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IRIS Recognition System using Machine Learning

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ABSTRACT

This paper aims to propose methods for preprocessing iris images for iris recognition, which include image enhancement and boundary detection. While iris recognition is widely recognized as a dependable identification method, its adoption is limited due to various factors such as production costs, processing time, and recognition rates. The challenges related to production costs and processing time are expected to be mitigated with advancements in integrated circuit technology. However, the primary issue affecting recognition rates is not the iris itself, but rather the acquisition of high-quality iris images. Consequently, the quality of iris images has become a critical aspect of current iris recognition systems. This preprocessing stage involves both hardware and software design considerations, both of which are addressed in this paper.

Keywords-Iris Recognition, Image Preprocessing, Hough Transform, Histogram Equalization

I. INTRODUCTION

Biometric technologies find extensive applications across various domains such as door access-control systems, passport authentication, and banking services. One key advantage of biometric authentication lies in its inherent resistance to loss or forgetfulness, as it necessitates the physical presence of the individual during the identification process [1]. Traditional biometric identification methods encompass fingerprint, voice, and facial recognition, among others. In the 1980s, American ophthalmologists L. Flom and Aran Safir made a significant contribution by demonstrating the uniqueness and stability of iris patterns, proposing them as a reliable human identifier [2]. Presently, biometric identification encompasses a range of modalities including fingerprint, hand geometry, palm vein, voice, face, and iris (as illustrated in Figure 1)..

Figure 1. Biometric identification examples

As a highly accurate method of biometric identification, iris recognition uses a lot of mathematical pattern recognition techniques on images of one or both of the irises of an individual's eyes. An iris is a protected organ located behind the cornea and in front of the lens. The randomness of iris patterns has high dimensionality, which make recognition decisions with confidence levels high enough to support rapid and reliable exhaustive searches. The iris of the eye has been described as an ideal part of the human body for biometric identification.

The algorithms for iris recognition were developed at Cambridge University by John Daugman who extracts iris textures using 2-D Gabor filter. The iris tests have been performed on over 9 million people by John Daugman with no false identification [3]. Wides analyses iris textures using 4-level Laplacian Pyramid [4]. Several iris recognition systems have been proposed after these works [5]. However, few of them associate physical iris structures into their systems. One of the successful systems is developed by Sun

Sun applied zero-crossing wavelet transform to segment what he called blocks of interest-BOIs.

II. SYSTEMATIC WORKFLOW

An iris recognition system consists of software part and hardware part. Hardware part usually includes a lens, a CCD or CMOS sensor, a processor and related peripherals as in Figure 2.

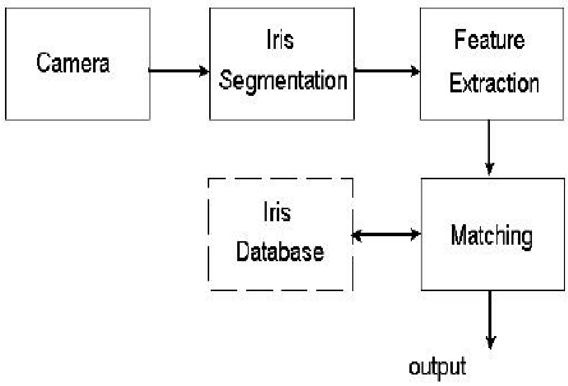

Figure 2. Hardware part.

The software component comprises several key stages including image acquisition, filtering, localization, normalization, extraction, and identification, as depicted in Figure 3. However, within an integrated software framework, there typically exists both an enrolment system and an identification system. In this context, the focus lies solely on the identification system, with emphasis placed on its discussion.

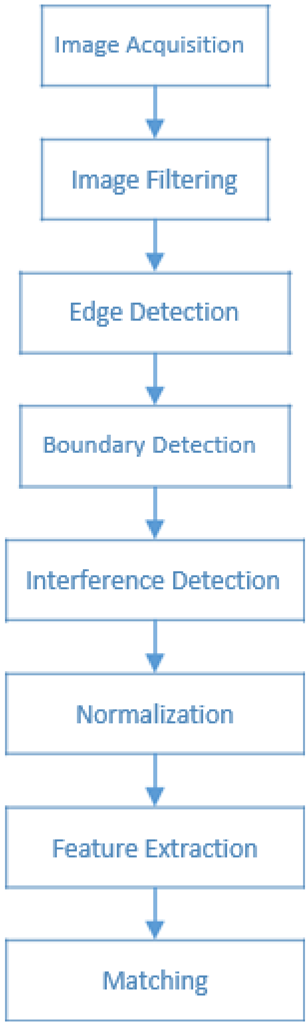

Figure 3. Software part.

