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Full Length Research Article

AN ENHANCED IRIS RECOGNITION AND AUTHENTICATION SYSTEM USING ENERGY MEASURE

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ABSTRACT
In order to fight identity fraud, the use of a reliable personal identifier has become a necessity. Using Personal Identification Number (PIN) or a password is no longer secure enough to identify an individual. Iris recognition is considered to be one of the best and accurate form of biometric measurements compared to others, it has become an interesting research area. Iris recognition and authentication has a major issue in its code generation and verification accuracy, in order to enhance the authentication process, a binary bit sequence of iris is generated, which contain several vital information that is used to calculate the Mean Energy and Maximum Energy that goes into the eye with an adopted Threshold Value. The information generated can further be used to find out different eye ailments. An iris is obtained using a predefined iris image which is scanned through eight (8) different stages and wavelet packet decomposition is used to generate 64 wavelet packages bit iris code so as to match the iris codes with Hamming distance criteria and evaluate different energy values. The system showed 98% True Acceptance Rate and 1% False Rejection Rate and this is because some of the irises weren't properly captured during iris acquisition phase. The system is implemented using UBIRIS v.1 Database.

Keywords: Local Image Properties, Authentication Enhancement, Iris Authentication, Local Image, Iris Recognition, Binary Bit Sequence.

1. INTRODUCTION

The goal of this work is to design a system that will improve iris authentication using pattern recognition algorithm which is extended using wavelet packet decomposition that generated 64-Wavelet Packet coefficients used for generating the energy values and also displayed the iris bit code which further research can be carried out to differentiate eye ailments.
The iris is the plainly visible, colored ring that surrounds the pupil. It is a muscular structure that controls the amount of light entering the eye, with intricate details that can be measured, such as striations, pits, and furrows. The iris is not to be confused with the retina, which lines the inside of the back of the eye. No two irises are alike. There is no detailed correlation between the iris patterns of even identical twins, or the right and left eye of an individual. The amount of information that can be measured in a single iris is much greater than fingerprints, and the accuracy is greater than DNA.
Biometrics is an automated method of recognizing a person based on one or multiple physical or behavioral characteristics. Among these biological characteristics, iris pattern has gained an increasing amount of attention because it is one of the most accurate and reliable human identification techniques. Also, iris patterns possess a high degree of randomness and uniqueness even between identical twins and remain constantly stable throughout adult's life (Mohammed, Dlay, & Woo, 2014).
Biometrics technology plays important role in public security and information security domains. In today's world, security has become very important. Iris Recognition Security System is one of the most reliable leading technologies for user identification. Biometrics accurately identifies each individual and distinguishes one from another. Iris recognition is one of important biometric recognition approach in a human identification is becoming a very active topic in research and practical application (Rahib H.Abiyev & Koray Altunkaya, 2008).
Iris Recognition systems is one of the most powerful biometrically based technologies for human identification and verification that utilizes the iris patterns which exhibits uniqueness for every individual (Shweta, Narendra, & Anuja, 2012).

Why the Iris? (Usham Dias et al. 2010)

i. **Accuracy**: Iris recognition has highest proven accuracy and has no false matches in over two million cross comparisons.
ii. **Uniqueness**: Uniqueness of iris pattern comes from the richness of texture detail of in the iris image such as freckles, coronas, stripes and furrows. Even twins have a totally different iris.
iii. **High information Content**: The amount of information that can be measured in a single iris is much greater than fingerprints.
iv. **Real time**: It allows high speed processing and the individual needs to just look into a camera for a few seconds.
v. **Stability**: iris texture is formed during gestation and the main structure of the iris is shaped after 8 months. It has also been show that the iris is essentially stable across life time. The iris is stable for each individual through his or her life and do not change with age.
vi. **Flexible**: Iris recognition technology easily integrates into an existing security system or operates as a standalone.
vii. **Reliable**: A distinctive iris pattern is not susceptible to theft, loss or compromise.

