Journal of Theoretical and Applied Information Technology
15th March 2012. Vol. 37 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

DESIGNING AND IMPLEMENTING INDIVIDUAL IDENTIFICATION SYSTEM BASED ON IRIS COLORS

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ABSTRACT

Currently, a number of biometric identification having been implemented as components of a variety of security system are fingerprint, palm geometry, face, facial thermo-graph, hand vein, signature, speech, eye iris and retina. It has been identified that the iris of the eyes has unique pattern/texture and color characteristics for every single individual, so that it has now been used as a component of a biometric system. A number of iris identification algorithms have been developed and applied in security systems; however, because such algorithms have only been based on the iris pattern characteristics, the results have not yet been optimum. This is caused by the fact that the result of extracting iris patterns is quite susceptible to the changes of light intensity and the movement of position in the process of iris image acquisition. This paper proposed a new model of identifying an iris based on an iris color with the aid of a 3-dimension color bin histogram. The advantage of using iris colors is that they are not quite sensitive to even small changes of light intensity and position. This kind of model has successfully been implemented as a system prototype by integrating a number of algorithms developed in the research. The trial run has been carried out by the use of a database containing 1877 iris images and 322 samples of test images. The analysis result indicates that the accuracy level of the developed system is relatively very good with the error rate of around 8 %.

Keywords: *Iris, Color, Identification, System, Recognition, Individual, Security, Biometrics, Eye*

1. INTRODUCTION

The increasing rate of crime has forced a number of services or agencies that require security systems to make a protection on the system they use. For example, every time people want to communicate with a computer, access the ATM, use a credit card, past the airport security area, and the like, they always require verification of identity that still rely on user name, password, ID card, and the like. The use of security systems with the help of a good password whether it is encrypted or not, is becoming insecure. Currently, password can be easily and quickly tracked with the help of a high-speed computer.

It has become a paradigm that increasingly sophisticated security system technology developments are continued to be followed or accompanied by the ability of the hijackers which are more sophisticated too. So research in the security system continues to grow in order to find a model that really can not be duplicated by the hijackers.

To overcome duplication by hackers developed iris biometric system based colors with consideration Iris has a characteristic flow or patterns and also colors that are different between each person. Similarly, in normal circumstances, the characteristics of the iris will remain stable. Another

Journal of Theoretical and Applied Information Technology
15th March 2012. Vol. 37 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

advantage of the iris is it would not leave a trail wherever their owners are. On this basis the image processing researchers are competing to develop iris recognition algorithms to be applicable to biometric systems.

Analysis of flow characteristics or patterns of the iris has been developed by several researchers including Daugman[1,2,3], Wildes[4], by Tisse [5], Masek [6], Cui [7], Liu [8], Guo [9], and Karmilasari[10]. These researchers have successfully developed methods of iris-based recognition of individuals and some of them have been applied to a number of security systems. Aside from the flow or pattern, color is a feature that strongly inherent in the iris and become a differentiator between individuals. Currently using iris color on the individual identification studies is still very rare, although a combination of characteristics of iris patterns and colors can improve individual identification system available today.

Based on the analysis on the characteristics of the iris pattern that is used as the basis of biometric security systems by previous researchers, it appears that the results are not optimal. The first problem is the iris image that is used is the gray level image where light intensity changes (although relatively small) will greatly affect the detection results of iris patterns. This will result in errors of the iris pattern matching for the same individual. The second problem is the distance between camera and eye on iris image acquisition and zoom setting are very influential on the results of pattern recognition. Thus, previous researchers require that the camera distance condition and the intensity of light are constant for each iris acquisition. The third problem is the result of detection of the iris pattern is also very dependent on the shifting view of the eye or eyelid (though relatively small).

Based on these three issues, this research will develop an individual identification system based on iris color. It is expected that eventually, iris color will further optimize identification results and recognition of each individual's iris. This is possible because the color does not depend on changes in distance, eye gaze shift and changes in light intensity that is relatively small. This research is the development of the research that has been developed by Karmilasari[10] namely the introduction of biometric based on iris pattern piece. In the end, both will be combined into a single unit and will be an iris patterns and colors-based individual identification system.

