

IRIS RECOGNITION SYSTEM USING A CANNY EDGE DETECTION AND A CIRCULAR HOUGH TRANSFORM

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ABSTRACT

A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual. Iris recognition is regarded as the most reliable and accurate biometric identification system available. In this paper, we describe the novel techniques we developed to create an Iris Recognition System, in addition to an analysis of our results. We used a fusion mechanism that amalgamates both, a Canny Edge Detection scheme and a Circular Hough Transform, to detect the iris' boundaries in the eye's digital image. We then applied the Haar wavelet in order to extract the deterministic patterns in a person's iris in the form of a feature vector. By comparing the quantized vectors using the Hamming Distance operator, we determine finally whether two irises are similar. Our results show that our system is quite effective.

KEYWORDS: *Bilinear Transformation, Biometrics, Canny Operator, Haar Wavelet, Hough Transform, Iris Recognition.*

1. INTRODUCTION

The term "Biometrics" refers to a science involving the statistical analysis of biological characteristics. Here biometrics is used in a context of analyzing human characteristics for security purposes. This measurable characteristic, Biometric, can be physical, such as eye, face, retina vessel, fingerprint, hand and voice or behavioral, like signature and typing rhythm. Nowadays, security is one of the important factors in the field of information, business, e-commerce, military and etc. For this reason, personal identification has become a significant topic. Some previous methods of identification such as PIN (personal Identification Number), password, ID card and signatures that are used widely, have some drawbacks [1, 2, 3]. ID card or PIN can be stolen, password may be forgotten and signatures can be imitated. Biometric characteristics are used to overcome these problems. Fingerprints, voiceprints, retinal blood vessel patterns can be substituted instead of non-biometric methods for more safety and reliability. The purpose of 'Iris Recognition', a biometrical based technology for personal identification and verification, is to recognize a person from his/her iris prints. In fact, iris patterns are characterized by high level of stability and distinctiveness. Each individual has a unique iris (see Figure 1); the difference even exists between identical twins and between the left and right eye of the same person. [6]

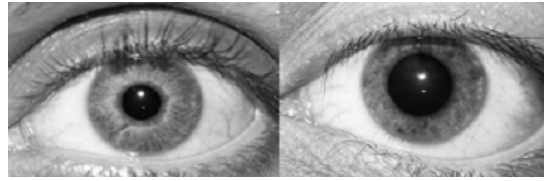


Figure 1: Distinctiveness of human iris

2. IMPLEMENTATION

2.1 Image acquisition

Image acquisition is considered the most critical step in our project since all subsequent stages depend highly on the image quality. In order to accomplish this, we used a CCD camera. We set the resolution to 640x480, the type of the image to jpeg, and the mode to white and black for greater details. Furthermore, we took the eye pictures while trying to maintain appropriate settings such as lighting and distance to camera.

2.2 Image manipulation

In the preprocessing stage, we transformed the images from RGB to gray level and from eight-bit to double precision thus facilitating the manipulation of the images in subsequent steps.

2.3 Iris localization

Before performing iris pattern matching, the boundaries of the iris should be located. In other words, we are supposed to detect the part of the image that extends from inside the limbus (the border between the sclera and the iris) to the outside of the pupil [6]. We start by determining the outer edge by first down sampling the images by a factor of 4, to enable a faster processing delay, using a Gaussian Pyramid. We then use the Canny operator with the default threshold value given by Matlab, to obtain the gradient image.

Next, we apply a Circular summation which consists of summing the intensities over all circles, by using three nested loops to pass over all possible radii and center coordinates. The circle with the biggest radius and highest summation corresponds to the outer boundary. The center and radius of the iris in the original image are determined by rescaling the obtained results. After having located the outer edge, we next need to find the inner one which is difficult because it is not quite discernable by the Canny operator especially for dark-eyed people. Therefore, after detecting the outer boundary, we test the intensity of the pixels within the iris. Depending on this intensity, the threshold of the Canny is chosen. If the iris is dark, a low threshold is used to enable the Canny operator to mark out the inner circle separating the iris from the pupil. If the iris is light colored, such as blue or green, then a higher threshold is utilized.

The pupil center is shifted by up to 15% from the center of the iris and its radius is not greater than 0.8 neither lower than 0.1 of the radius of the iris [2]. This means that processing time, dedicated to the search of the center of the pupil of this part is relatively small. Hence, instead of searching a down sample version of the iris, we searched the original one to gain maximum accuracy. Thus we have determined the boundaries of the iris as shown in Figure 2 and we can then manipulate this zone to characterize each eye.

