Biometric Patterns Of Eye Iris By Using Hidden Markov Model

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Abstract : Biometrics is an individual recognition system that consists of two kinds of modern and traditional. A biometric system is essentially a personal identification system by determining the authenticity of a physiological characteristic, or a particular behavior that the user possesses. Such biometric technology is defined as an automated method of identifying and authenticating a person's identity based on the user's physiological and behavioral characteristics. The purpose of this research is to know the accuracy level of iris pattern identification using Hidden Markov Model with Gabor wavelet method, to know the iris feature extraction process as part of image processing process using Gabor wavelet method. The method used for data processing is by using Hidden Markov Model, Gabor Wavelet and 2D Order Statistic Filter. The accuracy of the iris identification system indicates that using the Hidden Markov Model with the Gabor Wavelet filter provides a lower accuracy value than using the 2D Order Statistic Filter (ORDFILT 2). Gabor Wavelet filter gives 91.50% accuracy level while ORDFILT2 Filter gives 98.5% result.

1. Introduction
A Biometric recognition or biometrics, refers to the automatic identification of a person based on his/her physiological (e.g., fingerprint, iris) or behavioral (e.g., signature) characteristics. This method of identification offers several advantages over traditional methods involving ID cards (tokens) or PIN numbers (passwords) for various reasons for example acquired and measured for the processing only in the presence of a person [1]. The weakness of using knowledge base (password filling / PIN) is easy to forget and can be guessed by people, while the weakness of using token base (magnetic card/smart card) [2].

Human recognition by using biometric system by the characteristic of physiology could be a tool to verify human identity or identivication [3]. A biometric system is a personal recognition system by determining the authenticity of a physiological characteristic or behavior possessed by the user [4]. Such biometric technology is defined as an automated method for identifying and authenticating someone based on physiological characteristics and behavior of the user.
Two classes biometric techniques [5]:
1. Physiological based techniques include facial analysis, fingerprint, hand geometry, retinal analysis, DNA and measure the physiological characteristics of a person.
2. Behavior based techniques include signature, key stroke, voice, smell, sweat pores analysis and measure behavioral characteristics.
To be used as biometric technology, the characteristics of biometric data must meet certain requirements in order to be used as appropriate biometric technology. These biometric characteristics include: universal, unchanging, easy to measure, unique and singular, acceptable, summarized, reliable, and resistant to manipulation, private, comparable [6]. The way to identify the eye iris is through artificial intelligence (AI). Various types of Artificial Intelligent techniques, namely Hidden Markov Model (HMM), Fuzzy Logic and Neural Network. Fuzzy Logic Technique is the simplest, except that the variations in the conditions on each image are very limited. Artificial intelligent (AI) techniques that will be used in making this research are the hidden markov model (HMM) as a database-forming system because hidden markov methods will be much faster in processing time than the neural network and it is expected that the results obtained are more accurate. Besides, the eye iris segmentation process in this study used the gabor wavelet method because this method is often used in sound detection, eye iris, fingerprint, texture analysis, because of its effectiveness in recognizing patterns.

2. Hidden Markov Model
A hidden markov model (HMM) is a statistical markov model in which the system being modeled is assumed to be a markov process with unobserved (hidden) states. In regular markov model the state is directly visible to observer therefore the state transition probabilities are the only parameters. In a hidden markov model the state is not. An HMM can be considered as a simplest dynamic Bayesian network [7]. HMM architecture is shown in figure 1 [8].

![HMM Architecture](image1.png)

Figure 1. HMM architecture

HMM has 3 main parameters that must be searched for first. The three parameters are Parameter A, Parameter B, Parameter \( \pi \). Using the three main parameters, HMM can be written as \( \lambda( A, B, \pi) \). Of all the parameters, a probability of observation (O) can be obtained. The function for probability O is shown by equation 1.

\[
P(O) = \sum_{i=1}^{N} P(A_{ij}) * P(B_{li})
\]

3. Gabor Wavelet Method
Object recognition method can be defined as the process of determining object identification based on an existing image database. Gabor filters can be applied to images to extract features aligned at particular angles. Gabor filters acquire optimal localization properties in both spatial and frequency domains. The most considerable parameters of a Gabor filter are angle and frequency [9]. This study uses the gabor wavelet algorithm approach. The purpose of using gabor wavelet is to create special characteristic of images that have been convoluted to the kernel. As a filter used Gabor 2D kernel wavelet obtained by modulating 2D Sine waves at certain frequency and orientation with a Gaussian envelope.

