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# COMPARISON OF WAVELET TRANSFORM FOR IMAGE RECOGNITION SYSTEM USING LEARNING VECTOR QUANTIZATION

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***Abstract***

*Image is a spatial dimension contains information, color, and not time-dependent. Nowadays image is very important for recognition system as source/data. In order to obtain certain information (features), image transformed or extracted. Wavelet is mathematical function that is able to classify the image energy concentrated on a small group of coefficients (approximation), while other coefficient group (detail) contains very small energy which can be eliminated. This study purpose to compare wavelet family include Haar, Daubechies and Coiflet, then applied to the fingerprint recognition system and face recognition system.*

*There are three major steps in this paper, preprocessing that includes resize normalization, histogram equalization and thresholding, feature extraction using three different wavelet family, learning using Learning Vector Quantization (LVQ) and matching using Euclidean Distance. The experimental result show Haar is the best among the others. In Fingerprint recognition system the accuracy is 85% and 90% for face recognition system.*

***Keywords;*** *Daubichies, Haar, Image Recognition, Learning Vector Quantization, Wavelet Comparison*

## 1. INTRODUCTION

Image recognition is a part of artificial intelligence with the process of identification or detection of objects or features contained in the digital image. An entity can be identified and given the names by their characteristics (features). These features are used to distinguish a pattern with other patterns. Characteristic of an entity got by extraction from images or data sample. The needed for large storage space in the system spawned a pattern recognition method that applies wavelet compression function. Dimensional multilevel wavelet decomposition can extract features and reduce dimensionality [1]. Wavelet method is not new in the field of image processing and artificial intelligence. Wavelet known to have many variants, including Haar, Daubiches, Coiflets, Symlet, Morlet, etc

Many researchers have been using wavelet for feature extraction. In field of fingerprint recognition, [2] using Wavelet combine with Canberra Distance. Wavelet method Fast Fourier Transform (FFT) and Minutiae Extraction used in fingerprint by [3]. Gnanasivam P. also did research for fingerprint classification using Wavelet Transform and Singular Value Decomposition [4]. Beside fingerprint, Wavelet also often used for face recognition like by [5] that combine with PCA and [6] that add PCA and ANN.

Wavelet comparison also has been widely applied in the image compression. As wavelet image compression has revolutionized image compression field with unbelievable results. for low pixel size image Biorthogonal wavelet is best among all the families and for high pixel size image coiflets is better suited [7]. According Mean Square Error (MSE),

Daubiches family is better than Haar where db4 showed better results than the other Daubiches versions .[8] Comparison of wavelet has also been used in speech / music discrimination feature extraction and Daubiches again showed better results than other types of wavelets [9]. Wavelet comparison has been used by [10] but only using in single recognition, not compared with other recognition system.

Table 1. Previous Study using Wavelet as Feature Extraction and Compression

| Ref. | Method | Result |
|---|---|---|
| [2] | Wavelet + Canberra Distance | Accuracy: Up 95% |
| [3] | Fast Fourier Transform (FFT) and Minutiae Extraction | -- |
| [4] | Wavelet Transform and Singular Value Decomposition | Accuracy: 88,28% |
| [5] | Wavelet + PCA | Accuracy: 83 % - 90% |
| [6] | Wavelet + PCA + ANN | Accuracy: 84.4% |
| [7] | Wavelet for Image Compression | CR Biorthogonal: 93.75% |
| [8] | Wavelet for Image Compression | MSE Daub: 0.0012, SNR: 44.79 |
| [9] | Wavelet for music feature extraction | Daubiches: 99% |
| [10] | Wavelet for face recognition | Haar = Daubiches = 79.17% |

The absence of the type of wavelets as a standard for better results for images feature extraction in pattern recognition becomes raised issue in this study. To overcome this issue in this paper, show the comparison of wavelet between Haar, Daubiches, and Coiflet for image feature extraction especially for fingerprint and face recognition. For increasing accuracy of recognition, this study will use ANN LVQ for training database.

According of the purpose of this experiment, hypotheses that proposed is "Wavelet can be used for images feature extraction, where the successful percentage recognition depend on wavelet family that chosen or used in that recognition system".

## 2. RESEARCH METHOD

The research aims to show the comparison of wavelet between Haar, Daubiches, and Coiflet in image recognition. Wavelet is one of the functions that satisfy certain mathematical requirements are able to perform the decomposition of a function. Wavelet can be used to describe a model of the form of the image or the original image, a curve or a plane into a mathematical function [11]. Wavelet transform has wide applications in application processing and image processing. Using the classical wavelet decomposition, the image is decomposed into the approximation and details images, the approximation is then decomposed itself into a second level of approximation and details and so on.