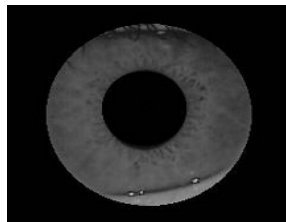


Figure 2: Localized Iris

2.4 Mapping

After determining the limits of the iris in the previous phase, the iris should be isolated and stored in a separate image. The factors that we should watch out for are the possibility of the pupil dilating and appearing of different size in different images. For this purpose, we begin by changing our coordinate system by unwrapping the lower part of the iris (lower 180 degrees) and mapping all the points within the boundary of the iris into their polar equivalent (Figures 3 & 4). The size of the mapped image is fixed (100x402 pixels) which means that we are taking an equal amount of points at every angle. Therefore, if the pupil dilates the same points will be picked up and mapped again which makes our mapping process stretch invariant.

When unwrapping the image, we make use of the bilinear transformation to obtain the intensities of the points in the new image. The intensities at each pixel in the new image are the result of the interpolation of the grayscales in the old image. [4]

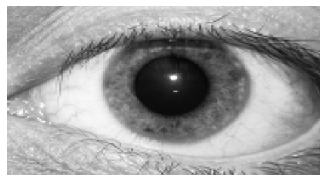


Figure 3. Original image

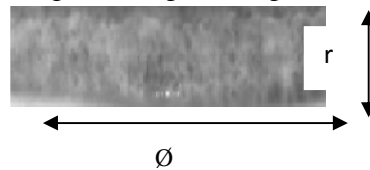


Figure 4. Iris isolated image

2.5 Feature extraction

“One of the most interesting aspects of the world is that it can be considered to be made up of patterns. A pattern is essentially an arrangement. It is characterize by the order of the elements of which it is made, rather than by the intrinsic nature of these elements” (NobertWiener) [4]. This definition sumari- zes our purpose in this part. In fact, this step is responsible of extracting the patterns of the iris taking into account the correlation between adjacent pixels. After performing lots of research and analysis about this topic, we decided to use wavelets transform, and more specifically the “Haar Transform” .The Haar wavelet is illustrated in Figure 5.

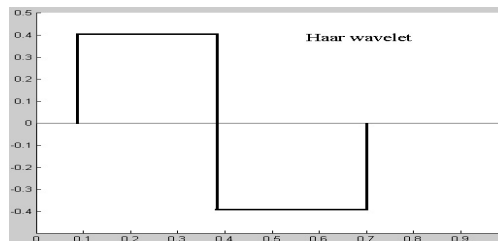


Figure 5. The Haar wavelet

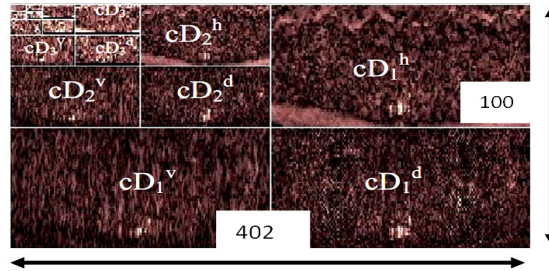


Figure 6. Conceptual diagram for organizing feature Vector

2.6 Haar Wavelets

Most previous implementations have made use of Gabor wavelets to extract the iris patterns [2], [3], [6]. But, since we are very keen on keeping our total computation time as low as possible, we decided that building a neural network especially for this task would be too time consuming and selecting another wavelet would be more appropriate.

We obtain the 5-level wavelet tree showing all detail and approximation coefficients of one mapped image obtained from the mapping part. When comparing the results using the Haar transform with the wavelet tree obtained using other wavelets we found that the Haar wavelet gave slightly better results. Our mapped image is of size 100x402 pixels and can be decomposed using the Haar wavelet into a maximum of five levels. These levels are cD_1^h to cD_5^h (horizontal coefficients), cD_1^v to cD_5^v (vertical coefficients) and cD_1^d to cD_5^d (diagonal coefficients).

We must now pick up the coefficients that represent the core of the iris pattern. Therefore those that reveal redundant information should be eliminated. In fact, looking closely at Figure 6 it is obvious that the patterns in cD_1 , cD_2 , cD_3 and cD_4 are almost the same and only one can be chosen to reduce redundancy.

