# IRIS Recognition Using Conventional Approach

**Essam-Eldein F. El-Fakhrany†, and Ben Bella S. Tawfik††,**

Arab Academy for sciences & Technology & Maritime Transport, Collage of Computers & Informatics Suez Canal University

**Summary**

The proper functioning of many of our social, financial, and political structures nowadays relies on the correct identification of people. Reliable and unique identification of people is a difficult problem; people typically use identification cards, usernames, or passwords to prove their identities, however passwords can be forgotten, and identification cards can be lost or stolen. Biometric methods, which identify people based on physical or behavioural characteristics, are of interest because people cannot forget or lose their physical characteristics in the way that they can lose passwords or identity cards. Biometric systems have been developed based on fingerprints, facial features, voice, hand geometry, handwriting, the retina, and the one presented in this work, the iris. Iris is difficult issue because of pre-processing and segmentation phases. In other word, preparing the iris in a rectangular image format is a complicated issue. This work concentrates on segmentation issue. A good segmentation reflects on perfect recognition with minimum number of features. With only three features, 100% recognition can be achieved. A comparative study between different methodologies is introduced. This study shows the efficiency of the proposed model

***Keywords***:

*Wavelet transform, IRIS, Segmentation, Biometric systems, Moments*

## 1. Introduction

### 1.1 Iris Definition

The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye. The iris is perforated close to its centre by a circular aperture known as the pupil. The function of the iris is to control the amount of light entering through the pupil, and this is done by the sphincter and the dilator muscles, which adjust the size of the pupil. The average diameter of the iris is 12 mm, and the pupil size can vary from10% to 80% of the iris diameter [20]. Front view of the iris is shown in Figure 1. The iris consists of a number of layers; the lowest is the epithelium layer, which contains dense pigmentation cells. The stromal layer lies above the epithelium layer, and contains blood vessels, pigment cells and the two iris muscles. The density of stromal pigmentation determines the color of the iris [5]

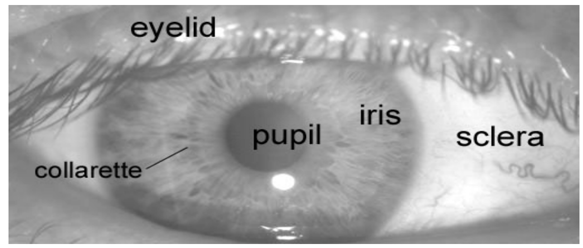


Fig 1 Front view of the iris

One of the main characteristic of iris is the dependency on genetics. So, no two irises are alike. Among the different biometrics, iris recognition has the following advantages. It is unique, even identical twins have totally different irises, the amount of information that can be measured in a single iris is much greater than that in fingerprints, iris is well protected inside the eye, so it is unlikely to get physically damaged, the iris is stable for each individual through his or her life and do not change with age, iris recognition does not involve physical contact and thus is more hygienic even if the system is to be used by a large number of people, and iris recognition has the lowest false match rate and false non-match rate, the false accepts rate is 1 in 1.2 million statistically [8].

### 1.2 Iris Recognition Stages

The typical stages of iris recognition systems (segmentation, normalization, feature encoding and feature comparison) are shown in figure 2, and illustrated in the next sections.

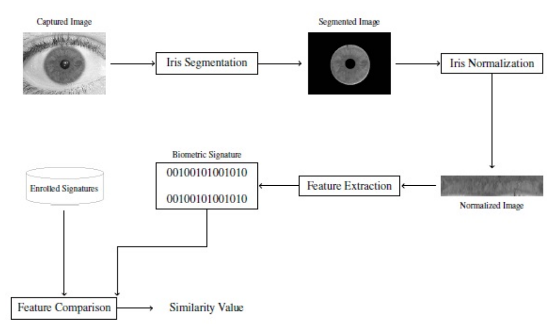


Fig 2 Typical stages of iris recognition systems

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### 1.2.1 Image Acquisition.

In order to capture, the image enrolment camera should have a capability of resolving the image of at least 70 pixels as the iris radius. This section identifies and describes the most common noise factors that result of non-cooperative image capturing processes. There are nine factors that are considered as noise: the iris obstruction by eyelids (NEO) or eyelashes (NLO), specular (NSR) or lighting reflections (NLR), poor focused images (NPF), partial (NPI) or out-of iris images (NOI), off-angle iris (NOA), motion blurred irises (NMB).

