IRIS RECOGNITION IN NON-COOPERATIVE ENVIRONMENTS

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ABSTRACT

This paper is a work proposed in Pattern Recognition. The project consist in a Iris Recognition.The traditional iris recognition systems achieve low error rates and has been widely used in domestic security systems with good quality images and a big number of restrictions. But generally the images taken are in non cooperative environment, so in this way we need good systems that can handle with this situation, because these conditions are so difficult to get. With all of this restrictions, the traditional methods aren't the best choice for many utilities. In this work, I study and implement a non cooperative recognition iris method based on the combination of local features: Linear Binary Patterns (LBP) and discriminable textons (BLOBs) are presently exploited, which aims to surmount problems with noisy iris images. I'm particularly interested in the effectiveness behaviour of this method by varying the number of samples and the number of subjects used. Experiments were performed using one largely and publicly available data sets in the literature, CASIA and UBIRIS, for analysing the effectiveness in terms of accuracy.

***Index Terms*—** Computer vision; biometrics; Iris recognition; Environment non cooperative;

1. INTRODUCTION

Nowadays, the term biometric(measured crudely life) have been associated with measure of physical features or behavioral of someone, being applied to distinguish each human based on differences in their physical and biological features, so it can be used as a way to identify someone. Biometrics is a recent technology, extremely useful to identify individuals and it works as a password or even better, with the objective of differentiation through the characteristics that are unique for each individual.

Today many parts of the human body can be used for biometric systems, for instance:

- eyes;
- hand palm;
- digital finger;
- retina;
- iris.

The biometric systems are reliable because the premise that each person is unique and retain physical and behavioral characteristics (voice, the way of how someone walks) and many others unique features. Some are very expensive to develop, although efficient, and others are very cheap, but less efficient. We will focus in the iris and develop a system (method) efficient and with low cost.

The main reason to use the iris is that it is one of the body parts with more details, all these come from texture details as freckles, coronas, crypts, grooves and etc. [1]. The formation of the iris depends on the environment in which embryo is formatted, but not totally, and many of your details are not correlate with the genetic load. Each person has a different iris, and this occurs even between of identical twins.

During the aging process, after a certain age, the iris does not change biometrically, this being the most important physiological characteristics. The iris is formed during the first three months in the beginning of the pregnancy, it is completed at eight months (the color may continue to change, but not the main information) and after this time some changes in the texture occurs. When the kid is about two or three years the changes stop.

The aqueous humor and the cornea protect the iris from the environment. This organs prevents or hinders the changing features of the iris. Fortunately, the development of the iris, not the color, do not follow any genetic pattern and it is formed almost entirely in a random way. They make and ensure the uniqueness of iris in each individual.

According Flom & Safir [2], in 1987, the probability of an iris be identical to another is approximately 1 in 10^{72}, for this reason methods based in iris recognition have been studied and proved their accurate and reliable.

One of the most important problem that makes so difficult the iris recognition in noisy environment is the image acquisition, because we can get images with a little information. One of the main obstacle is the low availability of distinctive features in images degraded, acquired in different perspectives lighting, occlusion rate, distance and other reasons.

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With the above factors, it is necessary to studies on extraction methods and iris classification in non-cooperative environments. In the last decade, some researches were developed to deal with the iris recognition in non-cooperative environment and they will be discussed in the next sections.

A typical iris recognize system includes the following five generic steps:

- image acquisition,
- preprocessing,
- segmentation of the iris,
- feature extraction,
- generation of a model,
- classification.

In the image acquisition, we basically take pictures from the environment without restrictions, it can facilitate or not the next steps. The preprocessing is used to clean and remove noisy from the image and to auxiliary the segmentation and the recognition. The next step is the segmentation of the iris, it is the most expensive processing and the result of it can impact the accuracy the whole system, in this part we will separate the iris from the rest of the image. Together with the segmentation we have the post-segmentation where we improve the result of the segmentation. Now we have the feature extraticion where will extract the main information from the iris and the generation of model, in this part we will create a model with the relevant information. The last step is the classification, we have two ways to do this, or we can assume that we have two values, yes or not, yes this iris belongs to some class in our dataset or not otherwise (verification problem), or we can have the problem of to say which class belongs the iris (identification problem). In this paper we will deal with the verification problem.

We will evaluate the accuracy of our method on the CASIA and the UBIRIS, we can see a example of them in the figure 1.

It was verified that LBP-BLOB produced a good results, with accuracy 96.5% of character recognition.