2. RESEARCH METHOD

2.1. Research Framework

The studies on the iris biometric system have been inspired by many of which having been developed previously like [11], [12], and [13]. However, in its development, each study is always adapted to the problem which will be solved. Similarly, in this dissertation, the process of iris recognition is performed through several stages that are generally shown in Figure 1.

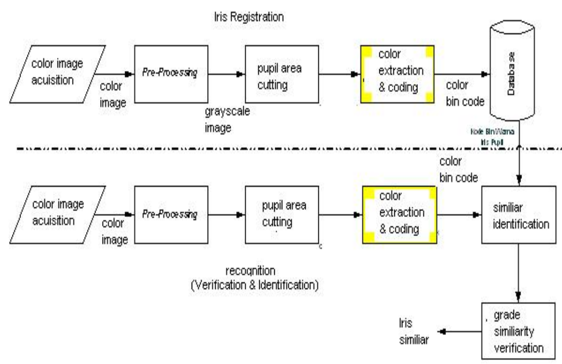


Figure 1. Research Framework

In general, this chart (as with other biometric systems) consists of two stages- registration and recognition. The registration activity is a series of activities of iris image data processing into information obtained by color coding and storage into a database. The recognition activity is a process of identification and verification of equality or similarity between the query image and the color of each iris having been registered in the database. Identification is a series of activities of iris image data processing of the query to obtain information on the color code and proceed with the calculation of similarity toward the color code of each iris contained in the database. Verification is the process of determining the level of similarity so that each iris having been identified is then tested whether it can be accepted or rejected.

2.2. Image Database Registration Process

2.2.1. Color image acquisition

In Figure 1 the initial stage in the method of iris recognition is the image acquisition which is the process of iris image capture with high quality. There are three important things that can be used as the standard in the iris image acquisition [4,12]. First, the camera used must be able to

Journal of Theoretical and Applied Information Technology
15th March 2012. Vol. 37 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

produce images with excellent resolution and sharpness. Second, the lighting on the image acquisition system must be able to produce a good contrast in the pattern and the color of the iris. Third, in the stage of iris image acquisition, the eye should be looking at the camera and is positioned directly in front of the camera. Researchers, who use the iris as the object, have started to provide iris images in a database that can be accessed freely by other researchers. In this dissertation research, the author does not develop or use the image acquisition system, but uses the iris images (secondary data) that have been available in the following databases:

1. Database Name: UBIRIS.v1 COCIA from Lab Soft Computing and Image Analysis Group, with the following characteristics:

• The camera used was Nikon E5700 model

• The software used for the image acquisition was E5700v1.0. JPEG format

• The image size was 2560 X 1704 pixels

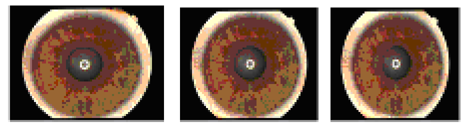
• The number of images was as many as 2892 images taken from 241 individuals. The images were taken only from the right eye of each individual. Image taking was carried out during September 2004 through 2 (two) different sessions and in 6 (six) times of taking for each eye. This is done to make it possible to evaluate the accuracy of iris recognition methods and algorithms.

• From 2892 iris images, there were only 1877 images having been determined as qualified to be used as research objects, while the rest was considered invalid. Therefore in this study, the samples used the number of iris images from as many as 1877 v1 Ubiris

• Some sample images in the database UBIRIS eye v1

Figure 2. Sample eye image in the database [UBIRIS v1].

