A Fast Iris Location Based on Aggregating Gradient Approximation Using QMA-OWA Operator

Yuniol Alvarez-Betancourt and Miguel Garcia-Silvente

***Abstract*— A very robust biometric for the identification of humans is Iris Recognition. In order to recognize the Iris the determination of its exact location is required. The contemporary localization approaches, although accurate, often require a very long calculation. This paper presents an Iris Location method that is both accurate and fast. The approach relies on the detection of circular boundaries under an approach of gradient analysis in points of interest of successive arcs. The quantified majority operator QMA-OWA[20] was used in order to obtain a representative value for each successive arc. The identification of the Iris circular boundary in an image portion will be given by obtaining the arc with the greatest representative value. Thus, a fast algorithm of identification of circular boundaries is obtained from an aggregation process, guided by the linguistic quantifier *many*. The experimentation was developed upon the image database CASIA-IrisV3.**

I. Introduction

Biometrics is the science and technology of measuring and analyzing biological data. Within this field, there are several well studied topics like Fingerprint recognition, Face recognition, Gait recognition, Iris recognition, Retinal recognition, Hand geometry measurement, Dynamic signature verification. The study of the iris is one of the most relevant topics.

Iris recognition has been classified as one of the most robust methods for human identification. The importance of the iris lies mainly on the fact that it remains unalterable during our whole life and it is different and unique for each person (it allows even to distinguish twins). Consequently, Iris recognition has become one of the most accurate and reliable methods within biometrics. Likewise, it also stands out for its non invasive process, i.e., the capacity to capture the biometric features without the need of physical contact with the subject to be analyzed.

The process of Iris recognition is composed by several stages of great importance. Among those stages are: image acquisition, iris location, iris extraction and subject identification. In Figure 1, it is possible to appreciate an eye with its iris between two non concentric arcs and the corresponding Iriscode in the top. In Figure 2, the Iriscode appears in more detail. The main idea of these stages relies upon the statistical techniques (such as: pattern recognition in signals, comparison and so on) or upon Soft-computing techniques (fuzzy logic, neural networks, genetic algorithms, etc). Likewise, several approaches have been developed [1–11] in order to manage the process of Iris recognition. Every stage has multiple associated issues that make more difficult to obtain relevant information. As result of these issues, several alternatives have been proposed recently. In [12] the multispectral acquisition method is proposed. The goal of this method is to try to remove different kinds of noise using the most appropriate channel of the spectrum. The codification is another critical aspect, gabor wavelet was initially proposed [2] but exists other options like the Discrete Cosine Transform (DCT) [13] and, consequently, different matching processes. Also, several alternatives to match measures have been proposed, for example, in [14] a measure that manages elastic changes in the iris texture is used. Finally, another example could be to segment the iris using active contours [15] or to compensate the deformed angle of the information in the acquisition [16]

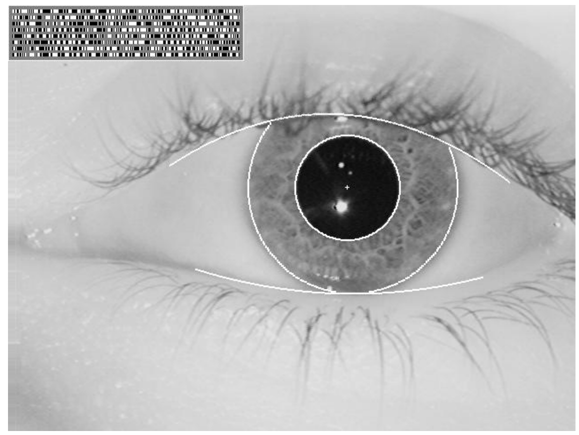

Fig. 1. Iris recognition system

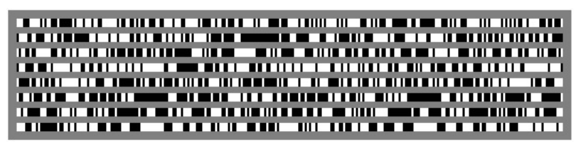

Fig. 2. Iris-code

The stage of Iris location is generally carried out after preprocessing the acquired image. This preprocessing is applied with the purpose of highlighting some details of the image which have resulted in degradation during the acquisition. The location of the Iris is an important step in the Iris recognition process, because if it is incorrectly accomplished, the resultant noise (e.g., eyelashes, reflections,

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pupils, and eyelids) in the image may cause a big degradation of the resulting iris code and so a low performance in the Iris Recognition Systems (IRS). For the location of the Iris, several approaches have been proposed, some with a higher technical support and some more practical funded. Although in both cases satisfactory results have been obtained, they cannot be considered conclusive in some situations.