### 1.2.2 Segmentation.

The next stage is iris segmentation, this process locates the iris inner (pupillary) and outer (scleric) borders, either circular or elliptical shapes for both of the borders. The success of segmentation depends on the imaging quality of eye images and the lighting effects. Persons with darkly pigmented irises will present very low contrast between the pupil and iris region if imaged under natural light, making segmentation more difficult. The segmentation stage is critical to the success of an iris recognition system, since data that is falsely represented as iris pattern data will corrupt the biometric templates generated, resulting in poor recognition rates. Figure 3 shows the captured image and the segmented image.

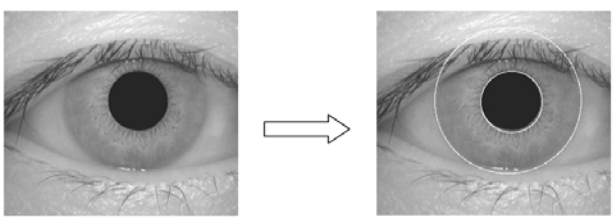


Fig 3: The captured image and the segmented image

### 1.2.3 Normalization.

Once the iris region is successfully segmented from an eye image, the next stage is to transform the iris region so that it has fixed dimensions in order to allow comparisons. The dimensional inconsistencies between eye images are mainly due to the stretching of the iris caused by pupil dilation. Other sources of inconsistency include, varying imaging distance, rotation of the camera, head tilt, and rotation of the eye within the eye socket. The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location. Figure 4 shows the segmented image and the rectangular image produced by the normalization process.

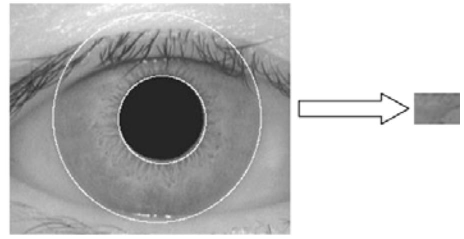


Fig 4: the segmented image and the normalized image

### 1.2.4 Feature Extraction.

In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of the iris must be encoded so that comparisons between templates can be made. In feature extraction, most methods are supervised.

### 1.2.5 Feature Comparison.

The template that is generated in the feature extraction stage will also need a corresponding matching metric, which gives a measure of similarity between two iris templates. This metric should give one range of values when comparing templates generated from the same eye, known as intra-class comparisons, and another range of values when comparing templates created from different irises, known as inter-class comparisons. These two cases should give distinct and separate values, so that a decision can be made with high confidence as to whether two templates are from the same iris, or from two different irises. Minimum distance, KNN (K nearest Neighbour), decision tree, and neural network can be used as classifiers in this stage.

## 1.3 Use of Moment invariants

Generally, in any recognition system to achieve maximum use and flexibility, the methods used should be insensitive to variation in shape and should provide improved performance with repeated trails. The set of moment invariant descriptors meet all these conditions to some degree. One may be interested in finding descriptors that are invariant to variations in translation, rotation or size. The moment approach discussed below is often used for this purpose, given a two-dimensional continuous function $f(x,y)$ we define the moment of order (p + q) by the following relation [28].

$$m^{pq} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x^{p}\ y^{q} f(x,y)\, dx\, dy \qquad (1)$$

For p, q = 0, 1, 2,

The central moments can be expressed as

$$\mu_{pq} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} (x-\bar{x})^p (y-\bar{y})^q f(x,y)\, dx\, dy \qquad (2)$$

Where

$$\bar{x} = \frac{m_{10}}{m_{00}} \qquad (3)$$

and

$$\bar{y} = \frac{m_{01}}{m_{00}} \qquad (4)$$

The normalized central moments can be defined as

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^{\gamma}} \qquad (5)$$

Where

$$\gamma = \frac{p+q}{2} + 1 \qquad (6)$$

For $p + q = 2, 3$, the used moments invariant are:

$$\Phi_1 = \eta_{20} + \eta_{02} \qquad (7)$$

$$\Phi_2 = (\eta_{20} + \eta_{02})^2 + 4\eta_{11}^2 \qquad (8)$$

$$\Phi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2 \qquad (9)$$

$$\Phi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} - \eta_{03})^2 \qquad (10)$$

## 2. Classification Phase

### 2.1. Minimum distance classifier

In pattern recognition, one of the most popular classifiers is the minimum distance classifier (MDC). It classifies an unknown pattern into a category to which the nearest prototype to the pattern belongs. The minimum distance classifier is defined as follows

$$x \in \omega_i \ \ if \ \ d(x, z_i) = \min_j \ d(x, z_j) \qquad (11)$$

Where $d(.)$ is the distance function which can be measured by different ways as we will see in the next sections.