Wavelet analysis involves two compounds: approximations and details. For 1-dimensional wavelet decomposition, starting from signal, the first step produces two sets of coefficients: approximation coefficients (scaling coefficients) and detail coefficients (wavelet coefficients). These coefficients are computed by convolving signals with the low-pass filter for approximation, and high-pass filter for detail. The convolved coefficients are down sampled by keeping the even indexed elements. Then the approximation coefficients are split into two parts by using the same algorithm and so on [1].

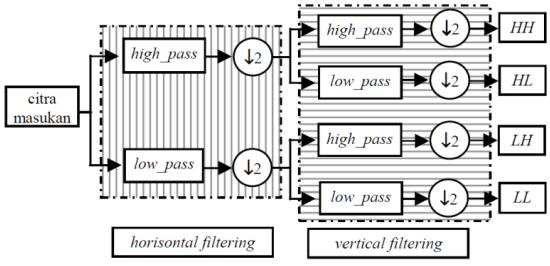



Figure 1. Illustration of decomposition wavelet transform

Stephani Mallat introduces the easy way to calculate decomposition using Mallat Pyramid Algorithm. For haar Wavelet, Mallat given low-pass. Coefficient value, h0 = h1 = -1/2 and for high-pass g0 = ½ and g1 = -1/2 1 [12]. Mallat Pyramid algorithm shown in figure below

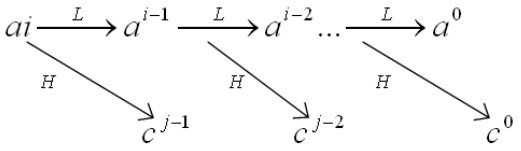



Figure 2. Mallat Pyramid Algorithm

The substance of Mallat Pyramid for level 1 decomposition is value of $a_i$, with formula (1)

$$a_i = \frac{s_i + s_i+1}{2} \qquad (1)$$

and value of $c_i$ from formula (2) as follows

$$c_i = s_i - a_i \qquad (2)$$

with $a_i$ is approximation image, $c_i$ is detail image and $s_i$ is pixel of image from column, and then result from column decomposition is re-decompose for row [12].

2.1 Wavelet Family

Wavelet family that used in this study for wavelet comparison are:

1. Haar
   Lower-pass filter (scale function) and a high-pass filter (wavelet function) of Haar Wavelet that normalized is: low pass filter = [ 0.7071 0.7071], and high pass filter = [-0.7071 0.7071].

2. Daubiches
   Filter length for all Daubechies family is DBN = 2N and 2N-1 width. For example, db2, filter length is 4. Low pass filter *db2* that was normalized = [0.48296 0.83652 0.22414 -0.12941] and high pass filter = [0.12941 -0.22414 0.83652 -0.4829].

3. Coeiflet
   The length of the wavelet filter for *coiflet* is 6N, 6N-1 and its width. For example, coif1, then the length is 6. Low pass filter coif*1* that normalized = [0.038581 -0.12697 -0.077162 0.60749 0.74569 0.22658] and high pass filter = [0.22658 -0.74569 0.60749 0.077162 -0.12697 -0.038581].

2.2 Learning Vector Quantization

LVQ neural network is the integrated network structure of supervised and unsupervised learning and its learning rate is much faster than Back Propagation (BP) neural network's. [13]. Tang et all also proven The Algorithm of Learning Vector Quantization have a good result on Classification[14]

According to [15] algorithm of Learning Vector Quantization consists of some steps:

1. Set weight value (w), maximum epoch (MaxEpoch), error minimum (Eps) and learning rate (α) ... (2.3)
2. Set Input: x (m, n); and Target: T(l,n)
3. Set Initial Conditions: Epoch = 0 and Error = 1 ... (2.4)
4. Do if (epoch<MaxEpoch) or (α>eps)
   a. Epoch = epoch + 1;
   b. If I = 1 until n
      i. Set Cj distance using formula Cj =||x – wj||
      ii. Repair wj with provision
      - If T =Cj so repair weight with using
        Wj' =wj + α (x-wj)
      - If T ≠ Cj so repair weight with using
        Wj' = wj - α (x-wj)
   c. Less with α

2.3 Euclidean Distance

The core of LVQ neural network is based on the nearest-neighbor method by calculating the Euclidean distance. Distances between each input vectors and competitive layer neural nodes can be calculated, and the output node which have minimum distance is designated as a winning node [16]. Formula (3) shows euclidean distance calculate the different between two vectors.