Iris localization has several issues: lighting conditions, specular reflectance, occlusions by eyelids, and so on. There are several open tasks in this field:

- to improve localization, and
- to reduce the running speed in order to be able to apply it to thousands and, even, millions of irises in order to identify a person in a very large database.

One of the most frequently used methods is the proposed by Daugman [2], which defines an integro-differential operator to identify the circular borders present on the images. It results very useful to detect the inner and outer limits of the Iris. This operator takes into account the geometry of the Iris (circular shape) in order to find its correct position, by maximizing the partial derivative with respect to the radius, which progressively increases with the amplitude of the analyzed arcs. Then, a throughout search is carried on in order to locate the pupil boundary.

Wildes [1] proposed another relevant method, It locates the Iris by using border detection and the Hough transform. First, the Iris is isolated by using Gaussian filters of low pass followed by a spatial sub-sampling. Afterwards, the Hough transform is applied and, from them, those elements that better fit a circle according to a defined criteria are selected.

Another method is presented by Boles and Boashash[28]. They used a differential type of filtering with Laplace or Gauss convolutions, that obtains information of the smooth intensity variations on the image.

Huang and Chen [29] use a similar method to Daugman's [2]. They improve the speed using an identification strategy of the transformation of the texture in the boundaries from a thick one to a thin one. This step takes place during the process of contour search. With this purpose, a re-scale of the image, a filtering and the extraction of the boundary with a Canny operator is performed. These operations are made over an image with both eyes of the analyzed person. The left one is used to make the recognition and to establish the direction the person is looking towards, and the right one permits to estimate the gaze direction.

Tisse et al. [23], present another modification of Daugman's algorithm. This new approach applies a Hough transform on a gradient decomposition to find an approximation of the pupil center. Subsequently, the integro differential operator is applied to specify the location of the Iris boundaries. This combined approach has the advantage of eliminating the errors caused on the images due to specular reflections.

Likewise, Cui et al. [25] present a new Iris localization approach. First, they utilize the information of low frequency of wavelet transform of the iris image for pupil segmentation and localize the iris with an integro differential operator. Then, the upper eyelid edge is detected after the eyelash is segmented. Finally, the lower eyelid is localized using a parabolic curve fitting based on the gray value segmentation.

Another approach is presented by Sung et al.[30], which consists of the use of traditional methods, such as equalization of the histogram and high pass filtering, in order to find the boundaries of the Iris.

J. Gil et al.[19] employ two different strategies to locate inner and outer Iris contours. For locating the inner contour of the Iris the Daugman's integro differential operator defined in [2] is used. For determining the outer boundary of the Iris three points of it are detected, which represent the vertexes of a triangle inscribed in a circumference and that models the Iris boundary.

F. Silva et al.[31] use an Adaboosting technique for locating circular objects which models the inner and outer boundaries of the Iris. They also employ an algorithm based on elements of analytic geometry, which particularly determines the bounded circumference of a tangential square that encloses the pupil and iris.

In another more recent research [9], Daugman presents a new method of detection and modeling of the inner and outer boundaries of the Iris based upon active contours. He also presents an approach based on the Fourier transform to estimate gaze direction performing projective transformations. Besides, he presents methods of statistical inference for detecting and excluding the eyelashes of the Iris image.

H. Liang [32] adjusts the contrast in an image to segment it through a threshold, taking into account threshold T. This threshold is experimentally obtained by means of the Otsu's method [33].

Z. He et al. [11] present a new segmentation method based on the assumption that this stage represents an essential module on Iris recognition, since it defines the useful portion of the image for the subsequent processing, such as feature extraction. In the first stage of this research, the image specular reflections are eliminated and an initial approximation of the Iris center is obtained by using the cascaded Adaboost technique. Later, the points of the Iris boundary are detected by using a pulling and pushing model based on the Hooke's law. Under this approach, the Iris center and the radius of the Iris boundaries are refined, matching force restoration of Hooke's law.

Classic works [1][2] are based upon the exhaustive search for circles on the entire image, which makes them expensive due to time consuming and computer processing. Another problem is given by the nature of the methods, they are based on circle detector models and may lead to unsuccessful segmentation guided by results of local maxima, obtained from non circular boundaries of the Iris.