2. Related Works

Iris recognition and authentication technique has been examined from different perspectives and through different research strategies. This chapter covers the literature from studies done by various researchers, which were reviewed in relation to the study. This chapter is very important because it has helped researchers to better understand the depth of the topic under study through the review of previously related works. (Zhipping, Maomao, & Ziwen, 2009) Used a 2D weighted PCA approach to extracting a feature vector, showing improvement over plain PCA. (Chen, Chuan, Shih, & Chang, 2009) Used 2D PCA and LDA, on UBIRIS images, showing an improvement over PCA or LDA alone. (Eskandari & Toygar, 2009); Explored subpattern-based PCA and modular PCA, achieving performance up to 92% rank-one recognition on the CASIA v3 dataset. (Erbilek & Toyga, 2009) Looked at recognition in the presence of occlusions, comparing holistic versus sub pattern based approaches, using PCA and subspace LDA for iris matching, with experiments on the CASIA, UPOL and UBIRIS datasets. (Guo & Xu, 2009) Proposed to extract iris features from the normalized iris image using a method that they called complete 2DPCA. (Mottalli & Patilkulkarani, 2010) Used wavelet analysis to create a texture feature vector, with experiments on the CASIA v2 dataset. (Vladan, 2009) Experimented with the use of oriented separable wavelet transforms, or directionlets, using the CASIA v3 dataset, and shows that they can give improved performance for a larger-size binary iris code. (Zhenan & Tieniu, 2009) Proposed using ordinal features, which represent the relative intensity relationship between regions of the iris image filtered by multi-lobe differential filters. (Hao, Daugman, & Zielinski, 2008) Presented a technique to speed up the search of a large database of iris codes, with an experiment that used over 600,000 iris codes from the ongoing application for border control in the United Arab Emirates. They used a “beacon-guided search” to achieve a “substantial improvement in search speed with a negligible loss of accuracy” in comparison to an exhaustive search. (Jonathan, Gentile, & Ratha, 2009) Experimented with generating a shorter iris code that maintains recognition power, and conclude that it is best to focus on the middle radial bands of the iris, and to sample every n-th band. (Connell, Gentile, & Ratha, 2009) also used a short length iris code to index into a large iris dataset to reduce the total number of iris code comparisons to search the dataset, with a small degradation in recognition rate.

3. METHODS AND MATERIALS

This deals with all the methods used to achieve the set objectives of the research. It is divided into three (3) distinct sections, which are:

I. Iris Extraction

Selecting an already predefined image, this is scanned through several phases. Using the gray scale conversion technique to primarily convert the full colored iris image to monochromatic color in order to reduce space complexity and makes further processing faster and which is then passed through median filter to reduce noises and occlusion. In other to find the threshold, smoothing, gradients values canny edge detection algorithm is used. For the exact detection of the inner and outer radius, pupil detection algorithm is used to find the values of both radii. In order for the feature extraction to be carried out on the blurred images, it becomes necessary to used Normalization technique for the elastic distortions of the iris to be reduced slightly. For the Features to be extracted, iris is been normalized in order to differentiate two iris images. In this corner detection algorithm is used. Daugman been the most used iris recognition algorithm, the algorithm is derived from geometric properties of a convex polyhedral cone which didn’t depend on any prior knowledge.
In the existing and related works, the biometric feature is basically used to identify faces, fingerprint, handprint, voice etc of individuals. But these all also have an error false report. Therefore in this system, iris will be used by generating code.