$$d_{ij} = \sum_{k=1}^{n} |X_{ik} - X_{jk}| \qquad (3)$$

2.4 Proposed Method

The proposed method includes training process and recognition process as shown in Figure 3

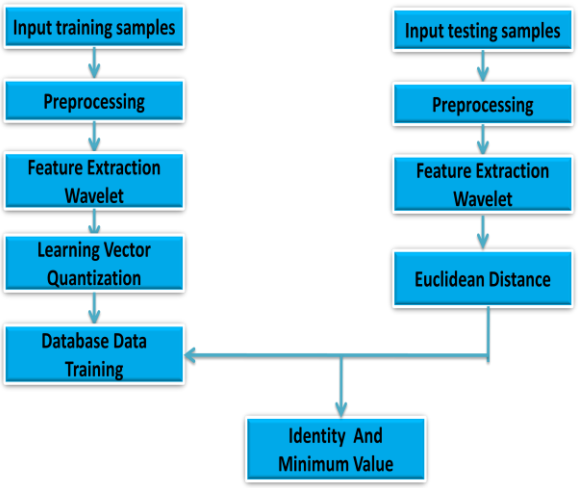



Figure 3. Proposed Method for Wavelet Comparison

In the training process, it is necessary to preprocess the infrared images of the finger veins. Preprocessing includes resize normalization, histogram equalization and thresholding. After the preprocessing apply wavelet family to extract the features of the training samples and training using learning vector quantization neural network to get the best weight for each class. The preprocessing and feature extraction in the recognition process are similar to that in the training process. After that, the testing image will be recognized ant the result of class will be shown up along with minimum value from each class. The minimum value of the class will be considered as the identity of that images

## 3. RESULT AND DISCUSSION

### 3.1. Database

In this experiment, fingerprint and face database are used as biometric to compare the best result between wavelet family. For fingerprint database downloaded from Database Machine Learning and Data Mining Lab, Shindong University[17], writer using 10 sample with each sample consist of 8 images of right thumb with size 152 x 200. The amount of sample for face is same with fingerprint, consist of 8 images of faces from 10 different person. Each image has size 180 x 200 pixel and downloaded from Computer Vision Science Research Project[18].

### 3.2. Preprocessing

The preprocessing includes resize normalization, histogram equalization and threshold. The original image of fingerprint (an example is shown in Figure 4(a)) is an 8-bit grayscale image with a size of 152 x 200. In order to reduce the computational complexity and for feature extraction needed we transform the original image to 128 x 128 pixel (an example is shown in Figure 4(b)). Resize using bilinear interpolation method, where the new pixel image is translated or mapped by neighborhood pixel from original image.

The next step is Histogram equalization, the purpose is to produce histogram of images spread evenly. This technique only re-distribute intensity from the first histogram. For re-distribute the first histogram, pixel of first histogram will be mapped become the new pixel using formula (4)

$$n(g) = \max(0, round\left[(L-1) * \frac{c(g)}{N}\right] - 1) \quad (4)$$

The result of histogram images can be seen in figure 4(c). After that image will threshold using Otsu method. Otsu method calculated threshold value automatically according input image. The approach taken by the Otsu method is to perform discriminant analysis that determines a variable that can distinguish between two or more groups naturally [16]. The thresholds value that must find example expressed by k whose value ranges from 1-255. Value of k chosen is the maximum of the equation using formula (5)

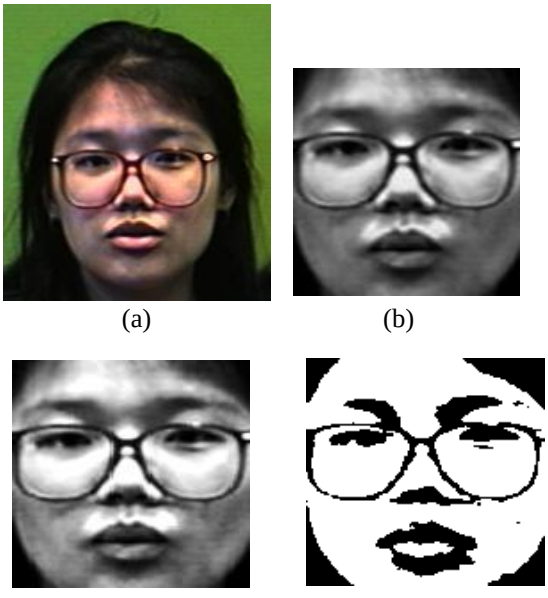
$$\sigma_B^2\,(k*) = \max_{1 \le k \le L} \sigma_B^2\,(k) \ldots (5)$$

the threshold image is shown in figure 4(d). The same preprocessing also using in face database where the result shown in figure 4.