This paper presents a new approach on Iris location. It is based on detection of circular boundaries. The proposed approach relies on the analysis of gradient approximations on points of interest of successive arcs. It allows calculating the representative value on each successive arc as a result of the fusion of points of interest among the gradients points using the quantified majority operator **QMA-OWA** [20]. The identification of an Iris circular boundary in an image portion will be given by obtaining the arc with the greatest representative value. In addition, we propose a preprocessing step that reduces the detail of the images. The idea is to lighten the detection of local maxima on non circular boundaries that may yield erroneous segmentation. Then, an initial approximation of the pupil center is obtained, which constitutes the reference to start the detection of circular boundaries. This way, the computational cost is significantly minimized. Under this methodology of Iris boundaries location, the responsibility of the verification of the existence of an Iris in the image is given in the acquisition stage. Therefore, a better performance and response time for the Iris Recognition System is obtained.

The overall structure of this paper is as follows. Section II describes the main contributions of this work. Section III shows the results obtained on the research made with the proposed algorithm. Finally, section IV presents the conclusions of this work.

II. Iris Location Algorithm

The Iris is an internal organ of the eye located behind the cornea and the aqueous humor. It consists of a weave of connective tissues, fibers, rings and colours which constitute a distinctive and unique mark of people when it is observed from a short distance.

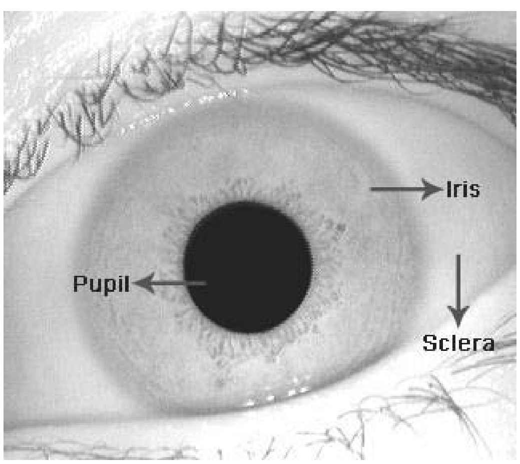

Fig. 3. Structure of the human Iris

By observing the Iris from the center of the circle which models the inner boundary up to its outer boundary, two delimiting borders can be identified (see Figure 3). The first one, Pupil - Iris, is defined by the shift of the intensity lower values (pupil area) of the image to middle intensities which characterizes the Iris region. The second border, Iris - Sclera is characterized by the shift of middle values of intensity to the highest values (sclera area) of the image. Besides, its geometric character (circular or elliptical shape depending on the point of view) constitutes another characteristic of great importance for automatic detection. Most of the approaches for Iris location exposed in the specialized bibliography have as their main objective the search of circular objects inside images.

Taking into account the mentioned above, the analysis of gradient variations for detection of the inner and outer boundaries of the Iris, turns interesting. Therefore, starting from an initial approximation of the center of the pupil, the appearance of circular borders towards the left, right, up and bottom, can be detected. Points of interest which belong to successive arcs, fitting portions of the Iris border are obtained in this way. On each analyzed arc, approximations of gradient variations on each point of interest with respect to the corresponding point in the following successive arc are obtained. Also, a representative value of each successive arc under an approach of group decision making is calculated.

One of the main problems on group decision situations is to find aggregation processes which consider all the opinions exposed by the individuals involved in the process. So, it is required that most of the expert criteria about the problem to solve are reflected in a positive way in the final result. The operators which are generally used in the aggregation processes produce results which can be considered inadequate from a group point of view, causing the so-called problems of negotiation and distribution. The distribution problems are mainly due to the way in which different alternatives or criteria are considered within the aggregation process. Group formation is carried out through negotiating processes in which participants progressively approximate themselves as the distance which separates them reduces.

Consequently, the operator of quantified majority **QMA-OWA** [20] was selected in order to obtain a representative value of each arc. This operator obtains the final value as a result of an aggregation process of gradient variation approximations. This aggregation process is guided by a linguistic quantifier *many*. Finally, the arc which fits better an Iris circular border is the one which obtains the highest value of the aggregation of gradient approximation variations.

Below, each one of the stages of the proposed location method is described in detail. The main contributions of this research are presented by means of mathematical models and images which show the results on each one of the stages.