### 2.2 Euclidean distance classifier:

One of the most commonly used distance measures is Euclidean distance. It is basically the square root of the sum of the squared distances of two vector values, and is defined as:

$$d(x_i, z) = \sqrt{\sum_{i=l}^{m} (x_l - z_{il})^2} \qquad (12)$$

### 2.3 Mahalanobis distance classifier:

One drawback of the Euclidean distance classifier is that it does not consider the correlation between two features. Mahalanobis distance takes into account the correlation of the features.

The Mahalanobis distance between two feature vectors x and y are represented as:

$$d_M = \sqrt{(x-z)^T - \Sigma^{-1}(x-z)} \qquad (13)$$

Where $\Sigma$ is the within-group covariance matrix of two samples. $\Sigma$ is defined as:

$$\Sigma = \frac{(n_x - 1)\Sigma_x + (n_z - 1)\Sigma_z}{n_x + n_z + 2} \qquad (14)$$

Where $n_x$ and $n_z$ are the size of $x$ and $z$ samples, $\Sigma_x$ and $\Sigma_z$ are the covariance matrices of $x$ and $z$.

## 3. Proposed Model

### 3.1. Proposed Model Phases

In this section the phases of personal identification using iris are introduced and each phase is briefly explained. The main two phases in design are training and testing are described. Due to the difficulty of obtaining good iris data, the data are collected via the internet. The main phases of building the system, personal identification using iris, are introduced and each phase is explained.

The recognition system mainly use a conventional method which is mainly include three phases namely, pre-processing, features extraction, and classification. In our system the only used features are the moment invariants. These features are four features located in the features space. The classification is done using two different classifiers (minimum distance using Euclidean distance and Mahalanobis distance). Finally the experimental results are presented. Figure 5 summarizes the main three different components of the recognition system. The proposed system consists of three principal stages as follows:

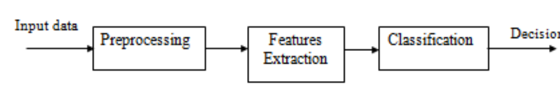



Fig 5: Principal components in recognition procedure

### 3.2. Training Phase

The collected data as shown in the appendix is for 60 persons, each person has different 3 views for the right IRIS. In other words, 180 raw iris images are captured (three sets). In training phase, we used only two sets (120 iris images). The last set is used for testing. In training, the decision (result) is known. In this phase, a mean value (center) value for each person is located in the feature space $R^4$. This is done by the following steps. First, the pre-processing step, in this step the images are prepared for features extraction. Second the four features are calculated for each person. Third, the mean value of each person is calculated and located in the features space.

## 3.3. Testing Phase

This phase is mainly for testing the implemented system. The used data set is 60 iris images for the 60 person which is the set that not used in the training. For each iris image (assumed to be unknown), three stages are done. First, pre-processing step which is the same as in the training, second step is features extraction which measure the same four features as in the training phase (four invariant moments). The last step which does not exist in the training phase is the classification step. In classification stage in the recognition system (testing phase), the distance from the unknown four values located in the features space and the centers of the all persons.