Since cD_4^h repeats the same patterns as the previous horizontal detail levels and it is the smallest in size, then we can take it as a representative of all the information the four levels carry. The fifth level does not contain the same textures and should be selected as a whole. In a similar fashion, only the fourth and fifth vertical and diagonal coefficients can be taken to express the characteristic patterns in the iris-mapped image. Thus we can represent each image applied to the Haar wavelet as the combination of six matrices:

- cD_4^h and cD_5^h
- cD_4^v and cD_5^v
- cD_4^d and cD_5^d

All these matrices are combined to build one single vector characterizing the iris patterns. This vector is called the feature vector [5]. Since all the mapped images have a fixed size of 100x402 then all images will have a fixed feature vector. In our case, this vector has a size of 702 elements.

This means that we have managed to successfully reduce the feature vector of Daugman who uses a vector of 1024 elements [3]. This difference can be explained by the fact that he always maps the whole iris even if some part is occluded by the eyelashes, while we map only the lower part of the iris obtaining almost half his feature vector's size

2.7 Binary Coding Scheme

It is very important to represent the obtained vector in a binary code because it is easier to find the difference between two binary code-words than between two number vectors. In fact, Boolean vectors are always easier to compare and to manipulate. In order to code the feature vector we first observed some of its characteristics. We found that all the vectors that we obtained have a maximum value that

is greater than 0 and a minimum value that is less than 0. Moreover, the mean of all vectors varied slightly between -0.08 and -0.007 while the standard variation ranged between 0.35 and 0.5.

If “Coef” is the feature vector of an image than the following quantization scheme converts it to its equivalent code-word:

- If $\text{Coef}(i) \geq 0$ then $\text{Coef}(i) = 1$
- If $\text{Coef}(i) < 0$ then $\text{Coef}(i) = 0$

The next step is to compare two code-words to find out if they represent the same person or not.

2.8 Test of statistical independence

This test enables the comparison of two iris patterns. This test is based on the idea that the greater the Hamming distance between two feature vectors, the greater the difference between them. Two similar irises will fail this test since the distance between them will be small. In fact, any two different irises are statistically “guaranteed” to pass this test as already proven. The Hamming distance (HD) between two Boolean vectors is defined as follows [2],[3]:

$$HD = \frac{1}{N} \sum_{j=1}^N (CA(j) \oplus CB(j))$$

where, CA and CB are the coefficients of two iris images and N is the size of the feature vector (in our case $N = 702$). The \oplus is the known Boolean operator that gives a binary 1 if the bits at position j in CA and CB are different and 0 if they are similar.

John Daugman, the pioneer in iris recognition conducted his tests on a very large number of iris patterns (up to 3 million iris images) and deduced that the maximum Hamming distance that exists between two irises belonging to the same person is 0.32 [2]. Since we were not able to access any large eyes database and were only able to collect 60 images, we adopted this threshold and used it.

Thus, when comparing two iris images, their corresponding binary feature vectors are passed to a function responsible of calculating the Hamming distance between the two. The decision of whether these two images belong to the same person depends upon the following result:

- If $HD \leq 0.32$ decide that it is same person
- If $HD > 0.32$ decide that it is different person (or left and right eyes of the same person)

3. RESULTS AND PERFORMANCE

We tested our project on 60 pictures, using a core i3 processor, and we obtained an average of correct recognition of 95%, with an average computing time of 23sec. Table 1 gives the efficiency of each part of the system. The main reason of the failures we encountered is due to the quality of the pictures. Some of these problems are bad lighting, occlusion by eyelids, noises or inappropriate eye positioning.

	Edge Detection	Mapping	Feature Extraction	Binary Code Generation
Efficiency (%)	98	100	98	100

Table 1.Efficiencies of the different parts

4. GRAPHICAL USER INTERFACE

To easily manipulate the images in our database we built an interface that allows the user to choose between different options. The first one is to select two images to compare. The second allows the verification of the correspondence between the name entered and a chosen eye image. The third option is to identify the person through his/her eye.

The iris recognition software that we implemented (Figure 7) is used to secure these three options. The flow chart in Figure 8 shows in detail how the interface we built operates.