A. Preprocessing

The stage of Iris image preprocessing intends to prepare the image to guarantee that the circular boundaries detector algorithm does not reach local maxima on non circular Iris boundaries.

In this sense, a median filter is applied to smooth the details of the Iris image. The median filter is implemented with a convolution mask 15 X 15. This way, all the details of the image which may cause erroneous segmentations of the Iris region are eliminated in an efficient way. Also, the negative effect of the specular reflections [17] in the Iris location process is mitigated. Figure 4 shows the results of applying a median filter on the raw image.

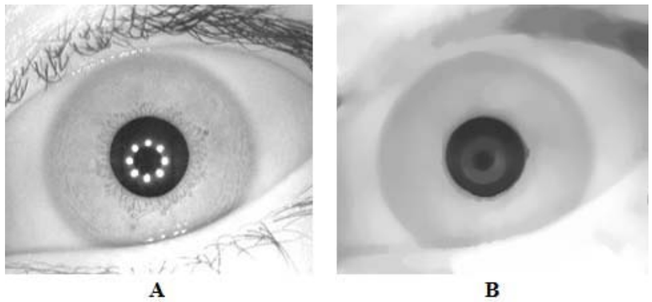

Fig. 4. **A**. Raw image. **B**. Resulting image after applying a median filter

B. Initial approximation of the pupil center

In order to obtain an initial approximation of the center of the circle which models the pupil boundary, an image threshold is performed. Because of the usual characteristics of iris images, the Otsu thresholding method [33] is usually a very appropriate algorithm. It is intended to highlight the pupil contour to facilitate its recognition. Figure 5 shows the results of the threshold. Otsu's Method is interesting due to its simplicity in run time computation and its statistical fundamentals.

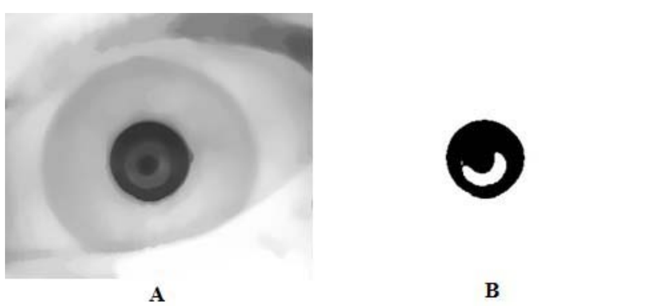

Fig. 5. **A**. Smoothed image. **B**. Thresholded image

Then, by using the method cvFindContours of the digital image processing library OpenCV[18], a set of contours of threshold image $C = \{c_1, c_2, ..., c_n\}$ is obtained. Where c_i has a set of points $P^i = \left\{p_1^i, p_2^i, ..., p_m^i\right\}$ which characterize the contour intensities.

Given these definitions, c_0 is the contour representing the pupil in a more suitable way if it is the contour having the major amount of points and $T = \underset{c_i \in C}{arg\min} S\left(c_i\right)$, $S\left(c_i\right) = \sum\limits_{p_j^i \in c_i} p_j^i$ where the p_j^i are obtained from the raw image. Therefore, the center point $V_0(X_0, Y_0)$ of the contour c_0 is obtained as a result of calculating the rectangle center which circumscribes the contour.

*C. Majority quantified operator (**QMA-OWA**)*

In order to obtain a final consent value on problems of group decision, several fuzzy techniques have been proposed. On this type of techniques an aggregation is done, guided through the concept of fuzzy majority. This concept of fuzzy majority is modeled by using linguistic quantifiers, such as *80% at least* and *many*. A linguistic quantifier is formally defined as a fuzzy subset within a numeric field. The semantic of a fuzzy subset is represented by a function of membership which describes compatibility of an absolute or percentage value with respect to the concept expressed by the linguistic quantifier [21]. This way, the linguistic quantifier can be seen as a fuzzy concept referring to the quantity of elements to consider in the reference set (see Figure 6).

$$Q_m\left(x\right) = \begin{cases} 1 & x \geq 0.9 \\ 2x - 0.8 & 0.4 < x < 0.9 \\ 0 & x \leq 0.4 \end{cases}$$

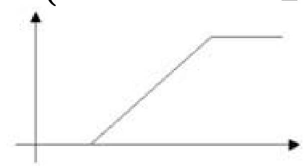

Fig. 6. Definition of the linguistic quantifier *many*

The operators OWA (Ordered Weighted Averaging) [21] represent the beginning of a series of operators which hold the concepts of group decisions taking. This kind of operators implement the concept of aggregation guided by quantifiers. The quantified majority operator **QMA-OWA** [20] develops from the application of the normalization of the MAOWA [20] operator. This normalization allows the guiding of the process of aggregation, indicating the degree on which each member of the set of alternatives represents the majority. Likewise, the operator **QMA-OWA** constitutes an important technique for the development of the Iris location stage. Regarding this subject, the circular boundaries which maximize the majority of gradient variations on points of interest are determined.