This work is divided as follows, first, in section 2 we show the others works in the literature and in the next, section 3, we introduce some concepts of Iris and in the section 4 we present the idea of the tecniques. Then, in section 5 we will describe the experiments and the results. In the last section, section 6, the conclusions will be presented.

2. RELATED WORK

Generally, all methods of iris recognition are divided in six general steps as follow, although it can have more in order to improve the accuracy of the system, like presegmentation, posegmentation and posrecognition for instance:

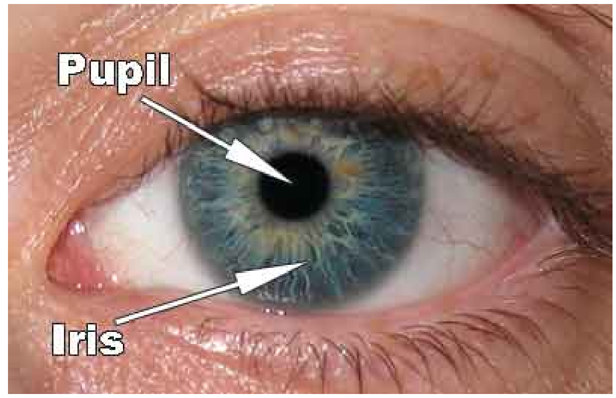


Fig. 1. Example of iris.

1. image acquisition,
2. segmentation of the iris,
3. normalization,
4. feature extraction,
5. representation of features (in a binary vector, for instance).
6. classification.

The most common step to do the segmentation is to locate the pupil contour and after the limbic contour. In [3], Li et. al. proposed a specific edge detector, because state-of-the-art methods are based on edge information, but it generate a large number of noisy.Basically they train a boundary detectors using Adaboost, after they do localization of pupillary and limbic boundaries, but in most cases the eyelids insert noisy in the iris, to avoid this are the eyelids localizartion. To improve the results of the segmentation, Li et. al. proposed another method in [4], the main difference between it and the other is that they used Adaboost in cascade.

In [5], Uhl and Wild detect and remove the reflexions to improve a better results in segmentation, after this, they detect corners and edges to remove possible eyelashes and finish with delimiting the pupil and the limbic. Already in [6], the authors divided segmentation in 4 steps, segment the iris in a brute way, locate pupillary, limbic, eyelid and eyelash and refine the first segmentation.

In normalization we just convert the segmented iris, which is in cartesian coordinates, in a rectangle area, which is is polar coordinates and origin is pupil center. This whole method was proposed by Daugman in 1993 [7].

A method very grounded in literature to extract features of normalized image and create a features vector is the Gabor Filter 2D, this features vector is the *Iris code*. This model of [7], though not robust when used in noisy images, it stills as reference to create iris recognition models.

Exists works in literature that extract features in different regions of the eye, like [8, 9, 10, 11]. In [8], *zigzag collarette* is used to extract features. Some methods use others iris aspects: ordinal measures and color analysis, and eyes: *texton* and semantic information, this approach is present in [9]. The periocular region also provides good characteristics, so in the works [10, 11] both do a combination of these features extracted with the iris features.

Proença and Alexandre [12] divide the iris in six independent subregions getting six dissimilarity values that are fused through a classification rele, the division occurs to avoid noisy and loss of biometric signature. Similar strategies are used en [13, 14]. In [15], iris is divided in small fragments without superposition, in each fragment is used the strategy of *Weighted Co-occurrence Phase Histogram* (WCPH) to represent texture pattern of each one.

Other papers are focused in compare performance of differents strategies. In [16], the features extracted from the filters *Log-Gabor*, *Haar wavelet*, *Discrete Cosine Transform* (DCT), and *Fast Fourier Transform* (FFT) are compared. [17, 18] use *Discrete Wavelet Transform* (DWT) and a ideal subset of Gabor group to extract features respectively. Marsico et. al. [19] combine two techniques, *Linear Binary Patterns*(LBP) and *Discriminable Textons*(BLOBs), LBP produce a local texture description and BLOB uniqueness of the texture(furrows, crypts and spots).

Daugman [7] also proposed a method to classify, he uses the Hamming Distance to calculate the dissimilarities between two images. It is possible fing similar process like in [17, 20].

In [8, 15] the focus was classification. In [8], SVM was used together with Haar Wavelet, if classifier doesn't indicate any class, the filter LoG(operator Laplacian together Gaussian filter) with Gabor 2D and the Hamming Distance are used to extract new features, after this applies again classification. In [15], *Matching* is used based on *Bhattacharyya Distance* and *Image Registration* using *Simple Image Patch Registration Method* to find the distance between two images.