(a) (b)

(c) (d)

Figure 4. Example of Fingerprint Preprocessing (a) original image, (b) resize normalization, (c) histogram equalization, (d) thresholding



(a) (b)

(c) (d)

Figure 5. Example of Face Preprocessing (a) original image, (b) resize normalization, (c) histogram equalization, (d) thresholding

### 3.3. Feature Extraction and Testing

After the preprocessing, all the images extracted using wavelet and then directly each images training using LVQ. In this experiment, it's comparison between Haar, Daubiches, and coiflet to proven what the best wavelet family for feature extraction. Decomposition of wavelet until level 4, so the original image processing with 128 x 128 pixel will be reduced to 8 x 8 pixel. The feature of images will be saved as matrix 1 x 64 in *.xml format. This feature will be trained by LVQ to produce the best weight for each class.

### 3.4. Recognition

In recognition, data testing will be preprocessed and also extracted and then using Euclidean distance to calculate which class that images belong. The result will show up along with distance value of each class, the minimum distance from image testing weight indicated that images is belong to that class.

### 3.5. Discussion and Analysis

All the experiments are implemented in java language programming using NetBeans as application to build up the application. Writer design six experiments to verify the efficiency of the proposed method, which three experiment using fingerprint images as dataset and the three other using face images. Three experiments in each dataset using different three wavelet family in feature extraction, that is Haar, Daubiches, and Coiflet.

In every experiment, its divide 8 sample from each individual become 6 images training and 2 image testing, so there is 60 images training and 20 image testing in every experiment.

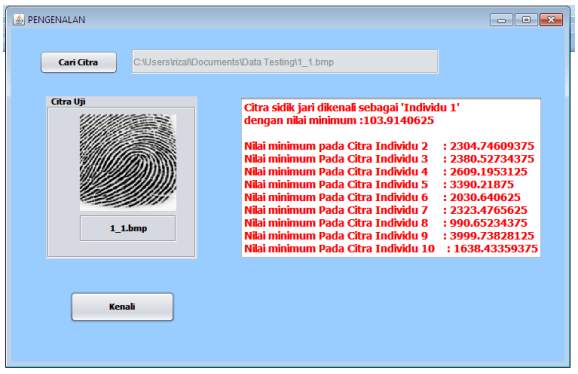



Figure 6. Example of fingerprint recognition

Figure 6 show example of testing. The image testing that uploaded will be recognized as class with minimum distance. Image "1_1.bmp" is image from person 1 which

successfully recognized as "Individu 1" because he has minimum distance than other nine Individual. The experiment result of wavelet comparison using 3 different wavelet family in fingerprint and face can be shown in Table 2.

Table 2. Percentage of Successful Recognition Using Wavelet Haar, Daubiches, and Coiflet

| Biometric | Wavelet Family | Correct Recognition | Percentage |
|---|---|---|---|
| Finger print | Haar | 17/20 | 85% |
| | Daubiches | 13/20 | 65% |
| | Coiflet | 11/20 | 55% |
| Face | Haar | 18/20 | 90% |
| | Daubiches | 16/20 | 80% |
| | Coiflet | 16/20 | 80% |

According to the Table 2, for fingerprint recognition Wavelet Haar show the best result with 85% of successful and then follow by Daubiches 65% and Coiflet 55%. In face recognition, there is no different result that Wavelet Haat still the best for recognition with percentage 90%. Daubiches and Coiflet same with 80% successful for face recognition. Haar wavelet become the best result because it's simplest possible wavelet that have attracting features including fast for implementation and able to analyze the local feature, so its good to be used in image processing such as for image compression and image feature extraction.

This study show better result than [10] which have the same proposed method for face recognition. In [10] the highest percentage for recognition is 79,17% provide by Haar and Daubiches and in this study its show the better result with 90% using Haar and 80% using Daubiches. And based on the result its proven wavelet can used for image feature extraction and show good result especially using Wavelet Haar which have accuracy until 90%.

## 4. CONCLUSION

This paper proposes a comparison wavelet family for feature extraction. Firstly, preprocess the images, then extract features using wavelet and trained using LVQ, and then recognize using Euclidean distance. The wavelet family that compares is Haar, Daubiches, and Coiflet which implemented to extract fingerprint and face images. The experimental results show that Wavelet Haar is the best family for images feature extraction, where in fingerprint recognition the successful percentage is 85% and for face recognition it increases until 90%.

## 5. RECOMMENDATION AND SUGGESTION

Future work is needed to increase the accuracy. Add the amount of data sample, using other wavelet family or using the other pattern such us iris or finger vein can be helped to know what the best wavelet family for images feature extraction.

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