The election of this operator was made empirically. This operator results interesting because is sensitive to sudden changes in the information. And inner and outer iris contour match this circumstance.

Definition: The operator **QMA-OWA** [20] is a function $F_{QMA} : R^n \times N^n \to R$ defined as:

$$F_{QMA}\left(a_1, a_2, ..., a_n\right) = \sum_{i=1}^{n} w_i^Q \cdot b_i =$$

$$\sum_{i=1}^{n} f_i \cdot \left(b_1, b_2, ..., b_n\right) \cdot b_i \tag{1}$$

Where $w_i^Q \in [0, 1]$ with $\sum\limits_{i=1}^{n} w_i^Q = 1$ and b_i is the i-th element of the bag $\left(a_1, ..., a_n\right)$ ordered ascendant according to cardinalities δ_i.

The calculation of the aggregated weights is performed in the following way:

$$w_i^Q = w_i^N \cdot Q\left(\frac{i}{n}\right) + \left[Q\left(\frac{i}{n}\right) \cdot \frac{1 - \sum\limits_{i=1}^{n} \left(w_i^N \cdot Q\left(\frac{i}{n}\right)\right)}{\sum\limits_{i=1}^{n} Q\left(\frac{i}{n}\right)}\right] \tag{2}$$

, being Q the linguistic quantifier *many*.

The calculation of weights w_i^N is done the following way:

$$w_i^N = f_i\left(b_1,...,b_n\right) = \frac{\gamma_i^{\delta_{\min}}}{\theta_{\delta_{\max}} \cdot \theta_{\delta_{\max}-1} \cdot ... \cdot \theta_{\delta_{\min}+1} \cdot \theta_{\delta_{\min}}} + \frac{\gamma_i^{\delta_{\min}+1}}{\theta_{\delta_{\max}} \cdot \theta_{\delta_{\max}-1} \cdot ... \cdot \theta_{\delta_{\min}+1}} + ... + \frac{\gamma_i^{\delta_{\max}}}{\theta_{\delta_{\max}}} \quad (3)$$

where $\gamma_i^k = \begin{cases} 1 & \delta_i \geq k \\ 0 & \text{otherwise} \end{cases}$

and $\theta i = \begin{cases} (\mathrm{T} \geq i) + 1 & i \neq \delta_{\min} \\ \mathrm{T} \geq i & \text{otherwise} \end{cases}$

Being δ_i the cardinality of the element i with $\delta_i > 0$, and T is the amount of elements with same cardinality.

The majority of the operators execute the aggregation according to the value δ_i which generally takes the cardinality value from the i-th element to represent its importance in the aggregation. In most of the processes, the formation of discussion groups or majority groups is considered according to its similarity or distances among the opinions of the experts, in a way that all the values within a separability distance are considered within the same group.

The most used method for calculating cardinality δ_i is:

$$\delta_i = \sum_{j=1}^{n} dist\left(a_i, a_j\right) \quad (4)$$

where $dist\left(a_i, a_j\right) = \begin{cases} 1 & |a_i - a_j| \leq x \\ 0 & \text{otherwise} \end{cases}$

The x value represents the flexibility of the final size of each group formed by the decision makers. It was selected $x = 20$ in the case of detection of circular borders of the Iris.

