Fingerprint Based Gender Classification Using Discrete Wavelet Transform and K-Nearest Neighbor

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***Abstract*— Fingerprint is a most common traits of human and has uniqueness and permanence because of the its graphical ridge design. Fingerprint has been accepted all over the world for security and identification purposed. Fingerprint has been clarified as a legal proof of evidence in courts of law. Fingerprint based gender classification can be done using Discrete Wavelet Transform (DWT) which is used to extract features in form of wavelet. The sample of this study consists of 100 respondent which is 50 male and 50 female. The sample data is divided into two datasets which is 70% train data and another 30% be the test data set. In this study, K-Nearest Neighbor is used as a classifier and achieved 96.7% of classification rate when K=1.**

Keywords—Fingerprint, gender classification, Discrete Wavelet Transform , k-Nearest Neighbor, 70% train 30% test

I. INTRODUCTION

Gender of a person can be identified using different biometric characteristics such as iris[1], gait[2], hand shape[3], fingertip [4], finger length [5] and fingerprint [6] [7] [8] [9] [10] [11] [12]. Fingerprint is the most common traits of human [10]. Fingerprint has been considered as legitimate proofs of evidence in court of law for a long ago. Fingerprint have some invaluable evidence in crime scene investigations because of its unique nature and does not change throughout the life [13].

The fingerprint data is very important in order to minimize the criminal suspect list [14]. Fingerprint plays an important role in convicting the person responsible for an impudent crime. In any documentation in banking and financial institution, fingerprint has been widely used as an identification and verification purpose [13].

The best gender classification system is depends on the effectiveness of the feature extraction. Image preprocessing is one main important steps in order to get best quality of images. The process of image enhancement is important to ensure the the important features can be extracted [15]. A grayscale representation of a fingerprint image is known to be unstable for fingerprint identification [16], and to solve this, we have used the binarization technique [15]. Another process is introduced to the process of image enhancement which is image filtering. This is to reduce the noise and enhance the edge of the ridge.

In this work, the process of gender classification is done by using Discrete Wavelet Transform (DWT) and k-Nearest Neighbor (k-NN). DWT is used in feature extraction were the fingerprint images is decomposed to features vector and k-NN is used as a classifier. The rest of this paper is organized as follows. Section 2 is the methodology that has been done in this study, while the discussion of the result analysis of this experiment were shown in Section 3. And lastly, the conclusion in shown in Section 4.

II. METHODOLOGY

The sample of this study consist of 100 fingerprint images which 50 fingerprints are taken from male respondents and another 50 fingerprint are from female respondents. The respondents are choosed randomly by using data collection form and a fingerprint thumb print pad. All respondents have been clearly be informed about the study and the consent is taken before the fingerprints acquisition taking place. All 100 respondents need to clean their right thumb before putting it on the thumb print pad and later pressing it on the data collection form over a flat surface. Then, the data collection forms are scanned by using Fuji Xerox DocuScan C4250 in order to proceed to the next stage.

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There are three stages in the gender classification process which are Image Preprocessing, Feature Extraction and Classification. In the first stage, there are three methods used in an image preprocessing stage, which is image normalization, image binarization and image filtering. Those three methods are used to enhance the quality of the latent image used and to get the clearly separated between ridge and valley structure. The next stage is a feature extraction stage, which we are implementing the Discrete Wavelet Transform (DWT) in order to extract the important data and the last stage is a classification stage. K-Nearest Neighbor (k-NN) is used as a classifier. All this is illustrated in Figure 1.

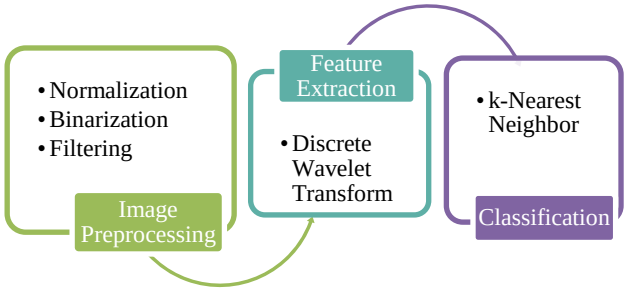

Fig. 1 Basic stage for gender classification

A. *Image Preprocessing*

Image pre-processing is used to enhance the quality of the latent fingerprint image. This stage is important in order to ensure the extraction of the reliability features do not have any problems. There are three processes used which is image normalization, image binarization and image filtering. The purpose of image normalization is shown in Figure 2 and image binarization is shown in Figure 3. Both processes are used to minimize the intra-class variance of the black and white pixel. Next, a filtering process is implemented in fingerprint images to filter out the noise of the image as shown in Figure 4. This filtering also will enhanced the edge of the ridge structure of the fingerprint image.