Identification of individuals based on their unique characteristics of iris pattern is called iris recognition. The patterns are perfectly good for biometric identification for the fact that it is hard to alter and complex as well. It has been detected that the stability of iris patterns are between one year of age until death, which shows that the patterns on the iris remain unchanged for a person’s lifetime. It is used in order to implement and analyze local intensity variation-based method. (Banurekha, Manisha, & Jeevitha, 2014) Consequently presented pattern recognition which was applied using algorithms like gray scale, median filter, Canny Edge Detector, Dougman’s iris localization and image processing techniques. Also, higher numbers of researchers proposed wavelets packet approaches in order to capture iris features at different scales using a wavelet packets based algorithm which will be adopted for iris identification and robustness evaluation. After the iris image segmentation process is completed, the iris code is performed using Haar wavelet packets as well as the energy of the packets sub-images to extract texture phase structure information of the iris and to compute the iris 64-bits codes (Farid & Kihal, 2008). Feature extraction extract the most distinct features present in an image. It gives both local and global information of iris. Discriminated iris texture information must be extracted and encoded to have correct comparisons between iris templates. Complexity of feature extraction affects the complexity of program and processing speed of iris recognition system (Abhineet, Anjali, & Akhand, 2016).

II Energy Value Generation

Figure 3.1 showed how an iris is decomposed. We have used the Haar wavelet in a 3-level wavelet packet decomposition to extract the texture features of the unwrapped images [18]. This generates 64 wavelet packets (output iris sub images), numbered 0 to 63. The images contain approximation (A), horizontal detail (H), vertical detail (V) and diagonal detail (D) coefficients respectively as shown in Figure 3.1

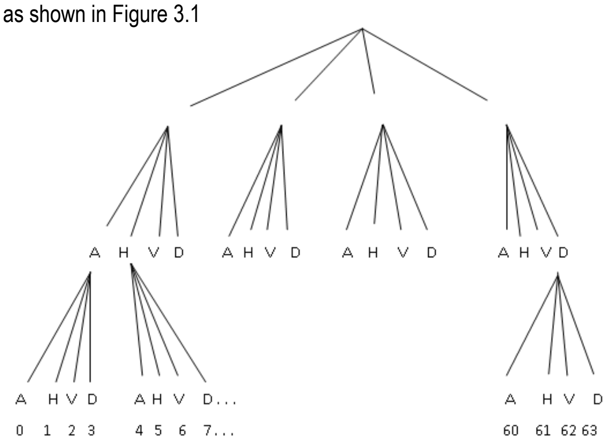


Figure 3.1: Wavelet Packets Decomposition

Wavelet Packets Energy Computation In order to obtain the most texture information in packet sub images, we have used an energy measure. The mean energy distribution allows evaluating which packets are used to compute the normalized adapted threshold for iris code generation. The energy measure E_i for a wavelet packet sub image W_i can be computed as follows (Farid & Kihal, 2008).

$$E_i = \sum_{j,k} W_i(j.k)^2 \quad (1)$$

We use the appropriate wavelet packet energies of each iris image to compute the adapted threshold to encode the 64 sub-images.

$$S = Coeff.\frac{\mu(E_1 \ldots E_\lambda)}{Max(E_1 \ldots E_\lambda)} \qquad (2)$$

$\mu(E_1 \ldots E_\lambda)$ = Mean wavelet peak Energy of the iris
$Max(E_1 \ldots E_\lambda)$ = Maximum Energy of the iris
Coeff. = constant
λ = number of appropriate Energy

III. Iris Binary Bit Code Sequence

After determination the appropriate wavelet packets energies and the normalized adapted threshold, we can carry out the coding of the 64 wavelet packets energies to generate a compact iris code by quantizing these energies into one bit according to each appropriate energy. Let E_λ be the appropriate energy of the peak λ. Then the iris code C_λ computed according to E_λ is defined by the following:

$$C_\lambda(j) = \begin{cases} 1 & if \quad \frac{E_j}{E_\lambda} > S \\ 0 & otherwise \end{cases} \qquad (3)$$

where j= 0…63

This approach will use significant wavelet coefficients of the iris sub image. Each used appropriate energy resulting in a total of 64 bits which correspond to the 64 sub images of the iris wavelet decomposition. Therefore, we obtain one iris code according to each energy.