Despite no instances of false identification occurring during tests conducted on over 9 million individuals, John Daugman acknowledged that the quality of the iris image directly impacts the accuracy of similarity calculations. Thus, iris image preprocessing assumes a crucial role in iris recognition.

III. PREPROCESSING

1. Image Acquisition

The hardware design serves as a prerequisite for effective image acquisition in iris recognition systems. Components such as infrared light sources, lenses, and CCD/CMOS sensors play pivotal roles in determining the quality of iris images. Among these, the selection of the image sensor is particularly critical in achieving optimal image quality. Factors such as sensor frequency, pixel resolution, and power consumption must be carefully considered during the sensor selection process.

Moreover, since the iris recognition system functions as a human-machine interaction system, the usability of the system is a crucial consideration in practical applications. This entails ensuring that the system is user-friendly and intuitive, facilitating seamless interaction between users and the acquisition process.

B. Image Filtering and Edge Detection

Image preprocessing plays a crucial role in the early stages of iris recognition, aiming to obtain an ideal iris image with a fixed region and high quality. To achieve this objective, image filtering and edge detection are essential components [7].

Image filtering precedes edge detection and serves to eliminate interference in the original image, thereby facilitating edge detection. This filtering process can occur in either the spatial domain or the frequency domain. Spatial filters include techniques such as mean filtering, median filtering, and Gaussian smoothing. Frequency filters operate on images in the frequency domain; the image undergoes Fourier transformation, is multiplied by the filter function, and then re-transformed into the spatial domain. In the context of iris recognition, low-pass filters are typically employed in the frequency domain. If the computer's memory capacity permits, frequency filters are preferred due to their higher speed compared to spatial filters.

The primary objective of filtering iris images is to remove high-frequency random noise, thereby ensuring accurate iris detection. Effective image filtering is essential for reliable iris recognition.

C. Edge Detection

Edges represent significant local changes in image intensity and are crucial features for image analysis. They typically occur at the boundaries between different regions within an image. In the context of iris localization, which involves extracting the iris from an image, two edge detection processes are essential: detecting the inner boundary and outer boundary of the iris.

Edges in an iris image signify notable local alterations in image intensity, often associated with discontinuities or significant changes in image intensity or its first derivative.

In the spatial domain, edge detection involves sharpening the image, contrasting with the smoothing process used in previous filtering steps. Due to the sensitivity of edge detection algorithms to noise, filtering of the image is imperative at this stage.

Several operators are commonly used for edge detection, including the Roberts, Prewitt, Sobel, Canny, and Laplacian operators.

Inner Boundary Detection:

The pupil, a distinctive feature of eye images, can be detected using various methods such as Canny edge detection, Sobel edge detection, and Prewitt edge detection, followed by the Hough transform. Additionally, the Otsu method can be employed for boundary detection.

The Canny edge detector, which approximates the first derivative of a Gaussian, is known for optimizing the signal-to-noise ratio (SNR) [13]. As illustrated in Figure 4, the Canny edge detection method proves effective in locating the pupil. With this information, including the center location and radius of the pupil, obtained, we can proceed with further steps.

