VOL. 10, NO. 22, DECEMBER, 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences


www.arpnjournals.com

CLASSIFICATION OF GENDER BY USING FINGERPRINT RIDGE DENSITY IN NORTHERN PART OF MALAYSIA

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ABSTRACT

This paper describes on how we can use the fingerprint ridge density to classify the gender in people living in northern part of Malaysia. Ridge density is the number of digital ridges per unit area and it is claimed varies according to sex, age, and population origin. The main objective of this study is to test the truth of the relationship between the fingerprint ridge densities and the gender of a person born and lives in Malaysia as until now, no work on such study has been reported among the population. The sample of this study consists of 50 participants coming from the age group of 18-60 year old and consists of 25 males and 25 females. All the respondents had been properly explained about the objectives of the intended study and the consent had been taken before their fingerprints collected. The fingerprint images that taken manually will be going through the image pre-processing phase using a MATLAB software before the ridge of the fingerprint from two topological areas, radial and ulnar can be counted and the mean can be calculated. The results show that fingerprint ridges of less than 12 ridges/25mm² is more likely belong to a male respondent while fingerprint ridges of more than 14 ridges/25mm² is more likely to be from a female respondent. From the result, we can conclude that in Malaysia too, woman tends to have a greater ridges density compared to man. It shows similar trends in sex difference as the other studies of the past conducted on other races in other countries and we can conclude that the trend is universal among all races in the world. From this conclusion, we know that the ridges density is highly trusted to be one of the best criteria for feature extraction in gender classification and this will inspire further research of other classification of feature extraction in gender determination by using a fingerprint.

Keywords: fingerprint, ridge density, gender classification.

INTRODUCTION

Fingerprint becomes most popular biometric authentication and verification since long ago and this is due to their high acceptability, immutability and uniqueness of the fingerprint itself [1]. The immutability of the fingerprint refers to the pattern that remains unchanged over time, whereas the uniqueness related to the differences of the individual ridge details across the whole fingerprint image. These two characteristics make fingerprint highly acceptable and trusted. Even two identical twins will never have the same fingerprint even they shared the same DNA profiles [2]. This attribute makes the fingerprint become a favorable biometric features for authentication and verification in several areas compare to others biometric features. Fingerprints are always associated with criminology especially forensics [3] and it has been used and accepted since 1975 as an important way to recognize the gender or sex of a person [4]. This is because of fingerprint characteristic is permanence, distinctiveness, reliability, accuracy, and acceptability [5]. Identifying the gender of the criminal from the crime scene is an important issue in minimizing the suspects in forensic sciences. Existing method uses teeth, bones and other identifiable body states of the people to estimate the age and sex [1]. Existing application of fingerprint is usually for person identification, but actually, it can be used more than that, for example, to identify age, race, blood group and gender of a person. Unfortunately, the process of latter identifying is hard, complex and takes time to process. A lot of steps involved need to be revised and tested before any conclusion can be made. Fingerprint based gender classification involves forensic stage processes which are not well understood and lack of the organize classification procedures and more on a conceptual description on how to classify based on the structure fingerprint. Fingerprint classification is an important step in any fingerprint gender identification system because it reduces the time taken in identification of fingerprints, especially where the accuracy and speed are critical [1]. The problem studied in this paper consists of classifying the fingerprints images based on the gender, either it is from a male or a female. The category was defined during the early investigation about fingerprint structure by looking at the intensity of ridges; ridge thickness and ridge count of the fingerprint images [6] [7] [8] [9] [10] [11]. Recently, many studies have been carried out the method of storing fingerprint in computer for rapid search and matching of fingerprint, but a few studies available on this method of feature extraction using ridges density [10, 12]. Therefore, this study and experiment is planned to find the relationship between gender and fingerprint ridge density and to verify the facts that women tends to have higher ridges density compared to men as has been claimed by other countries. This study also planned to find the actual distribution of ridges density among Malaysian people especially living in northern part of Malaysia as until now was long as we are concern, there is no work on such study has been reported among this population.

GLOBAL FEATURES

There are two levels of features in fingerprint structure, which is known as a global feature, and a local feature. The local ridge and valley detail carries the information about the individuality of fingerprint while global pattern features carries the information about the fingerprint class. The global features of fingerprint including the fingerprint ridge frequency, fingerprint ridge orientation map, core and delta locations. In this study, we will use the global level features in the fingerprint, which is the ridge to investigate the fingerprint class.

Fingerprint is a pattern on the fingertip and consists of ridges and valleys. The ridges are the black lines and the latter are white area between two adjacent ridges. This is shown in Figure-1 below.