IV. System Flow Diagram

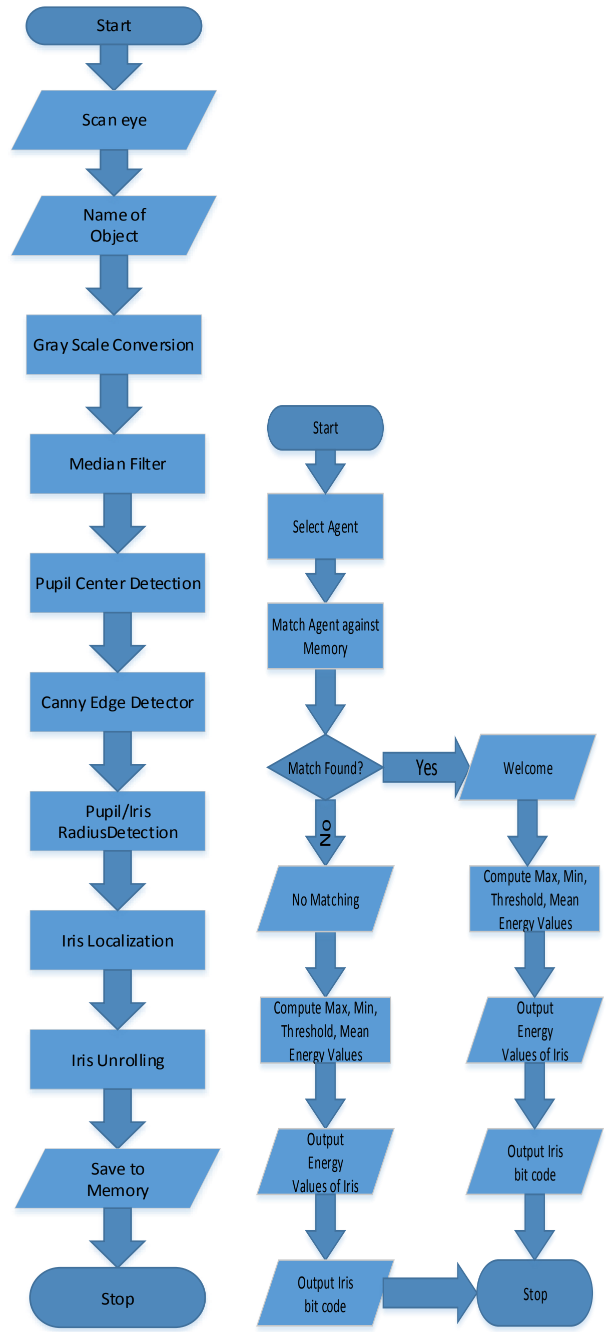
The system design describes the whole processes from eye scanning through binary pictorial representation then iris authentication enhancement. The system design is shown in Figure 3.2.

Figure 3.2 (a) showed the acquisition phase which is described below:

A predefined image is simulated into the system (scan eye) this image is a full colored image with 24bit RGB, the image is named for future referencing, then converted to gray scale image (which is a two colored image to make further computation faster and reduce space complexity), the median filter is used here to reduced noise that affect the Image during gray scaling conversion, then the center of the pupil is detected because it is the center of of the eye in order to have accurate iris extraction and Canny edge detector algorithm is used to detect the edges, furthermore, the radius of both pupil and iris were also detected, for the iris localization, here is exact iris is extracted and the is, the iris is unrolled because at the point of simulation through to localization, the iris is in a circulation fashion then lastly, the image is saved into memory.

Figure 3.2 (b) showed the authentication and enhancement phase which is explained as:

The first stage here is that an image is selected from pool of other iris template which will be matched against the image which is already stored in the memory during acquisition phase, if the image is from the same or different eye then the user will be allowed or denied access to the system and simultaneously displaying the energy values and the binary bit code representation of the image which can further be used to see the similarities or differences of the two images.



(a) (b)

Figure 3.2: Iris acquisition and authentication enhancement flow diagram

V. Implementation And Output Of Iris Recognition Algorithms

The Iris Recognition System was implemented using Java Programming Language.