2. In addition to the color images taken from UBIRIS.v1, the researcher also used the images accessed from the University of Bath and the University of Palacky, Czechs. A number of 144 images taken from 24 individuals consisting of the irises of the left eye and the right eye, taken as many as 3 times the size of the image capture with 768 x 576 pixels. The code 017 from the image file name 3.3 and 3.4 explains the 17th person, and the codes L and R respectively expresses the left iris and the right one, while the codes _1, _2 and _3 show the first, second and third acquisitions.



a)Citra 017L_1.png (b) Citra 017L_2.png (c)Citra 017L_3.png

Figure 3. The iris and pupil images of the left eye of the 17th individual [the University of Bath and the University of Palacky]

2.2.2. Pre-processing

Each iris image readable through a computer program is always presented in the basic color space RGB (Red Green Blue). As set forth in [13] the recognition and retrieval of color-based images should use a color space similar to the visual representation of the human eye. Consequently in this research the writer uses the HCL color space (Hue Luminance chrominance). For that, the image that has been read in the RGB color space must be converted into the HCL color space representation. Another reason of doing the color space conversion is to facilitate the separation of components of Hue, Luminance and chrominance. Luminance component is called the gray-level image of the iris which is then used to facilitate the process of localization of the pupil-iris.

2.3. Localization of The Iris Pupil Area and The Cropping of Such An Area.

Pupil has a characteristic intensity that is darker than the other parts of the eye, so by changing a color image into a gray image (by way of processing the Luminance component) it will be easier to get the pupil area. In this study, the author uses a method or algorithm having been developed by Karmilasari, 2008, to localize the pupil area and the cropping of the area of interest of the iris. The process of localizing and determining the midpoint pupils is performed sequentially through such processes as: binary processing, image morphology (dilation and erosion), skeleton processing, searching the edge of the pupil (using Freeman code), and finding the

Journal of Theoretical and Applied Information Technology
15th March 2012. Vol. 37 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

midpoint of the pupil (through the calculation of the mass center of the object).

The research by Karmilasari[10] also described that the image of the eye, which is presented or acquired, is often imperfect. Sometimes there are a number of images where the top of the iris is covered by the eyelids. Similarly, in a number of other images, sometimes the bottom of the iris is covered by the eyelid and some eye images at the top and bottom of the iris are partially closed by eyelids or eyelashes. Based on the observation of the images in the database, the iris area with a relatively small level of interference is on the left and the right pupils in the left eye and the right eye. For this reason, the focus of making the extracted iris color is in the area of horizontal cross from the left side to right side of the pupil in each eye. Determining the location of areas of interest as well as the cropping is based on the midpoint of the pupil circle. The area of the pupil-iris is capable of adapting to the direction of visual motions (motions of the pupil iris). Sliced pieces are made in rectangles with the height and length of the ribbon determined with certainty (fixed). From the initial experiments having been conducted on the eye image in the database of UBIRIS v1, it is known that the radius of the pupil ranges from 30 to 50 pixels (only applies to the systems used by UBIRIS v1 iris image acquisition). Consequently the highly-cropped slices of the pupil area are determined by the width of 61 pixels (30 pixels to the top + 30 pixel to the bottom + middle point). This value is taken with the assumption of remaining to accommodate pupils with a minimum radius. While cropping the iris pupil area to the left and the right is 3 times larger than the top and bottom cuts. The cropping area of the pupil-iris and the width are qualified and acceptable because it remains in an area that has been defined by Daugman [1] which says that the ratio between the pupil and iris radius ranges from 0.1 to 0.8.

2.3.1. Color Extraction and Encoding

The extraction phase of the characteristics of an iris color is a part of the main stages in this research. Broadly speaking these phases of activities are shown in Figure 4.