3. THEORETICAL FOUNDATION

To this paper we disconsidere the color of the image, since it can change the color because of the light, so it can affect the whole system.

We divided the pipeline of our system in four steps: segmentation, normalization, feature extraction and the classification. Basically the normalization is to transform the iris segmented in a rectangular region to the next step (feature extraction).

Usually, in the act of normalize an image we basically convert the cartesian coordinates representation in polar coordinates space, and the origin is at the center of the pupil. This model was proposed by Daugman, in 1993 [7].

We can see the rectangular region in the figure 2.

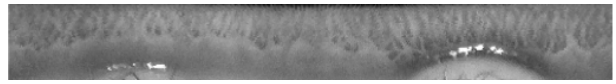


Fig. 2. Example of a rectangular region.

4. IMPLEMENTATION

To evaluate the results of the method that we are studying we will compare it with others method, for instance we will compare the results with a very famous feature extractor of literature, HoG[1], we use that because it is a very used method in literature and we have good results with this in others problems.

All the experiments were executed in a intel core i7 with 6Gb of RAM and the code was developed in Matlab.

The system is divided in three parts, the segmentation, feature extraction and the classification.

4.1. Segmentation

To segment iris, we first mark the image manually, separating the area of interest from the rest, first we draw a red ellipse separating the iris and the pupil and second we draw a green ellipse separating the iris from the sclera. After this process we use a ready method to segment and normalize the image[21]. We did it to the UBIRIS dataset, to the CASIA we did not have to segment manually. If the segmentation fail the system will fail as well, so this step is very important.

4.2. Feature Extraction

To extract the main information of the iris we use four approaches, Linear Binary Patterns (LBP), BLOB, the fusion between the both and HoG.

4.2.1. LBP

That method was proposed by [22] to analyse the image texture. There were variations like [23] and [24]. The computation consists in take a pixel and your eight neighbors, then if neighbor's value is less than the central pixel, we put zero in its place, otherwise we put one. At this process we create a binary vector taking the left pixel and run from left to right taking the rest, then the binary vector is transformed in decimal number, this process is show at the figure 3.

This method is very used as a local texture descriptor and to identify quite regular patterns. It is very appropriate to analyse images with high resolution, because it has a low computational cost.

In [25], Ojala proposed a change in the LBP, basically they extended to process pixel neighbourhoods of variable dimension and turn the method invariant to rotations.

[1]The code can be found in http://www.vlfeat.org/

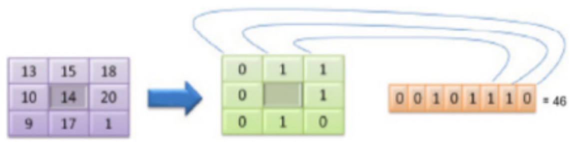
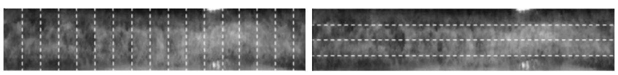


Fig. 3. Process of LBP.

In [26], they subverted the idea of [27] and instead of doing the usual method, Sum divide image into blocks and calculate histograms of them, although the method of [19], different of [26] divided the image into bands(horizontal, figure4(a), or vertical, figure4(b)) as in figure 4. The number of bands is very connected to the normalization parameters.

To measure the distance between two images, we calculate the distance between their respective histograms by correlation, or intersection or Bhattacharyya.



(a) Iris divided vertically (b) Iris divided horizontally

Fig. 4. Iris divided into bands.

4.2.2. *BLOB*

The BLOB is used to extract uniqueness of the iris texture, that occurs in the form of irregular distribution of local feature blocks composed by furrows, crypts and spots. It is also used to identifying lighter or darker regions in the iris. This method was proposed by [28, 29].

The method consists in apply the Laplacian Operator with Gaussian filter(LoG). The Laplacian Operator is a contour detector, although it is sensible to noise, so to minimize it we use the Gaussian filter to smooth the image, thus reduce noise.

The LoG was applied four times with different arguments, the results are shown in figure 5, this result, for each argument, is a matrix with positive and negative values, after that is calculated the max of pixels in the same positions in differents bands. After that, the positive values are converted to one and the negative, zero.

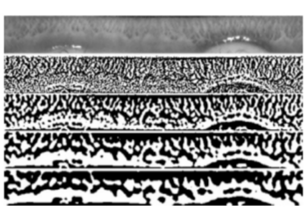


Fig. 5. Application the arguments in LoG.

4.2.3. *LBP-BLOB*

The result of LBP and BLOB fusion is average between LBP and BLOV results, so, in this way, durring the encoding and matching a method does not affect the other.