5. CONCLUSION

We have successfully developed a new Iris Recognition system capable of comparing two digital eye-images. This identification system is quite simple requiring few components and is effective enough to be integrated within security systems that require an identity check. The errors that occurred can be easily overcome by the use of stable equipment. Judging by the clear distinctiveness of the iris patterns we can expect iris recognition systems to become the leading technology in identity verification.

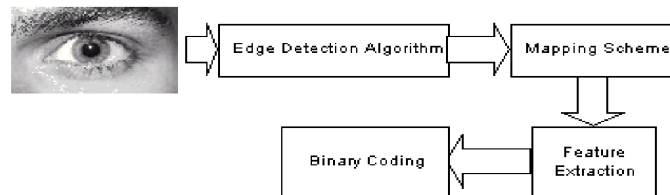


Figure 7. Flow Chart of Iris Recognition

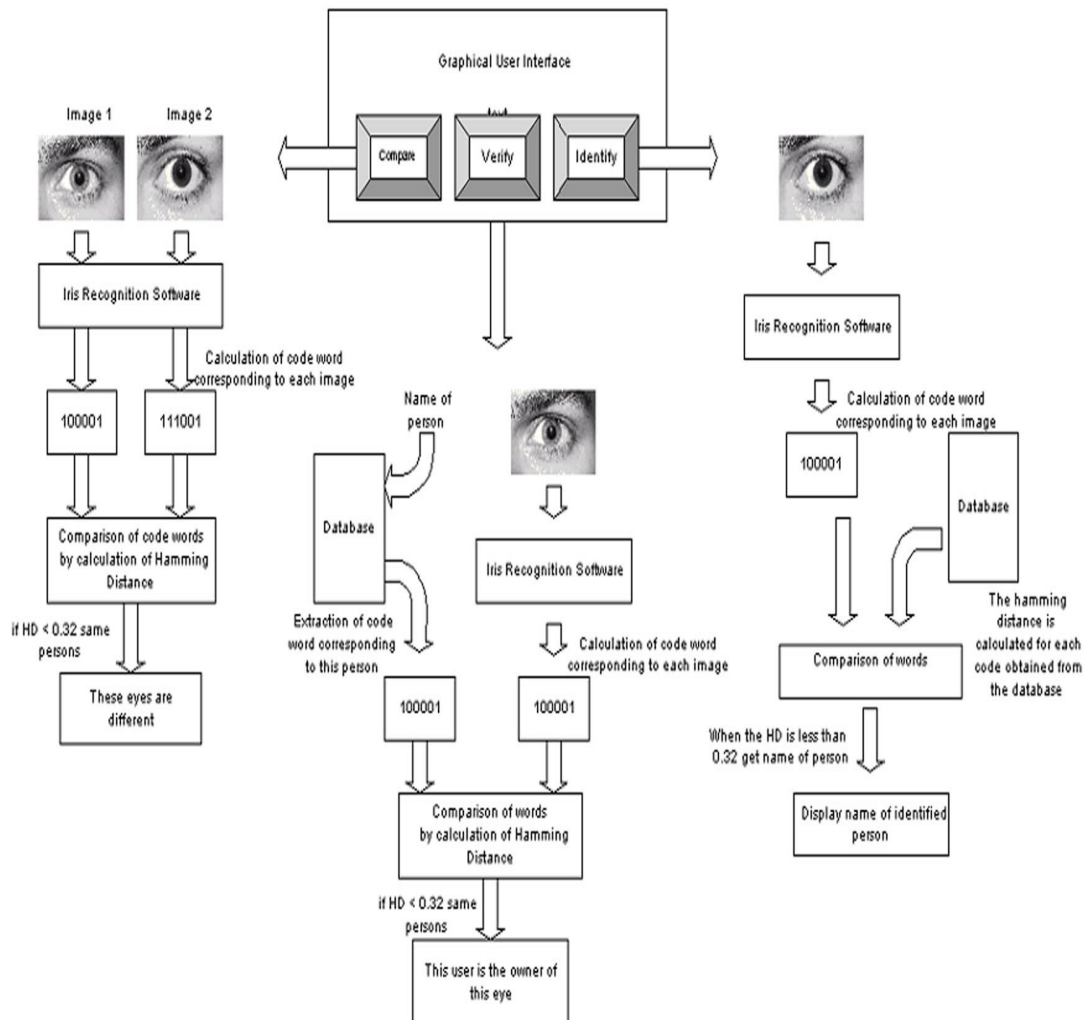


Figure 8. Flow Chart of the Project

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