Iris Recognition System

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I. Introduction

Iris recognition is the process of recognizing a person by analyzing the random pattern of the iris (Figure 1). The automated method of iris recognition is relatively young, existing in patent only since 1994.The iris is a muscle within the eye that regulates the size of the pupil, controlling the amount of light that enters the eye. It is the coloured portion of the eye with colouring based on the amount of melatonin pigment within the muscle (Figure 2).

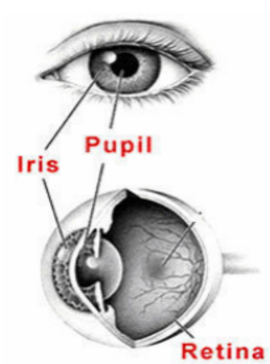

Fig. 1. Human Eye

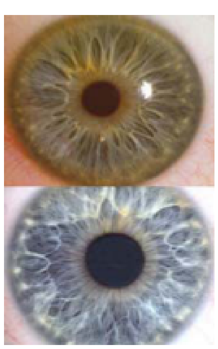

Fig. 2. Colored portion of eye

II. State of the Art and Related Work

There are different biometric authentication systems that are based on the characteristics of an individual. Recognition of face, fingers, voice and iris are among the most used characteristics for recognition. Currently, iris recognition is also used in different security systems, and recently, in clinical application systems.

In [3] it is mentioned that one of the main complications that have arisen to carry out the iris recognition has been the distance in which the image is acquired. When an image is obtained at a distance greater than 3 m, the iris image regularly becomes blurred, and, therefore, deficient in details such as to identify the texture of the iris due to the loss of information compared to images that are obtained at a smaller distance. In [4] other problems are identified, such as movement, lighting and noise, as well as the present refraction in the images. In addition to the obstruction of the eyelids, the use of glasses and hair prevent obtaining a complete image of the iris. It is considered that the fundamental objective of the segmentation process is to extract the iris texture from the structures that surround it, for example, the pupil, the eyelids, the sclera and to eliminate or reduce reflections of light in the iris. In recent years, segmentation methods have been presented with the aim of increasing the percentages of success in the identification. To facilitate segmentation processes, different iris databases have been used, in different sizes, distances and positions.

Study [8] has proposed an automatic segmentation algorithm using the circular Hough transform to identify the Iris pupil boundary and linear Hough transform for detecting the occluding eyelids. To remove the eyelashes and reflections thresholding is employed. The segmented region is normalized using the Daughman's rubber sheet model. The normalized Iris image is convolved with the 1D Log-Gabor wavelets and the resulting phase data is used to extract the feature from the Iris image. And finally for the template matching Hamming distance is employed. This recognition rate achieved a FAR of 0.005 percent and FRR of 0.238 percent for CSISA images.

A. Canny's Edge Detector Method

The identification of shapes by means of their edges in the images facilitates the classification of objects. In order to carry out the identification, some figures can be formed by the edges that compose them. [5] use the Canny's method with the first derivative for edge detection, based on the variation of intensity between pixels.

B. Hough Transform

The Hough transform consists of constructing a parametric space of regular geometric structures. The maximum zones of this space denote the regions with a high probability of finding these structures. Various investigations have shown that it is possible to detect different figures. Investigations have been conducted in which the Hough transform has been used to locate and segment the iris using different methodological approaches that mostly aimed at the elimination of noise, the location of the eye, and location of the center of the pupil, using different techniques to achieve iris segmentation. the Hough transform was used to detect the center of the pupil and from it to project the iris. Using different techniques for the elimination of noise on the images, in [6] the elimination of noise was made by applying a Gaussian filter.

III. Method Description

For this project we decided to develop a functional code for detecting the iris and the pupil. This involves applying image pre-processing operations using the Python programming language, along with some libraries (OpenCV and NumPy), within the Google Colab working environment.

A. Acquisition Phase

The image acquisition was performed from the CASIA-IrisV4 dataset (Chinese Academy of Sciences Institute of Automation - Iris Version 4)[7]. This dataset is renowned for its extensive collection of iris images, widely used for research and the development of recognition algorithms.

B. Pre-Processing Phase

Acquired images went through a previous process also called pre-processing, mainly due to the fact that photographs were obtained by different devices and conditions. Images that were obtained in color were transformed to gray scale in order to work better with them. It is important to note that the original images in the dataset are by default in grayscale. This conversion facilitates subsequent processing, considering that most edge detection and contour analysis algorithms operate efficiently on grayscale images. This image preprocessing step prepares the data for the subsequent stages of our analysis and feature extraction process.

C. Applying Gaussian Filter

The Gaussian filter blurs the desired area and cuts the noise with higher frequencies. It works the same as mean filters while representing average weight uniformly. These are linear filters that reduce the noise and blur the edges effectively. They are created as matrices in digital image processing, passing through each pixel of the selected portion.