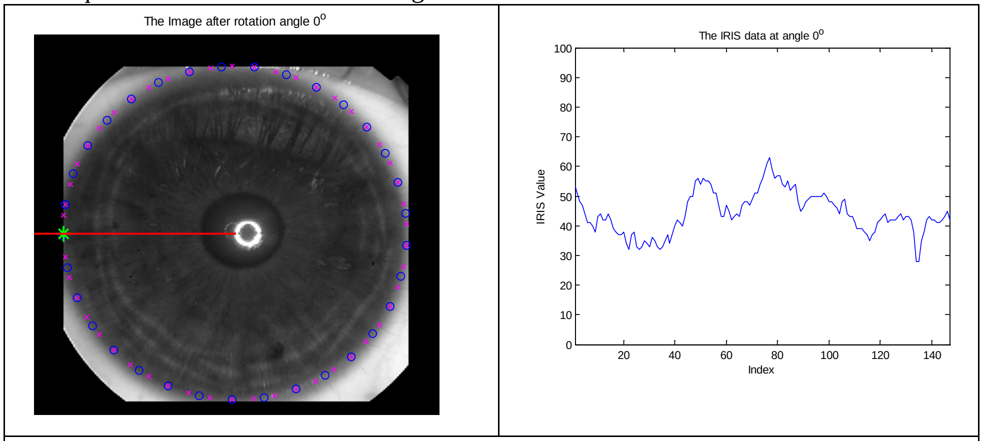
## 3.4. Pre-processing

The pre-processing process is an important stage; it is concerned with the preparation of the input data for recognition. It includes the segmentation and normalization steps. In iris recognition, the pre-processing is extended beyond these previous steps; it includes iris image enhancement for contrast enhancement between the iris region and the sclera region, iris segmentation, and finally converting it to a strip image. Our proposed system introduces a new efficient approach for pre-processing in all these steps. First step is to check the three main graphics operation, namely, scale, shift, and rotation. From the nature of this data (shift and rotation) are fixed. The last process is scaling. In order for the image to be scale invariant, scaling process around the origin is done so each input image after this operation will be in a mesh size of 380×380 pixel size. Second Step is studying the eye regions with different intensities. This is done by studying the histogram of the image which defines the statistic of the intensities (number of occurrence of each intensity of the image). The main objective is to increase the difference in intensity of each region and the other. This is called contrast enhancement. In our model, we used the three techniques together to reach the best contrast achievement between the sclera and the iris region. The main objective is changing the sclera intensity of the eye to make the difference between each region high which is called contrast enhancement. When this is done as mentioned before. The third step is to detect number of points located on the contour of the iris. To maintain the best result, we used one- dimensional edge detection by taking a horizontal line from the center of the iris (image center) and find edge points of this line. The next step (fourth step) of the pre-processing stage is to define the iris contour; from the training we found that the geometric shape for this contour is ellipse. From the detected points of the previous step, the best fitting is maintained. Then the best fitting for the ellipse is done which ends up with one hundred points on the iris contour. Then assume linear interpolation between these points to get the whole ellipse points.
The sixth step is to draw a cutting line (horizontal line from the center to the left). The red horizontal line is the cutting line that intersects with the ellipse and which is considered the first point of the iris line. Now we can cut from this point to the right before the pupil to get the first line of the iris rectangular image. The seventh step is to rotate around the center of the ellipse (the center of the image) with specific angle, the smaller this angle the higher the iris rectangular image resolution. Figure 6 shows the image after rotation with different angles and the intensity values with horizontal cut at the center of the image at these angles. We take higher angular resolution to show the intensity variation. The result of the cutting signal is padded in a rectangle iris image. The rectangle image size is vertically equal to number of cutting plus one. Horizontally, the size is the length of the line.

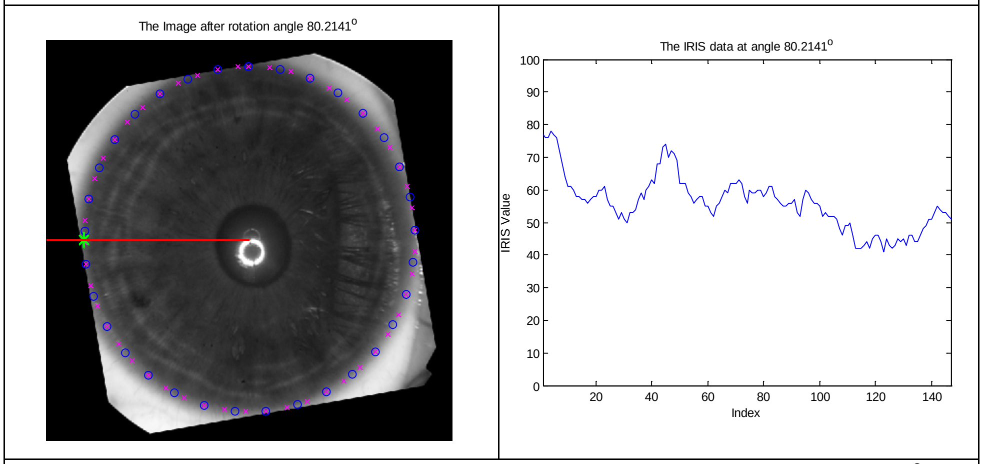
This step (rotate and cut) is repeated full cycle around the ellipse from zero to 360 degree. For each rotation angle we got a line of information about this iris. Again, by arranging these lines on top of each other we got a strip of information representing this iris.
At the end of this stage (Pre-processing Stage), the following is a summarized algorithm of this stage:

1- Read the input colored iris image.
2- Scale the input image in a fixed mesh of 380×380 pixel size.
3- Use three different techniques (as mentioned above in step 3) to enhance the contrast of the image.
4- Convert the image from color to gray.
5- Locate a number of points (9 points) on the contour of the iris.
6- Use the located 9-points to find the best fitting ellipse.
7- The fitted ellipse is represented by 100-points.
8- Draw a line (horizontal) from the center to the intersection point with the ellipse, at any location there will be intersection point use linear interpolation for the 100-points ellipse to be infinite number of points.
9- Start from the intersection point to the right for a fixed number of pixel (150).
10- Find the corresponding value of pixel intensity and store it.
11- Rotate the iris image around the center, and then repeat steps 8, 9.
12- Append the result 120 values on the top of the previous values.
13- Do the next rotation angle then repeat step 11, and 12, then for the whole angles from 0-360.

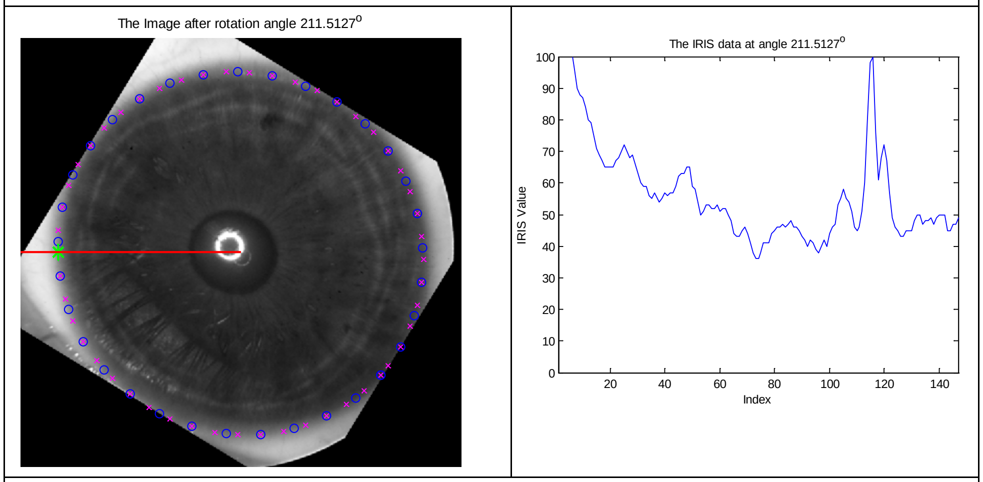
14- The final result will be a rectangular image with number of rows equal to number of rotation angles plus 1, and number of columns equal to 150.