\[
11,1,1,11 = \exp\left(-\frac{1}{1} \begin{bmatrix} 11^{+1}1^{+1}1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}\right) \cos\left(11111111 + 11111111 \right)
\]

If all Gabor filters with variations in frequency (f) and orientation (\( \theta \)) are applied to one particular point (x,y), then there are many filter responses for that point, for example: four frequencies (f= 3, 5, 7, 10) and eight orientation (\( \theta \)) are used, 32 filter responses will be generated for each image point convoluted.
with the filter. Database images and images that will be recognized are convoluted first with Gabor filters. The convolution will generate points with a certain value called a Gabir jet response. Gabor jet response points from database images and images that will be recognized compared to applying graph matching procedures to the image that will be recognized, that is by maximizing the similarity of the Gabor magnitude between the transformed face model graph and the graph representation of the image to be recognized. The application of the graph matching can be defined by equation (4), where \( J \) is the Gabor jet model from the database image and \( J' \) is the Gabor jet model of the image that will be recognized.

The similarity function \( S(J, J') \) is defined by equation (4), where \( a_j \) and \( a'_j \) are each response points from the Gabor jet database image model and the image to be recognized.

\[
s(J, J') = \frac{\sum_j a_j a'_j}{\sqrt{\sum_j a_j^2 \sum_j a'_j^2}}
\]

4. 2D Order Statistic Filter (ORDFILT2)

In image processing, the filter propagation response gives a description of how the pixels in the image are processed. Convolution of image matrices with order statistic filters is used in noise reduction. Order-Statistics Filters are spatial filters whose response results are based on ordering pixel values. Implementation of maximum filter and minimum filter as order ranking filters. The command requires three input, namely the image, the index values of the output sorted [10] (Siahaan. 2018).

5. Research Methods
5.1 Pre-processing

Pre-processing process or better known as pre-processing is a step to improve the image to accentuate the image character you want to extract.

5.2 Pre-processing Algorithm
a. Image Capture
   This iris image is in the form of right eye images from various races and ethnicities taken from CASIA database version 4.0 and UBRIS.v2.

b. Eye iris Extraction
   1) Eye iris image acquisition
   2) Intensity setting process
   3) Autocrop
   4) Filtering the image using the Gabor wavelet filter.

5.3 The formation of Hidden Markov Model
a. The process of making eye iris image database
b. Making the accuracy of the eye iris recognition.
c. Making eye iris recognition through images.

6. Results and Discussion

Eye Iris testing in this study used 40 individual samples, where each individual contained 10 eye iris images/file in .jpg format. The eye iris recognition system uses the Gabor Wavelet filter and the hidden markov model method uses the number iterations and the number of different blocks as a comparison. The algorithm used in the hidden markov model method on this system is the Baum-Welch algorithm. Each number of iterations and the number of blocks are different so the eye iris recognition system (GUI system) used is also different. This is to facilitate the naming of m.file and database scripts store in the form of matlab audio format, so that each different iteration and block has a different system folder.

The database used in each system has a number of iterations and a certain number of blocks will be compared in calculating the value of the eye iris recognition. But in this system the database is set according to the script m.file in one system folder. Then to calculate the value of the accuracy of the system in recognizing the eye iris the button presses the value of accuracy.

HMM Model is used in the classification of each individual to distinguish each individual in the formation of the database. The values of the HMM parameters obtained in MATLAB are processed using
Baum-Welch algorithm. From the results of processing using Baum-Welch algorithm in the example of 1st person (person 1) with 10 iteration and block 52 obtained:

6.1. **Estimated probability of the initial state for \( \pi = 1 \), i.e.:**
\[
\pi_A = [\gamma_1(1) \gamma_2(2) \gamma_3(3)] = [1 \ 0.6 \ 0.4]
\]
The value above is the initial opportunity estimate. Meaning that for \( P(O|\lambda') \geq P(O|\lambda) \) value to be fulfilled or \( \pi_A(i), \ 1 \leq i \), then the probability of the process being in state 1 is 1, for state 2 is 0.6, for state 3 is 0.4.