The fusion between of the methods can be describe as:

$$\delta(c1,c2)=\frac{\delta_{LBP}(C_{1,LBP},C_{2,LBP})}{2}+\frac{\delta_{BLOB}(C_{1,BLOB},C_{2,BLOB})}{2} \quad (1)$$

Basically, the arithmetic average.

4.3. Classification

We classify the new examples in two different ways, first, we compare the images with hamming distance(BLOB) or histogram intersection(LBP), second, we use SVM.

5. EXPERIMENTS AND RESULTS

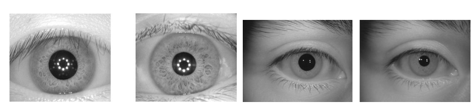
We first describe the dataset used, after the experiments and in the final the results we obtained.

5.1. Dataset

All experiments was did in two famous public dataset in the literature, CASIA [30] and UBIRIS [31]. The both datasets have more than 1000 images.

We will use the dataset CASIA-IrisV4, it is one of the most used to test iris recognition system. It contains a total of 54.601 iris images of more 1.8000 natural individuals and 1.000 virtual individuals.

In figure 6 we have examples of the images that we can find in the [30]. The images from this base follow a pattern where the iris is in image center.



(a) Example 1 (b) Example 2

Fig. 6. Images of the dataset CASIA

For UBIRIS we will use UBIRIS-V2 [31], in this dataset we find images that try to represent realism of a non-cooperative environment with more noisy factors. The images were captured on non-constrained conditions, we have images at-a-distance, on-the-move and on the visible wavelength (more realistic noise factors).

In this database we have 261 subjects with the both iris (522) and 11 images per individual. There are more men(54.4%) than woman(45.6%) with all ages.

In figure 7 we have examples of the images that we can find in the [31]. In this base, people can be walking at a slower than normal speed and to look at some lateral marks that force them to rotate the head and eyes.

(a) Example 1 (b) Example 2 (c) Example 3

Fig. 7. Images of the dataset UBIRIS

5.2. Experiments

We did a several experiments with the LBP, BLOB and LBP-BLOB, however LBP-BLOB generated the best result with an accuracy 96.5% in CASIA and 57% in UBIRIS of iris verification.

From the whole dataset, we get 600 from each. We are working with verification problem, so put 200 images from 40 different classes and more 400 from 80 different classes.

Extractor	**Classifier**	**AIR(%)**[2]
LBP	Intersecting vectors	80.25
BLOB	Intersecting vectors	92.5
LBP-BLOB	Intersecting vectors	96.5

Table 1. Results in the database CASIA

Extractor	**Classifier**	**AIR(%)**
LBP	Intersecting vectors	57.00
BLOB	Intersecting vectors	50.00
LBP-BLOB	Intersecting vectors	49.75

Table 2. Results in the database UBIRIS

5.3. Results

In figure 8, it is possible to check the ROC curve. We can see that LBP-BLOB produce a better result than others.

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6. CONCLUSION

In this paper the proposed method by [19] was implemented. This method has three approaches to iris recognition: LBP, BLOB and fusion of both. LBP divides the iris in bands and calculate histograms in each, that will be compared with others histograms of others images. BLOB is the maximum of each pixel between different images underwent LoG with will be compared with other.

[2] Accuracy of Iris Recognition

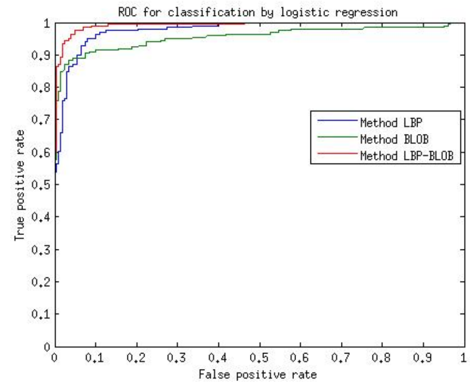

Fig. 8. Results in CASIA

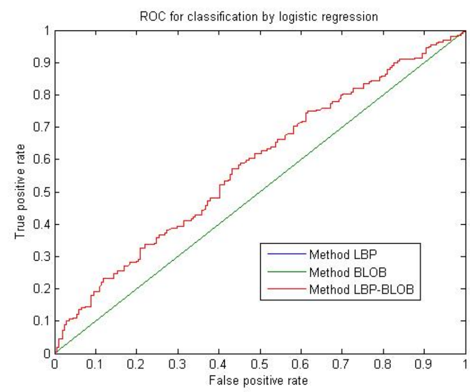

Fig. 9. Results in UBIRIS–

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