D. General formulation of the proposed algorithm

In order to determine the circular boundary which represents the inner or outer boundary of the Iris in a better way, the following problem is formulated as to determine the radius $r_s^* \in R$, $R = \{r_{\min}, r_{\min}+1, ..., r_{\max}-1, r_{\max}\}$ of the circle with center $P\left(X_0, Y_0\right)$ such as:

$$r_s^* = arg \max_{r \in R} D_s\left(r\right) \quad (5)$$

$$D_s\left(r\right) = \underset{(x_i,y_i)\in C_s(r,X_0,Y_0)}{F_{QMA}} \left(\frac{\partial f(x_i,y_i)}{\partial s}\right) = \underset{(x_i,y_i)\in C_s(r,X_0,Y_0)}{F_{QMA}} \left(f\left(x_i + \Delta_{sx_i}, y_i + \Delta_{sy_i}\right) - f\left(x_i, y_i\right)\right) \quad (6)$$

where $C_s\left(r, X_0, Y_0\right)$ is the set of points of interest belonging to the semicircumference in the sense $s \in S$, $S = \{left, right, top, bottom\}$ such as:

$$C_{left}\left(r, X_0, Y_0\right) = \{(X_0 - r, Y_0)\} \cup \left\{\left(x_i, y_i\right)/y_i = y_{i-1} \pm i; x_i = X_0 - \sqrt{r^2 - \left(y_i - Y_0\right)^2}\right\} \quad (7)$$

$$C_{right}\left(r, X_0, Y_0\right) = \{(X_0 + r, Y_0)\} \cup \left\{\left(x_i, y_i\right)/y_i = y_{i-1} \pm i; x_i = X_0 + \sqrt{r^2 - \left(y_i - Y_0\right)^2}\right\} \quad (8)$$

$$C_{top}\left(r, X_0, Y_0\right) = \{(X_0, Y_0 - r)\} \cup \left\{\left(x_i, y_i\right)/x_i = x_{i-1} \pm i; y_i = Y_0 - \sqrt{r^2 - \left(x_i - X_0\right)^2}\right\} \quad (9)$$

$$C_{bottom}\left(r, X_0, Y_0\right) = \{(X_0, Y_0 + r)\} \cup \left\{\left(x_i, y_i\right)/x_i = x_{i-1} \pm i; y_i = Y_0 + \sqrt{r^2 - \left(x_i - X_0\right)^2}\right\} \quad (10)$$

with $i = 1, ..., m$

Likewise $f\left(x_i, y_i\right)$ represents the intensity of a pixel of the image F, in coordinates (x, y). Details of gradient approximation are provided in the Appendix.

In Figure 7 the increments of the radius to search for circular borders in the S sense are visualized.

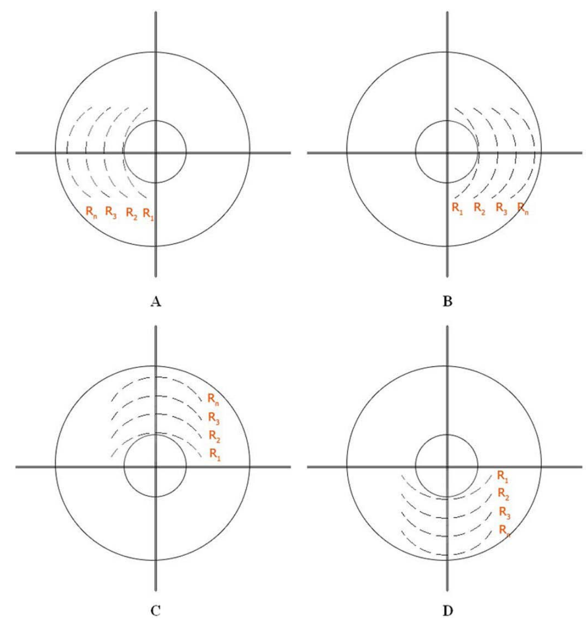

Fig. 7. **A**. Left sense. **B** Right sense. **C** Top sense. **D** Bottom sense

In the same manner, Figure 8 visualizes the points of interest analyzed in two successive arcs in the sense towards the right.

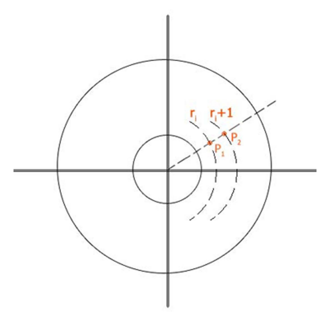

Fig. 8. Points of interest of successive arcs

III. Experiments and Results

In the experimentation of this work, the computer system was an Intel Celeron (R) 1,8 GHz with 1GB of RAM memory. A sample of 1000 images of the subset CASIA-IrisV3-Interval [22] was also selected. This database is almost considered a standard for iris researching. Also, it is interesting because of its great variety of images belonging to people of Asian and non Asian origin. With these preconditions, an experimentation describing two different configurations of the proposed method to locate the inner and outer boundaries of the Iris was arranged. Taking these testings into account, the results are presented considering accuracy and running time.