Fig. 2 Image after Normalization process

Fig. 3 Image after Binarization process

Fig. 4 Image after Filtering process

B. *Feature Extraction using Discrete Wavelet Transform*

Discrete Wavelet Transform is most popular transformation technique used in image compression [17]. The process of transformation gives high compression ration in an image. For this study, we used 1st level l of 2D-DWT as shown in Figure 5.

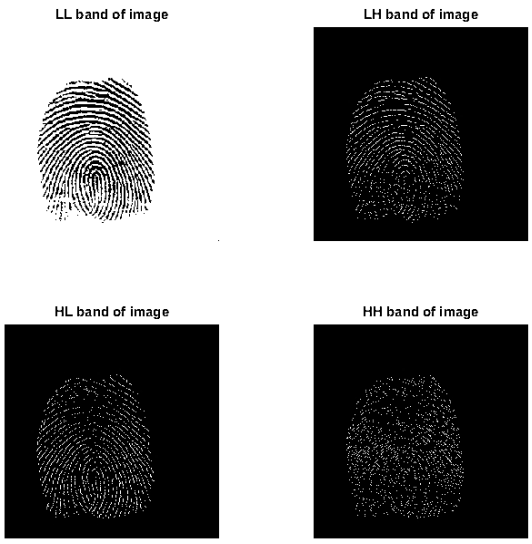

Fig. 5 1st level decomposition for 2D-DWT

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Wavelet transforms decomposed a fingerprint image into a series of wavelet band and will be stored in a block of pixel. It decomposes images into wavelet coefficient. This characteristic is very useful for image compression. The wavelet is created from the translation and dilation of the fixed function. It is good for eliminating the blokiness of the image [17]. The Low-Low (LL) band of images is selected for classification because it is the most of energy retained by the band.

C. Classification using k-Nearest Neighbor

The process of classification is done using Weka. K-Nearest Neighbor is selected as a classifier because of k-NN is the most popular classifier used in classification problem [14]. The process began with the database of the extracted feature. The 100 fingerprint images are divided into two, which 70% train and 30% test. The extracted features of a test and train set are arranged as shown in Figure 6.

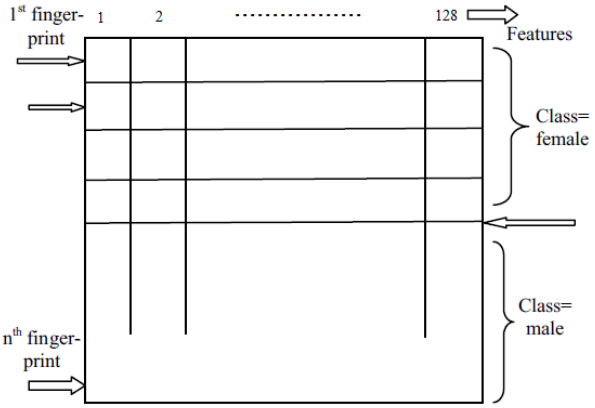

Fig. 6 Extracted features arrange in the database

The result of the classifier is shown in form of classification rate and a confusion matrix.

III. Result and Discussion

Table I shows the result analysis gets from WEKA. From 30 respondents for the testing, 96.67% of it are correctly classified as male and female while another 3.33% is incorrectly classified as his/her gender. The mean absolute error of this study is 0.0504. The mean absolute error is used to measure how close the prediction with the true value.The lower the value of mean square error, the better the prediction.