Fig. 3. Images before applying Gaussian Filter

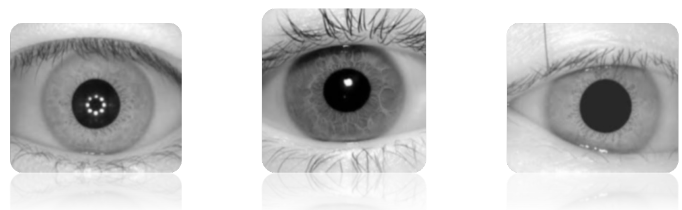

Fig. 4. Images after applying Gaussian Filter

D. Using Canny's Edge Detector algorithm

Canny's algorithm was used to detect the edges present in the image and to facilitate the object identification, mainly circles, by means of the Hough transform. The edge detection was made taking into account the intensity variation existing between one or more regions present in an image.

Points out that Canny's method uses the first derivate for the edge detection, taking into account the intensity: in those regions where the intensity does not change, it is established a value of 0, while in the case of a sudden intensity change, a value of 1 is established. These characteristics are used for edge detection.

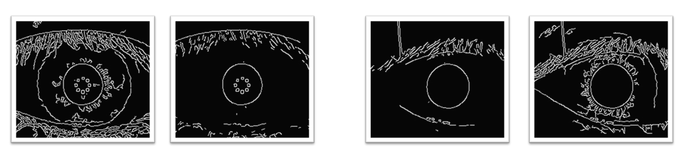

Fig. 5. Images after applying Canny's Edge Detection

E. Applying Hough transform

The Hough transform is a standard computer vision algorithm that can be used to determine the parameters of simple geometric objects, such as lines and circles, present in an image.

The circular Hough transform can be employed to deduce the radius and centre coordinates of the pupil and iris regions.

Firstly, an edge map is generated by calculating the first derivatives of intensity values in an eye image and then threshold the result. From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point.

Here's a simplified explanation of the Hough Transform in the context of iris recognition:

1) Edge Detection: Before applying the Hough Transform to detect the iris, it's necessary to detect the edges of the iris in the image. This can be done using edge detection algorithms such as Canny Edge Detection.

2) Parametric Representation of Circles/Ellipses: The iris can be approximately described by a parametric equation of a circle or ellipse. A parametric equation for a circle, for example, can be written in general form as:

$$(x-a)^2 + (y-b)^2 = r^2$$

where (a,b) is the center of the circle, and r is the radius.

3) Hough Transformation: The goal of the Hough Transform is to identify lines or curves in an image. To detect circles or ellipses, a variant of the Hough Transform known as the Hough Circle Transform is used.

4) Accumulation in Hough Space: Each point on the iris edge is transformed into a curve in Hough space. If multiple curves intersect at the same point in Hough space, it indicates that these points are part of a circle or ellipse.

5) Choosing the Relevant Circles or Ellipses: After accumulation, points of maximum in Hough space indicate suitable circles or ellipses to represent the iris. These points can be identified and used to extract the necessary information for iris recognition.

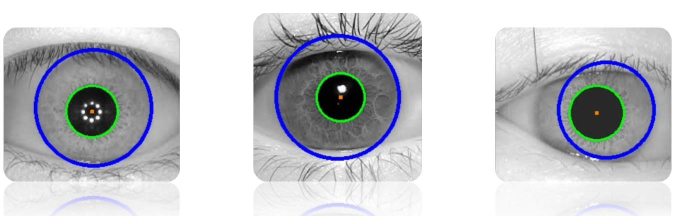

Fig. 6. Images after applying Hough Transform

IV. Preliminary Results

We managed to create a Python script in which we applied the method described above, the final image displaying the original iris image with circles detected in both passes of the Hough Circle Transform. After grayscaling and applying the gaussian filter, Canny's Edge Detection algorithm and Hough Transform were applied twice using different parameters for a better optimization.

V. Preliminary Conclusions

The Hough transform can be used for iris detection due to its circular structure. The definition and the right following up of the process suitable for image processing facilitate the detection and segmentation of the iris.

The algorithm determination to be implemented to achieve segmentation must consider conditions in which the images were acquired and in accordance with the databases used. In this way, each phase of the process will fulfill its function and will contribute to improve the image and to remove elements that are not relevant for the segmentation process.

While we have achieved success in pupil and iris segmentation, challenges persist in handling eyelid occlusion. The algorithm struggles with accurate segmentation when eyelids partially or fully cover the eye. Eyelid occlusion poses difficulties in identifying the complete iris region, leading to inaccuracies in the segmentation process. As it follows, we are going to try to handle the eyelid problem exploring additional image processing techniques, such as contour analysis and convex hull, is underway to address this limitation.

References

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