It is important to explain that accuracy is considered as the number of cases correctly determined by the evaluated algorithm with respect to the total number of cases. The correction was evaluated by visual inspection because no golden standard segmentation is available.

A. Iris location

1) Location of the Iris inner boundary: The circular boundaries detector algorithm defined in former stages from the point $V_0(X_0, Y_0)$ of the smoothed image, in the senses towards the left, right, top and bottom, is applied. For this processing, several points of interest are obtained on each successive arc in the above mentioned senses, in a set within a range of radius between 30 and 60. We have estimated experimentally a number of points equal to 11. Finally the pupil radius is estimated by averaging the radius obtained in the senses mentioned above. In these way the pupil center is corrected depending on the new pupil radius and the initial point approximation $V_0(X_0, Y_0)$. An example of a segmented Iris inner boundary is visualized in Figure 9.

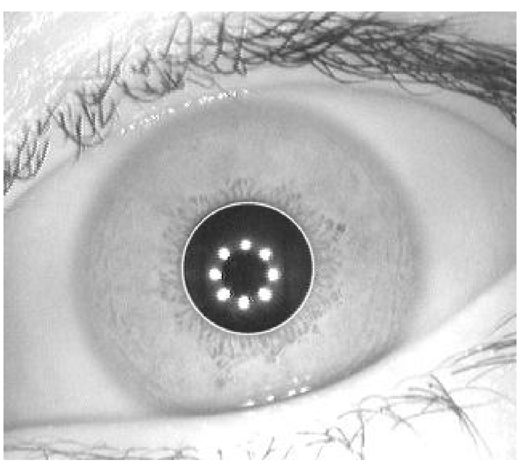

Fig. 9. Segmented Iris inner boundary

2) Location of the Iris outer boundary: In this stage, the detector algorithm of circular boundaries to segment the outer Iris boundary is adjusted. This procedure is applied in the smoothed image from the point $V_0(X_0, Y_0)$, defined in former stages, in senses towards the right and left. Also, several points of interest are defined on each successive arc in the above mentioned directions, in a set in range of radius between 90 and 120. In this case, we have experimentally estimated a number of 21 points. The Iris radius is determined by the middle value between the radius obtained in senses towards the right and left. Therefore the column of Iris center is updated based on the new Iris radius and the initial point approximation $V_0(X_0, Y_0)$. For the row of Iris center it is assumed the same of pupil center. In Figure 10 we show a result of a segmented Iris outer boundary.

TABLE I
ACCURACY AND RUNNING TIMES CONSIDERING THE DIFFERENT STAGES OF THE PROPOSED LOCATION METHOD

Stages	Accuracy	Time (Mean)
Pre processing	-	Less than 1 ms
Initial approximation	-	Less than 1ms
Inner boundary location	97%	6 ms
Outer boundary location	98 %	7 ms

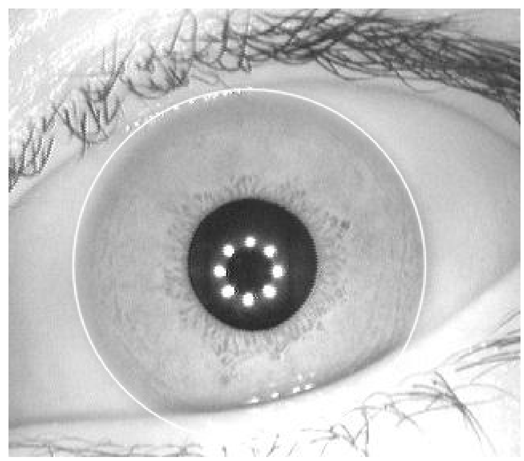

Fig. 10. Segmented Iris outer boundary

3) Successful Iris location: The Figure 11 shows an image sequence of successful Iris location. These results are obtained using the proposal Iris location method. The images used in the experimentations vary in quality. In spite of this quality variation Iris location results are successfully reached with the proposed method.

B. Results on Iris location

Table I shows the results on accuracy and running times for each of the stages of the proposed location method.

By other way, Table II presents some results published by some authors in this research field. These results are compared by using the proposed Iris location method taking into account accuracy and execution times.