TABLE I
Result Analysis from WEKA

Correctly classified Instances	96.67%
Incorrectly classified Instances	3.33%
Kappa Statistic	0.9333
Mean absolute error	0.0504
Root Mean Squared Error	0.1566

Table II and Table III show the confusion matrix and the details of accuracy by class gender. TP Rate is a value of true positive. True positive is the number of data predicted positive that are actually positive, while FP Rate is the value of a false positive where number of data predicted positive but actually the data is negative. The result of TP rate for male is 0.933 where 11 of 15 respondents are true classified as Male, while for female the value is 1 because of all female are true classified as a female.

$$\text{Precision} = \frac{TP}{TP+FP} \quad (1)$$

$$\text{Recall} = \frac{TP}{TP+FN} \quad (2)$$

The value of precision is calculated using formula (1) and the value of recall is calculated using formula (2).

TABLE II
Confusion Matrix

	Male	Female
Male	11	4
Female	0	15

TABLE III
Detailed Accuracy By Class

	Male	Female
TP Rate	0.933	1
FP Rate	0	0.067
Precision	1	0.938
Recall	0.933	1
F- Measure	0.966	0.968
ROC Area	0.994	0.994

DWT is commonly used in fingerprint gender classification as shown in Table IV. In 2010, Thaiyanalnayaki *et. al.* [6] used DWT and Canberra Distance Metric. They achieved 95.00% of classification rate using local features of the fingerprint.

In year of 2012, Gnanasivam *et. al.* [7] and Alam *et. al.* [8] used DWT with different hybridization method. Gnanasivam *et. al.* [7] hybrid Discrete Wavelet Transform (DWT) with Singular Value Decomposition (SVD) and they used k-Nearest Neighbor as a classifier in their study. They achieved 88.28% of classification rate. While, Alam *et. al*. [8] combine two methods between Discrete Wavelet Transform (DWT) and Region of Interest (ROI) with used of column vectors as a classifiers. They achieved 94.60% of correctly classified male and female.

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TABLE IV
PREVIOUS WORK ON FINGERPRINT GENDER CLASSIFICATION USING DWT

Author	Year	Feature Extraction	Classification	Classification Rate	Representation
Thaiyalnayaki *et. al.* [6]	2010	Discrete Wavelet Transform (DWT)	Canberra Distance Metric	95.00%	Local
Gnanasivam et. al. [7]	2012	Discrete Wavelet Transform (DWT) & Singular Value Decomposition (SVD)	k-Nearest Neighbor	88.28%	Global
Alam *et. al.* [8]	2012	Region of Interest (ROI) & Discrete Wavelet Transform (DWT)	Column Vector	94.60%	Local
Tom *et. al*. [9]	2013	Discrete Wavelet Transform (DWT) & Principle Component Analysis (PCA)	Euclidean Distance	70.00%	Global
Chad *et. al.* [10]	2013	Discrete Wavelet Transform (DWT) & Singular Value Decomposition (SVD)	k-Nearest Neighbor	80.00%	Global
Akhbar *et. al*. [11]	2014	Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) & Principle Component Analysis (PCA)	k- Nearest Neighbor & Support Vector Machine	95.00%	Global

qaIn year of 2013, Discrete Wavelet Transform (DWT) combined with Principle Component Analysis (PCA) studied by Tom *et. al.* [9]. From the study, they use Euclidian Distance in order to classify gender and they achieved 70.00% of classification rate, while Chad *et. al.* [10] studied on hybridization of Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) for classifying gender. They used k-Nearest Neighbor (k-NN) as a classifier and they achieved 80.00%.

Akhbar *et. al*. [11] studied a comparison of accuracy on two types of classifier on Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) and Principle Component Analysis (PCA). They compared between k-Nearest Neighbor and Support Vector Machine (SVM). Overall classification rate achieved is 80%.

IV. CONCLUSION

In conclusion, this study use Discrete Wavelet Transform (DWT) as a method of feature extraction and k-Nearest Neighbor (k-NN) as a classifier in classifying gender based fingerprint. The used of image preprocessing method before the feature extraction process helps in extracting the valuable features and from the result, k-NN achieved 96.67% of classification rate. Our future work will be continued with the hybridization of method DWT with specific region of 25mm^2 square box Mark Acree's Theory for the feature extraction process.

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