Fig. 3.1 showed the user input interface of the system. The interface showed where user's name can be typed for identification and verification and saved to memory.

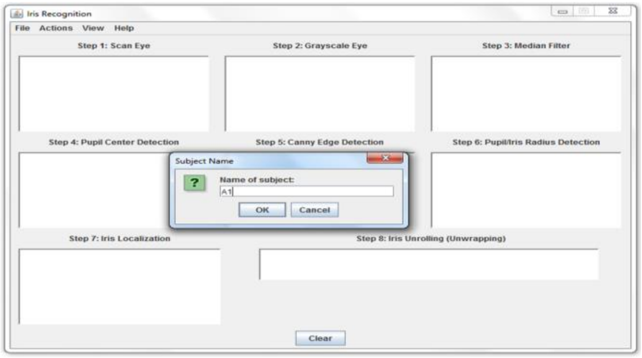


Fig. 3.1: Eye A1 Username Input Interface

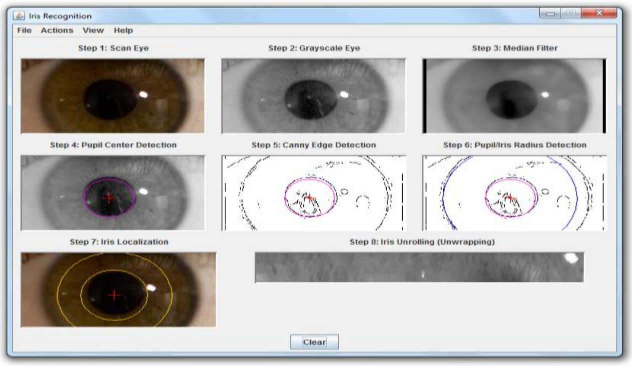


Fig. 3.2: Iris Extraction (Eye A1)

Fig. 3.2 shows how the eight (8) stages of iris extraction works.

i. The first is the scan eye, this is where the image is manually selected and simulated into the system, and this is a full colored image from UBIRIS database.

ii. The second image is the converted full colored image to gray-scale which is in black and white and looks a bit rough due to the conversion process.

iii. The third, is the image after media filtering, this was done to reduce the noise due to conversion in order to get the exact iris for user authentication.

iv. Pupil center detection, the red circle is where the pupil is and this is done to get the pupil which is the center of the eye by orienting a coordinate at the center.

v. Canny edge detection that is used to detect edges of iris and pupil.

vi. Pupil/ Iris radius detection, here the radius of both pupil and iris are detected in order to know where the pupil/ iris start and stop for further calculation.

vii. Iris localization, this is where the exact iris is extracted.

viii. Iris unrolling, all the above processes where carried out in circulation fashion, here iris normalization is done to fixed the iris to a specific size(polar coordinate system) in order avoid false acceptance or false rejection of an authentic or intruder into the system.

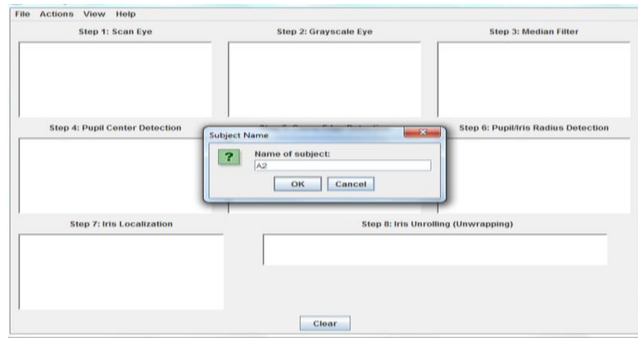


Fig. 3.3: Username Input Interface (Eye A2)

This is the second iris called A2 that is been used to compare the effectiveness and performance of the system with iris image A1.