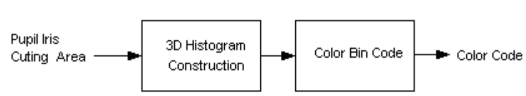


Figure 4. Block diagram of the process of color extraction and coding

The objective of this stage is to transform the iris color from the RGB color space to the HCL color space that is visually similar to the human eye in distinguishing colors. The HCL 3D histogram is calculated based on the number of (the frequency of appearance of) pixels in the iris image that has the same value for the component of H, C and L. The histogram is represented in the form of 3D matrix with about 17 million color elements. The number of colors with a position adjacent to each other in the 3D histogram is visually similar or have no significant difference. Based on these reasons, the authors perform the quantization process to split HCL into 16x16x16 color histogram bin. This means that all pixels in the image that has a value of H, C and L in vulnerable between 0-15 are expressed in the same color bin, and so on. The use of the color bin will greatly speed up the process of calculation of similarity and also minimize the use of the memory in the color code storage in the database.

2.3.2. Database development

Developing a database is intended to store all the information needed to facilitate the searching and recognizing iris images. Information or data stored in the database contains the ID of each iris image, the iris image color characteristics in the form of the value code of the color bin histogram and the iris image file names (including the name of the directory where the iris image is saved). The software used is MDB database access. Here are described the results of the implementation of the iris registration algorithms into the database using the Java programming language. When the program is executed, the main windows interface displays such three menu choices as Database Iris, Iris Recognition and Exit as shown in Figure 5.

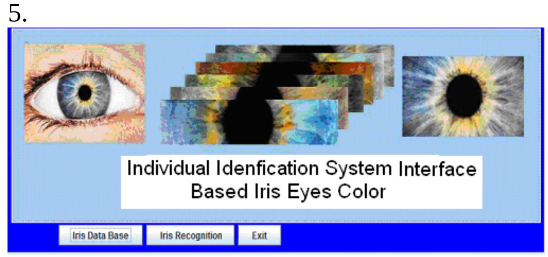


Figure 5. Individual identification System Interface based on Iris Colors

2.3.3. Test similarity

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Next to the formation stage of the database and registration number of iris into it, the introduction stage can be performed (shown in Figure 6). In this process, the first step is the extraction of color codes of the iris image query (the process is the same as the one at the registration stage). The resulted color code is then matched to the color codes of all the iris images contained in the database. The Matching or recognition is done by two processes. The first process is called identification in which the calculation of the similarity of the query iris color to the iris colors having been listed in the database by using the histogram intersection. This process will generate a number of candidate iris images to be found and sorted from the most similar to the least similar. Subsequently, the process of verification is done to compare the level of similarity that has been determined by the system to the level of similarity having been calculated in the identification process. Similarity level system is determined by the threshold value or threshold (TH) similarity. TH is the threshold value that determines the limit of how far the query iris image is still considered the same or similar to the iris image recorded in the database. If there is a candidate iris having a level of similarity that is greater than or equal to the value of TH systems then such an iris is declared recognizable; otherwise, unrecognizable. The lower the threshold, the less accurate the system; whereas the greater the given threshold, the more accurate the system.

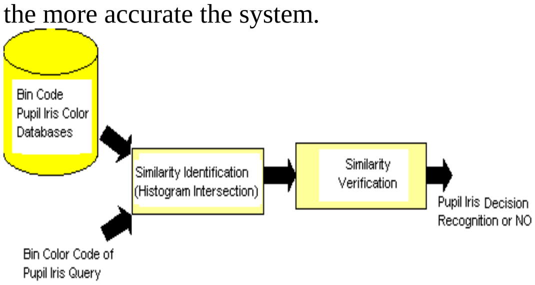


Figure 6. Block diagram of iris matching

The interface of the iris matching or recognition process is shown in the description below. By selecting the menu Iris Recognition in Figure 5, it will show a new window as shown in Figure 7. In the figure there are 3 menu choices of Image Query Iris, Iris Recognition and Similarity Threshold. Iris Image Query menu is used to open the iris image as a query or an iris that will be matched with all the iris images in the data base to recognize. Iris recognition is to ask the system for the identification process. Similarity Threshold is used to find the level of similarity between the query with the images in the database with the choice of similarity level between 0% to 100%.