The speed improvement makes the proposed algorithm interesting in order to implement some kind of real time system or to be used in a large iris image database. Also, it is possible to note that the accuracy is lower than the obtained by other approaches. This is, to a large extent, due to the amount of images with quality problems used in the experimentation. Another element to take into account in order to improve the accuracy of the proposed location method is the initial approximation of the Iris center. In this regard, the robustness of the method used to obtain the initial approximation of the Iris center, must be improved. There were some images where good approximations of the Iris center were not obtained, which caused unsuccessful segmentations with the proposed method. However, the execution time is reduced considerably with respect to the other examined approaches. The worst case is 213 ms that it is unacceptable for real applications. We reach very good execution time with the proposed location method. Therefore, this proposal represents a robust solution for applications where it requires fast response time and the accuracy it is not so determinant.

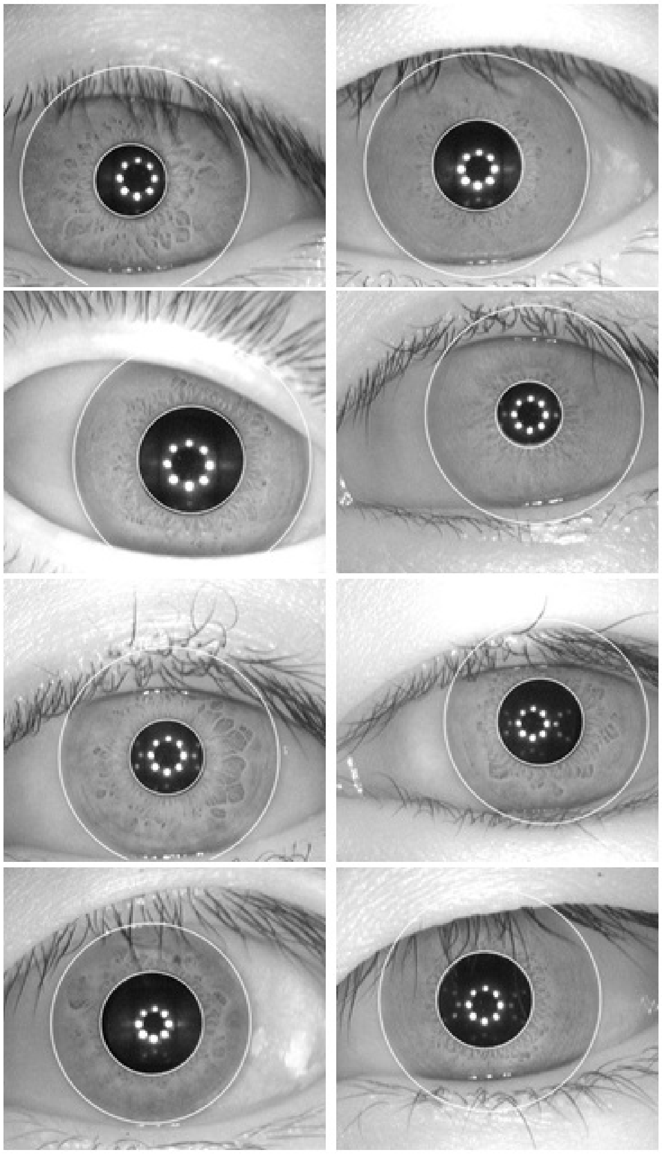

Fig. 11. Successful Iris location

TABLE II
COMPARISON WITH OTHER LOCATION METHODS

Method	Accuracy	Time
Daugman [24]	98 %	213 ms
Tisse [23]	99 %	153 ms
Cui [25]	99.54 %	117 ms
Wildes [26]	99.5 %	66 ms
Daugman [2]	98.6 %	56 ms
Gil [19]	98 %	16 ms
Proposed	98 %	14 ms

IV. CONCLUSIONS

A thorough study about the process of Iris location has been made in this work. Regarding this subject, a new efficient Iris location method has been proposed, based on the analysis of gradient approximations in points of interest of successive arcs. This way, the representative value on each successive arc is calculated, as a result of the fusion of the points of interest among gradients using the quantified majority operator **QMA-OWA**. Consequently, the Iris circular boundary in an image portion is given by obtaining the arc with the greatest representative value. This new proposal is efficient on time. Nevertheless, the accuracy of the proposed method can be improved. Likewise, a better initial approximation of the pupil center must be obtained in order to use the proposed method.

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