spectrum of real-world applications. This manuscript delves into the research conducted by other scholars in the field of iris recognition for authenticating individuals. Additionally, it offers a comprehensive overview of the systems commonly employed by researchers to develop iris recognition systems. Furthermore, it explores the diverse applications of iris recognition systems in various domains.

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