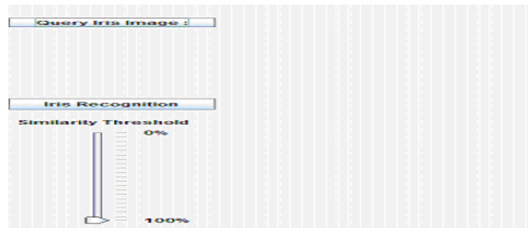


Figure 7. The interface of the color-based iris recognition.

By selecting or clicking the query menu, one can choose the desired iris image file. The selected iris image will appear beside the Query menu and the file name is listed next to the left image of iris pupil like what is shown in figure 8 (the name of the selected file in this example is 018L_1.png).

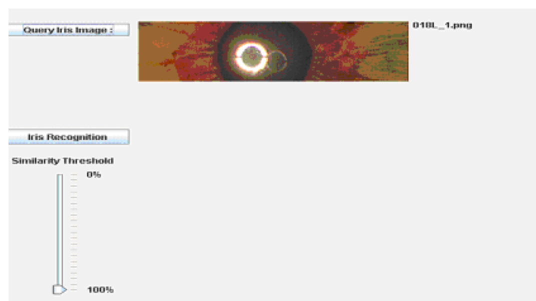


Figure 8. The query image of the pupil iris being matched

After the pupil-iris image is selected, the next step is to ask the system identification process by determining the first similarity threshold. Threshold is set to 100% which means that the system is asked to find the level of similarity between the query and the image in the database with 100% similarity level, then select / click on Iris Recognition. The result appears in a new window as shown in figure 9.

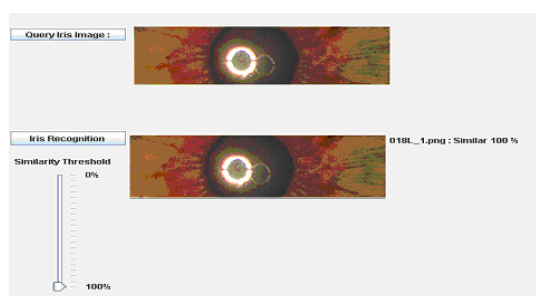


Figure 10. The pupil iris image is 100% compatible with the query iris.

Journal of Theoretical and Applied Information Technology
15th March 2012. Vol. 37 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

But if the value of the Similarity Threshold is lowered to 90% as shown in Figure 11, while clicking the iris recognition menu there appears the image 017L_3 with the similarity level of 100%, image 017L_2 with the similarity level of 98%, and the image 017L_1and 017R_4 with the similarity level of 96% an and 95%, as shown in Figure 3:19. Two of the first images that come out of 017L_2 and 017L_1 are the pupil iris images of the same eye as the query pupil iris images 017L_3 query, this shows that for TH> = 96% the query image is still well recognized. It is also significant that while in the process of the iris image acquisition there is a slight change in intensity and / or a slight shift of the position of the iris compared to the time of acquisition that have been stored in the database, the system is still able to recognize properly. For the TH value = 95% the pupil iris image of a different eye begins to appear as 017R_4 (the right eye from the 17th individual). Actually the recognized iris remains the iris of the same individual but to improve the accuracy of system, the iris of the left eye and the one of the right eye of the same individual are considered two different iris images. Thus we can say that for the value of TH <= 95.

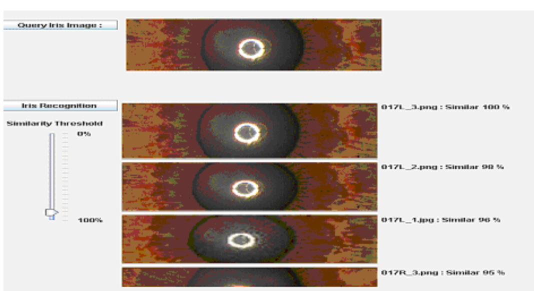


Figure 11. Example of the query iris image recognition pupil 017L_3 with TH = 90%.