6.2. **Transition matrix estimates,**
\[
i.e. \ A_1 = \begin{pmatrix}
-0.5786 & 0 & 0 \\
0 & 4.1901 \ e^{+03} & 605.2140 \\
0.0321 & 419.0078 & 86.4592
\end{pmatrix}
\]
The matrix illustrates that the transition from state 1 to state 1 is -0.5786, from state 1 to state 2 is 0, and so on can be seen on the \( A_1 \) matrix.

6.3. **Estimated emission matrix,**
i.e. \( B_1 = \begin{pmatrix}
0 & 3.4201 \ e^{+03} \\
3.4201 \ e^{+03} & 139.7995
\end{pmatrix}
\]
The matrix illustrates that emission in state 1 are 0, the probability in state 2 is \( 3.4201 \ e^{+03} \), and the probability in state 3 is 139.7995.

Accuracy Value. The accuracy value in the system is in units of percent, so that it can facilitate the user in knowing the value of the accuracy of the system being run.

The relationship of the number of block with the level of accuracy in the identification of eye iris with the number of iterations 1, 10, and 20 is shown in the following Figure 2.

![Graph of the relationship of the number of blocks with the level of accuracy](image)

**Figure 2.** Graph of the relationship of the number of blocks with the level of accuracy in each number of iteration.

Information:
A shows the number of iteration 1
B shows the number of iteration 10
C shows the number of iteration 20

The effect of the number of iterations on the level of success in the process of identifying eye iris can be seen from variations in the number of iterations. If the number of blocks is fixed but with the number of iterations varied between 1 and 10, an increase in the level of accuracy will be obtained as seen in Figure 2. But in the number of iterations 20 shows the same results with the number of iterations 10, this is because
the number of iterations 10 is the maximum iteration of the eye iris recognition system using the Gabor Wavelet filter.

An increase in the percentage accuracy in the system is caused by the increasing number of iterations that can control the maximum number of steps carried out by the algorithm in the system before the end of process. Another factor that can reduce the level of accuracy is the quantization process carried out in making the database, where data from the original image that is wasted causes matrix elements not to represent the matrix elements of the original image because of the pre-processing process.

The influence of the number of blocks on the level of success in the process of identifying eye iris can be seen from the variation in the number of blocks. If the number of iterations is fixed but with the number of blocks that are divided, namely 13, 26, and 52, there will be an increase in the level of accuracy as seen in Figure 2.

Besides the Gabor Wavelet filter there is another filter which turns out to show a greater level of accuracy, namely the 2D order statistical filter (ORDFILT2). That is because the filter replaces each element in the original image by the order element in the neighboring group which is sorted determined by the zero element in the domain. So elements to replace pixels in the original image are specified in more specific scalar integers. The following is an accuracy ratio for the Gabor Wavelet filter and 2D order statistical filter (ORDFILT2):

| Number of Iterations | Number of Block | Accuracy (%) on Gabor Wavelet | Accuracy (%) on 2D ORD FILT2 |
|----------------------|-----------------|-------------------------------|----------------------------|
| 1                    | 13              | 88,50                         | 77,00                      |
| 1                    | 26              | 89,00                         | 94,50                      |
| 1                    | 52              | 91,00                         | 98,00                      |
| 10                   | 13              | 89,50                         | 81,00                      |
| 10                   | 26              | 90,00                         | 95,50                      |
| 10                   | 52              | 91,50                         | 98,50                      |
| 20                   | 13              | 89,50                         | 82,50                      |
| 20                   | 26              | 90,00                         | 96,00                      |
| 20                   | 52              | 91,50                         | 98,50                      |

From the Table 1, it is known that the level of accuracy using 2D order statistical filter (ORDFILT2) is higher compared to the Gabor Wavelet filter on a higher number of iterations and blocks, although in a lower number of iterations and blocks, the 2D order statistical filter the 2D order statistic (ORDFILT2) gives more accuracy low.

7. Conclusion
1. The number of iterations and the number of blocks affects the level of iterations in the system. But, if the number of iterations has been maximized then if the number of iterations is added it still shows the same results with the maximum iteration, as in the 10 and 20 iterations.
2. There is another solution in improving the eye iris recognition system, one of them is by using a different filter, namely 2D order statistical filter (ORDFILT2), where with the filter the system can provide an accuracy rate of 98,50%.

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