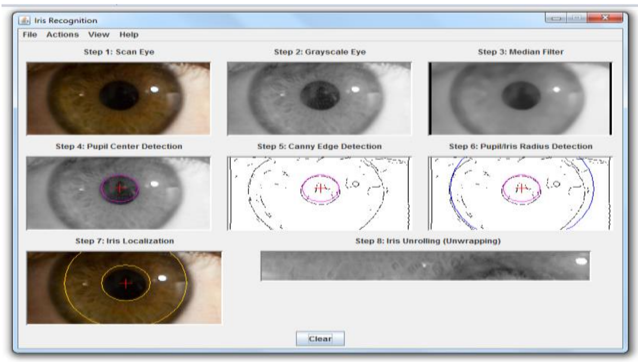
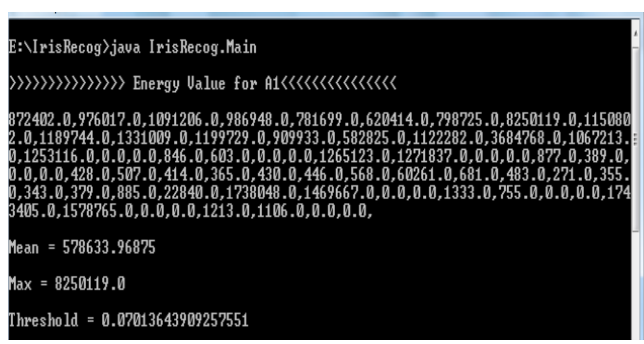


Fig. 3.4: Interface for 8 Iris Extraction (Eye A2)

4. RESULTS

The figures 4.1(a) and 4.1(b) shows the mean energy, median, maximum energy and threshold values of eye A1 and A2 and it can be seen clearly that the values came from different eyes which also show that no two individuals can have same energy value even if they are captured using same apparatus simultaneously.


```
E:\IrisRecog>java IrisRecog.Main

>>>>>>>>>>>>>>>> Energy Value for A1<<<<<<<<<<<<<<<<

872402.0,976017.0,1091206.0,986948.0,781699.0,620414.0,798725.0,8250119.0,115080
2.0,1189744.0,1331009.0,1199729.0,909933.0,582825.0,1122282.0,3684768.0,1067213.
0,1253116.0,0.0,0.0,846.0,603.0,0.0,0.0,1265123.0,1271837.0,0.0,0.0,877.0,389.0,
0.0,0.0,428.0,507.0,414.0,365.0,430.0,446.0,568.0,60261.0,681.0,483.0,271.0,355.
0,343.0,379.0,885.0,22840.0,1738048.0,1469667.0,0.0,0.0,1333.0,755.0,0.0,0.0,174
3405.0,1578765.0,0.0,0.0,1213.0,1106.0,0.0,0.0,

Mean = 578633.96875

Max = 8250119.0

Threshold = 0.07013643909257551
```