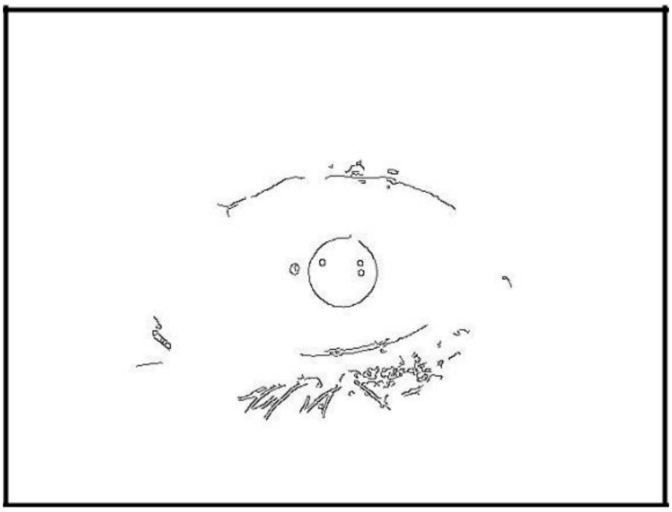

Figure 4. Canny edge detection

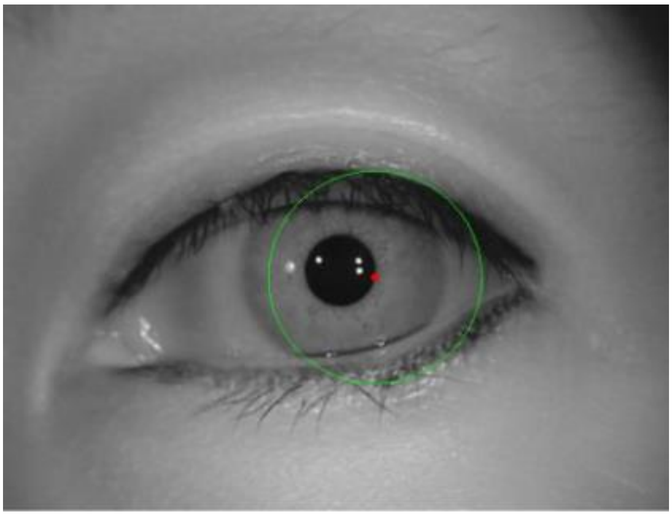

Figure 5. The inner boundary of the Iris

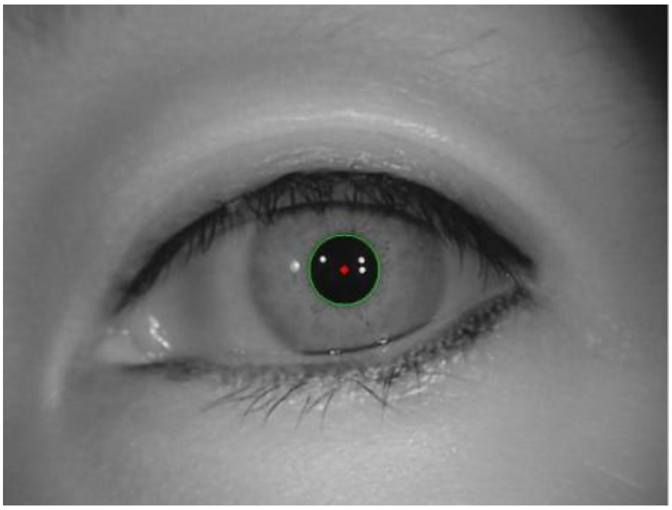

Figure 6. Inaccurate Iris outer detection

Figure 7.Reduced image

Scope Reduction:

Directly performing outer boundary detection after inner boundary detection may yield unsatisfactory results, as depicted in Figure 6. In this scenario, the edge fails to cover the outer boundary of the iris accurately, and the diameter may differ from the actual value due to interference from excessive pixels in the original image. These interfering pixels are challenging to eliminate during image filtering. However, a simple method of reducing the scope can address this issue.

By leveraging the information obtained regarding the pupil, such as its center location and radius, we can estimate the center be used to find the pupil [11]. We use canny edge detection and Hough transform here. The result of pupil segmentation is as shown in Figure 4 and Figure 5 [12]. The location and radius of the iris and subsequently reduce the image scope. The pupil center can serve as the new image center, resulting in a square image with a side length greater than the pupil's diameter. The outcome of this reduction is depicted in Figure 7, where the colors of the original image from Figure 4 have been inverted for enhanced observation.

Iris Segmentation:

Following scope reduction, the image becomes more suitable for boundary detection. Sobel edge detection is employed before...

Hough transform. However, sometimes the image is not good enough for boundary detection, so we may need to perform histogram equalization or adaptive thresholding to optimize the iris image according to the environment. The results of histogram equalization, Sobel edge detection, and outer boundary detection are shown in Figure 8, Figure 9 and Figure 10 respectively.

H. Iris Image Quality Assessment

Although iris recognition has been the most reliable biometric in terms of recognition and identification performance, these iris recognition systems are affected by poor quality imaging.

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