3. DISCUSSION AND RESULTS

The iris recognition algorithms have been developed, implemented and carried out with a number of trials. At the stage of the formation of the iris database, there were registered as many as 1877 iris images from the database UBIRIS.v1 of the Lab - Soft Computing and Image Analysis Group of the University of Bath and the University of Palacky, Czechs. Meanwhile in the introduction stage, trials have been conducted as many as 622 slices. The trial was divided into two parts: the first used 322 query iris images having been registered in the database and the second used 300 query iris images that have not been registered in the database.

Table 1 shows the 16 samples of the iris recognition-tested queries having been registered in the database of all the existing images. Threshold value indicates the accuracy of the iris recognition system developed. The higher the threshold value, the more accurate (more secure) the system, conversely the lower the threshold value, the more reduced the level of accuracy (less secure)of the system. The names of the iris images are meant to distinguish the slices of each individual, for example, the iris image of 017L3 shows slices of the 17th individual, L indicates the left eye of the individual (L = left and R = right) and 3 indicates the third acquisition . Accordingly the images named 017L1, 017L2 and 017L3 mean the same one iris image with 3 different times of acquisition. This means that if the iris recognition process is conducted for one of the three query images, all the three images must appear in the first sequence. The following is the trial run result for the query image 017L3 when the recognition system is set at 100.

Table1. Clarification of the similarity test result of the registered query iris in the database.

No	Nama citra Iris	Threshold								
		100%	99%	98%	97%	96%	95%	94%	93%	92%
1	017L3	017L3	017L2			017L1	017R3			
2	017R3	017R3				017R1		017R2 024R2		
3	018L3	018L3			018L1	018R3	018R2			
4	018R1	018R1			018R2 018R3			018L3 018L3		
5	019L2	019L2				019L3	019L1	019R2		
6	019R1	019R1		019R3	019L3					024R2
7	020L1	020L1				020L3	020L2		021L2	
8	020R3	020R3			020R1 020R2			021R2 021R2		
9	021L1	021L1				021L2	021L3	021R1		
10	021R3	021R3	021R2		021R1		021L3			
11	022L1	022L1		022L3				022R3		022R3
12	022R1	022R1				022L3	022L1	022R3		
13	023L1	023L1		023L2	023L3	023R1				
14	023R3	023R3	023R2	023L2 023R1						
15	024L2	024L2				024L1 024L3 024R2				
16	024R1	024R1		024R2	024R3	024L2				

Table 2 shows the 12 sample-test results from the query iris image that has not been registered in the database. This table shows that if the threshold value is set to 100%, then none of the iris image is found. The same image is applied to the threshold value of 97%. This situation shows that the system does not make a mistake in accepting or in other words, the system remains secure.

Journal of Theoretical and Applied Information Technology
15th March 2012. Vol. 37 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table 2. Identification of the similarity test result of the query iris which is not registered in the database.

No	Nama citra Iris	Threshold								
		100%	99%	98%	97%	96%	95%	94%	93%	92%
1	017L3	017L3	017L2			017L1	017R3			
2	017R3	017R3				017R1		017R2 024R2		
3	018L3	018L3			018L1	018R3	018R2			
4	018R1	018R1			018R2 018R3			018L3 018L3		
5	019L2	019L2				019L3	019L1	019R2		
6	019R1	019R1		019R3	019L3					024R2
7	020L1	020L1				020L3	020L2		021L2	
8	020R3	020R3			020R1 020R2			021R2 021R2		
9	021L1	021L1				021L2	021L3	021R1		
10	021R3	021R3	021R2		021R1		021L3			
11	022L1	022L1		022L3				022R3		022R3
12	022R1	022R1				022L3	022L1	022R3		
13	023L1	023L1		023L2	023L3	023R1				
14	023R3	023R3	023R2	023L2 023R1						
15	024L2	024L2				024L1 024L3 024R2				
16	024R1	024R1		024R2	024R3	024L2				