Fig. 4.1(a) Energy Generations for Eye A1

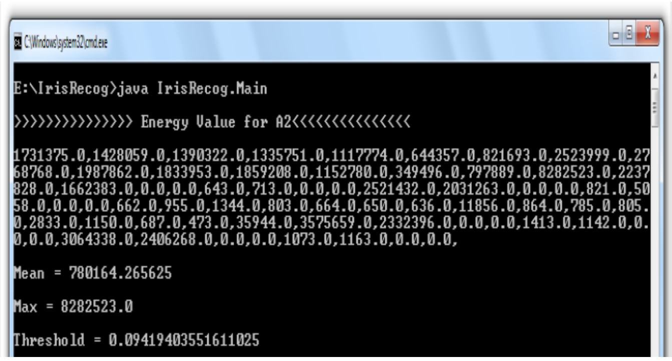


Fig. 4.1(b) Energy Generations for Eye A2

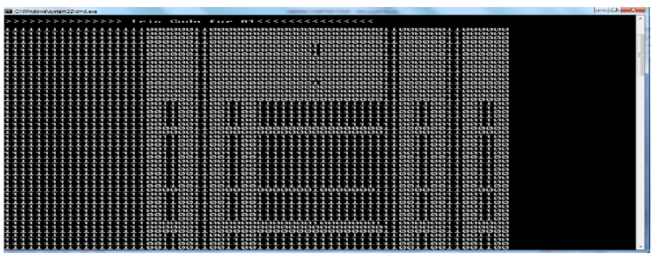


Fig. 4.2(a) Binary Pictorial Representation for Eye A1

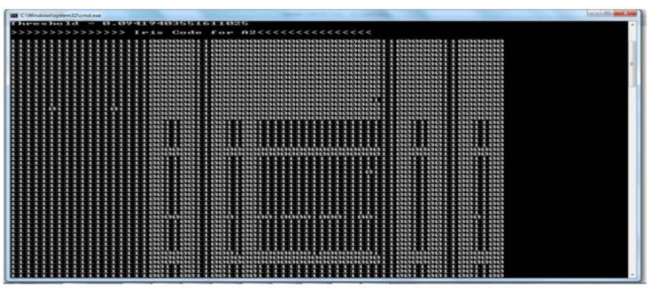


Fig. 4.2(b) Binary Pictorial Representation for Eye A2

Figures 4.2(a) and 4.2(b) shows the binary pictorial representation of two different irises captured. Both figures are 64 x 64 matrix, by segmenting the matrix into four quadrant, in the first quadrant at points 18 x 6 and 18 x 14, the values generated were different which can be deducted that eye A1 and A2 are from different eyes captured and therefore it has uniquely identifies an iris.

II. SYSTEM EVALUATION

Twenty-four different irises were randomly selected and test run through the system and none failed except four (4) and the reason was that during iris capturing, the irises were not captured by the camera, thereby making the system appropriate for very high security environments.

The percentages of accuracies were calculated as follows

$$\text{False Acceptance Rate } (\mathbf{FAR}) = \frac{\text{No.of Images falsely accepted}}{\text{Total No.of images}} \text{ x } 100 \qquad (4.1)$$

$$\text{False Rejection Rate } (\mathbf{FRR}) = \frac{\text{No.of Images falsely rejected}}{\text{Total No.of images}} x\ 100 \qquad (4.2)$$

$$\text{True Matching Rate } (\mathbf{TMR}) = \frac{\text{No.of Images correctly accepted}}{\text{Total No.of images}} x\ 100 \qquad (4.3)$$

Table 4.1: Appropriate Iris Energy Values

S/N	Images	Mean	Maximum	Adapted Threshold
1	A1	578633.96875	8250119.0	0.07014
2	A2	780164.26562	8202523.0	0.09419
3	A3	1048348.73437	932295.0	0.11245
4	A4	578633.96875	8250119.0	0.07014
5	A5	768632.89062	1.4043953E7	0.05473
6	A6	171423.35938	8256962.0	0.20761

Table 4.2: Evaluation Time

Evaluation Name	*Time (Second)*
Average Enrolment / Iris Extraction Time	*10*
Average Verification / Authentication Time	0.5

Table 4.3 Authentication Metrics and System Performance

Authentication Metrics	System Performance (%)
False Accept Rate (**FAR**)	1
False Reject Rate (**FRR**)	1
True Acceptance Rate (TAR) or True Match Rate (TMR):	98
True Rejection Rate (TRR) / True Non-Match Rate (TNMR)	1

5. Conclusion And Future Work

The average iris extraction time was found to be less than or equal to Ten (10) seconds, it took a second to match two different iris templates. Also, the algorithm was extended with the capability to generate energy values of each iris and a pictorial bit code representation of the iris was generated. Consequently, the development of an iris recognition and authentication application using a pattern recognition algorithm which was extended with the ability to generate 64-wavelet-packet energies and also to output iris binary bit code sequence representation has been achieved. As future work, we will develop an algorithm based on the binary bit sequence generated; vital information can further be used to mine other useful information example could be associated sickness of the human body or symptoms of ailments associated with the eye.

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