The iris image and the intensity value of the iris at rotation angle 0°




The iris image and the intensity value of the iris at rotation angle 80.2°




The iris image and the intensity value of the iris at rotation angle 211.5°

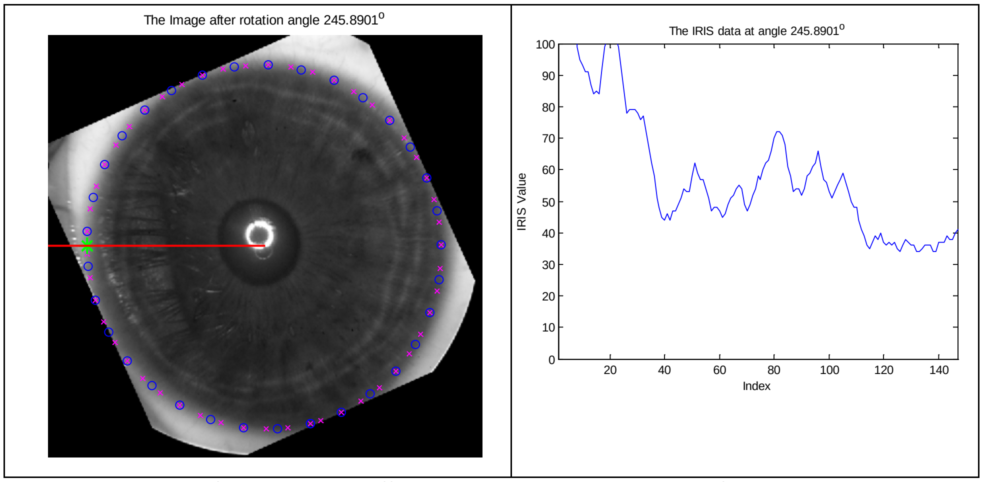



Fig 6 the image after rotation with different angles and the intensity values of the iris at these angles

### 3.5. Feature Extraction

The system retrieves image features by calculating the first moment invariant, second moment invariant, third moment invariant and fourth moment invariant values [Φ1, Φ2, Φ3, Φ4] that have been illustrated before. The feature space in our case is $R^4$, we locate centroid for each person to get sixty centroids which build our classifier. The system is divided into two main parts; the first part is building the system, the second part testing the system.

Building the system is done by the following steps:

1- Use two iris images for each person, and keep the last for testing (two right and two left).
2- Read the first iris image (after the pre-processing, it is a rectangular image).
3- Calculate Φ1, Φ2, Φ3, and Φ4.
4- Repeat for the whole set (2×60 = 120 rectangular image).
5- Calculate the mean for each person (mean of two values) which is the centroid of that person.
6- Now we have a value in feature space for each person in $R^4$.
7- Save the result.

Now, the resulted system is supervised system which detect the input person iris to be one of the sixty persons in our library.

### 3.6. Classification

The classification is final stage to get the decision. In this research we will use minimum Euclidian distance, and Mahalonobis distance classifiers. The minimum distance classifiers can be computed through computing the distance between the test image and the training images (matrix in which each image is represented as a vector) and then find the minimum distance between the test image and the training images. The value of the minimum distance decides the group of the test images. After we arranged the feature vectors of the training images into a matrix X of n column vectors $x_1$; $x_2$,…$x_n$. The distance d between a given test feature vector $x_{test}$ and each of the training feature vectors xi is calculated using various distance metrics.

Testing phase can be summarized as follows.

1- Use the 60 iris image (1×60) to test the system.
2- Read each iris image (pick random one out of 60).
3- Do the whole pre-processing steps to convert the iris image to a rectangular image.
8- Calculate the features Φ1, Φ2, Φ3, and Φ4.
4- Locate the result value to be one point in the feature space $R^4$.
5- Find the distance from this point and the other 60 centroids.
6- Find the minimum distance.
7- The input iris belongs to the person whose centroid is the closest one (minimum Euclidian distance).
8- Repeat using Mahalanobis distance instead.
9- Do the same for the all 60 person.
10- Locate the false and the correct decisions.
11- Repeat for only 3-features $R^3$.
12- Repeat for only 2-features $R^2$.
13- Repeat for only 2-features $R^1$.

The results of the previous steps are comparison between Mahalanobis, and Euclidian distance classifier for different number of features. The next section discusses these results.

## 4. Discussion and Experimental Results

The performances of using two classifiers (minimum distance, mahalanobis distance) are evaluated in this section. UPOL iris database images [29]. UPOL iris image database, 2004] is used in this experiment. The UPOL iris image database was built within the University of Palack´eho and Olomouc. Its images have the singularity of being captured through an optometric framework (TOPCON TRC50IA) and, due to this, are of extremely high quality and suitable for the evaluation of iris recognition in completely noise-free environments as can be seen in figure 7. The database contains 384 images extracted from both eyes of 64 subjects (three images per eye).