However, at the threshold value ranging from 96% down, the system states that the query is recognized but views the iris image that is not the same query iris image. In these circumstances it is said that the system made a mistake in accepting which is called False Accept. A complete table showing the results of this trial can be seen in appendix 3 that containing1998 data from 300 test data. To find out how high the level of accuracy of the color-based iris recognition system having been developed, mathematical measurement is done to calculate the number of mistakes the system has in accepting False Accept occurrences and in rejecting the False Reject occurrences. To calculate such errors, in the biometric system, the equations of False Accept Rate (FAR) and False Reject Rate (FRR) are used. The FAR or False Accept Rate is calculated on the basis of a suitability test on a set of test data from individuals who are not registered in the database (imphoster test) while the FRR (False Reject Rate) or also known as a rejection error rate is calculated on the basis of a suitability test on a set of test data that have been registered in the database (genuine test). Both equations are given below.

$$FAR = \frac{\text{The Number of False Accept Occurrences}}{\text{Total Number of Occurances}} \times 100\% \qquad (1)$$

$$FRR = \frac{\text{The Number of False Reject Occurances}}{\text{Total Number of Occurances}} \times 100\% \qquad (2)$$

Based on the description of the test result table about the occurrences of errors in receiving and errors in rejecting as well as by using the entire images as the number of occurrence, it is obtained as outlined in a graphical form in Figure 12. The graph shows that when the system is set at the highest security level (threshold = 100%) there are no errors in receiving, but the error in rejecting reaches 100%. If the security level of the system is slightly reduced by lowering the threshold value at 98%, there are no errors in accepting (0%) but the error in rejecting reaches about 50%. This situation shows that the system can perform the recognition process up to 59% without any mistakes in the passing of individuals who are not registered. So forth, it seems that if the threshold value is less than 90%, the error in rejecting the individual who has been registered reaches 0%, but the error in the accepting can reach 100%. As a result the system becomes insecure. Consequently, it is necessary to determine the threshold value that gives the lowest value of errors in accepting as well as in rejecting (the lowest error rate). The graph shows that the intersection between FAR and FRR are on the threshold value in the range of 96%. Within this value range of the threshold, the system error in the FAR and FRR has been accurately calculated as around 8%. This means that the system having been made with the iris database such as having been described above can work optimally by using the threshold values in the range of 96% with the refractive error rate reaching 8%. It should be noted that these characteristics are not necessarily applicable to a different database or if there is an addition of a large number of databases.

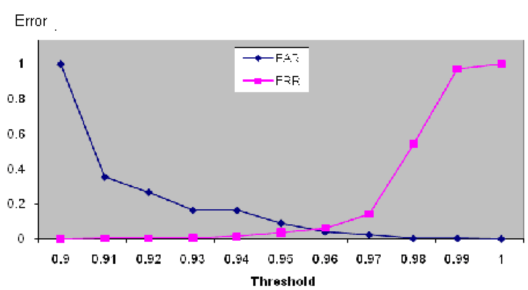


Figure 12. Graph of FAR and FRR of the system test results against a database developed in this study.

4. CONCLUSIONS

The implementation of the algorithms of determining and cropping the area of the iris pupil in color images have worked well, so that it has to be used as information concerning color characteristics that is sufficiently representative of each iris.

The HCL color space which is in according with the human visual perception has been

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

selected and implemented to represent each color of the iris into the 3D histogram. This color histogram can produce color matching between two slices of iris nearly with the real human visual.

The pupil iris color coding algorithm using a 16x16x16 color bin has successfully been constructed. The color code of each pupil iris image using this measurement has been proven to ease the uploading into the database and can speed up the calculating process of matching the color codes between two slices of pupil iris images. Such matching calculation and recognition processes use a similarity measure called Histogram Intersection.

The result of trials of the individual identification system based on iris colors with the support of such an algorithm mentioned above shows that the system developed has the best accuracy at 96% threshold value with the value of the Equal Error Rate (EER) of about 8%. This value applies to the database used in the trial in this study.

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

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