Table 1 shows a comparison of the results of using these two classifiers. Figure 8 illustrates the relation between the number of features and classification success using minimum distance classifier, Figure 9 illustrates the relation between the number of features and classification success using Mahalanobis distance classifier.

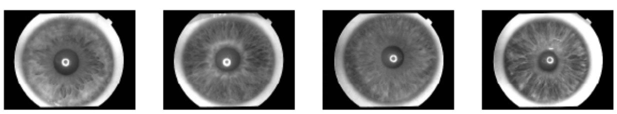


Fig 7 Examples of iris images from the UPOL database.

Table 1: The relation between number of features and classification success for the two classifiers

| **Number of Features** | ***Classifier 1 Success percentage*** | ***Classifier 2 Success percentage*** |
|---|---|---|
| 4 | **66.7 %** | **100 %** |
| 3 | **66.7 %** | **100 %** |
| 2 | **38.3 %** | **68.3 %** |
| 1 | **16.7 %** | **11.6 %** |

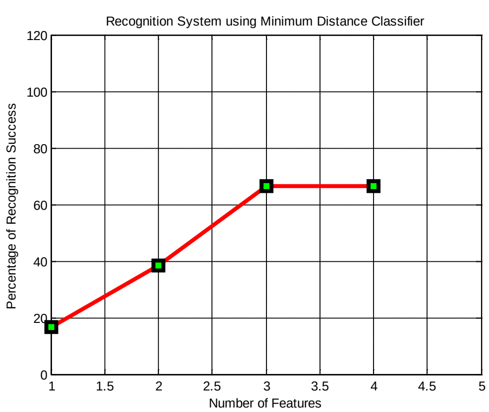



Fig 8 The relation between the number of features and classification success using minimum distance classifier (Euclidean distance)

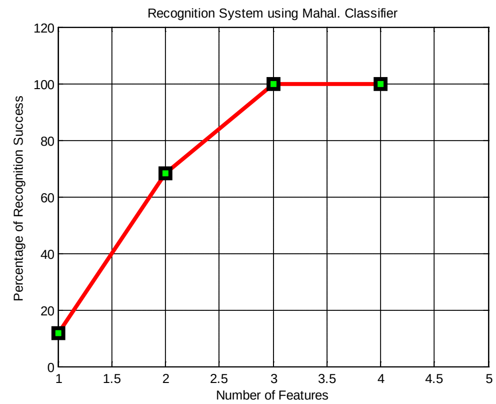



Fig 9 The relation between the number of features and classification success using Mahalanobis distance classifier.

The angle increment affect the resulting image resolution as mentioned before. A comparison between the different angular resolution that have been used is shown in table 3. The best results are achieved when using angular resolution 0.1 radian.

Table 2: Performance evaluation using different cutting angles and different number of features.

| Features Angle | 1 | 2 | 3 | 4 | Pre-processing Time |
|---|---|---|---|---|---|
| 0.3 | 33.3% | 85% | 88.3% | 88.3% | 2.333 |
| 0.2 | 38.3% | 88.3% | 96.6% | 91.6% | 2.341 |
| 0.1 | 31.6% | 90% | 100% | 100% | 2.348 |
| 0.05 | 20% | 90% | 96.6% | 93.3% | 2.352 |
| 0.03 | 18.3% | 86.6% | 93.3% | 90% | 2.384 |
| 0.01 | 8.3% | 85% | 90% | 88.3% | 2.393 |

## 5. Conclusion

In this work, several experiments for personal identification using iris recognition are presented. These results emphasize in that the eligibility of using iris into human identification and its suitable biometric as a noninvasive technique. In this work, the moments as invariants features are used. Also, this work emphasize the importance of segmentation. The good segmentation minimizes the number of extracted features. Two different classifiers are tested. The recognition rate reaches 100% when using the Mahalanobis distance as a classifier. This work emphasizes the importance of the preprocessing stage which yields in high detection results. From the iris images, we conduct that the best representative of the iris contour is the ellipse not a circle. Regarding the rotate and cut process, the lower cutting angle the higher resolution of the iris rectangular image. The experimental results prove that the conventional invariant moments with only three features can achieve high recognition success. Iris rectangular image has special characteristics, one of these is the small variation of the pixel intensity. Mahalanobis distance classifier is the best in iris recognition; because it depends on the statistics of the whole data.

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