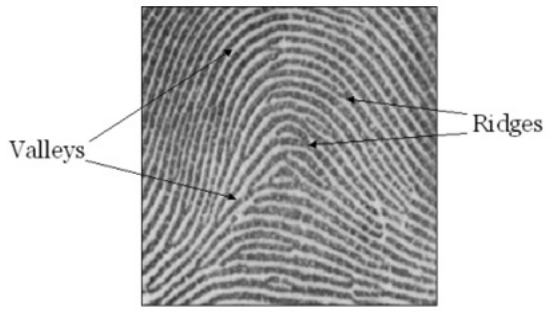

Figure-1. The ridge and valley.

METHODOLOGY

The study involved 50 participants, which are 25 females and 25 males in the year of 2015 in Northern state of Malaysia. The participants were chosen randomly from the age group of 18-60 years old. The plain technique is adopted in this fingerprint images collection procedure. This procedure is chosen because of the simplicity as the respondent only needs to clean their thumb before putting it on the thumb print pad, and later pressing it on the personal data form placed over the flat surface. The material use in this data collection is Unicorn thumb print pad, ruler, pen, measuring tape and data personal form. The data personal form contains basic details including the height, weight and blood type of each participant. All the fingerprint images will go through image pre-processing phase in order to reduce any noise and intensify the fingerprint images. The sample result is shown as in Figure-2(a) and Figure-2(b).

In Figure-2(b), the original fingerprint image is turned into the grayscale. As the grayscale representation of a fingerprint image is known to be unstable for fingerprint recognition [13], the approached have been modified by using binarization. Image binarization will converts a grayscale image to a black and white image or famously known as a bi-level (black & white) images.

Figure-2(a). Before pre-processing.

Figure-2(b). After grayscale pre-processing.

The binarization procedure need a threshold value and classify all the pixels with values above this threshold to white and make other pixels as black.

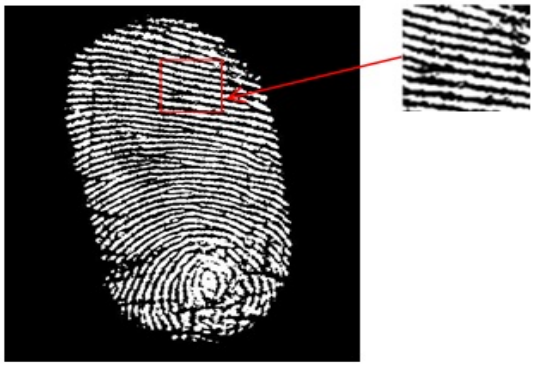

Figure-2(c). After binarization pre-processing with 25mm^2 square area at upper portion of radial and ulnar border of the fingerprint image.

Figure-2(c) shows the binarizationpre-processing on the image of Figure-2(b). This binarization processing will reversed the colour of the image pixels of the original image. The ridges will take the white pixels while the valleys will take the black pixels. This will make the process of calculating the number of ridge easier. As the study use the popular method of 25mm^{2}or better known as the method of Acree [12] to calculate the ridge density, an area of square box measured by 5 x 5 mmis placed at the

upper portion of radial and ulnar border in the fingerprint image. Our study slightly modified themethod of Acree as we are calculating the ridge number through the fingerprint image that has been gone through the binarization pre-processing. The original Acree method calculates the ridge flow by manual original fingerprint image inspection with the help of the magnifier glass. The location of the square area is chosen because from the previous studies, this region will give a similar and clear ridge flow [13].The value of ridges density represented in the number of ridges/ 25mm² square areas is calculated by using the formula in (1).

$$\text{Ridge density},x = \frac{(\text{number of ridge in the square})}{25\text{mm}^2} \quad (1)$$

After the ridge number in the square area have been counted for all respondents, the other measurements are determined to find the median, the mean value and the standard deviation by using formula (2) and (3).

Mean,

$$\mu = \frac{\sum x_n}{N} \quad (2)$$

Standard deviation,

$$\sigma = \sqrt{\sigma^2} = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \mu)^2}{N}} \quad (3)$$

where

x	is the number of ridge count,
n	is the number of the participant and
N	is the total number of participant.
Σ	is the population standard deviation,
μ	is the mean,
x_i	is the i th number of ridge count,

The probability inferences of gender based on the ridges density (RD) values is calculated by using the Likelihood Ratio (LR) as in equation (4) which is based on the Bayes Theorem. (A) is a probability densities from male respondents while (B) is a probability densities from female respondents.

The Like-hood Ratio (LR) formula is given as below:

$$LR = \frac{\text{Probability of the observed RD given that the fingerprint image come from male (A)}}{\text{Probability of the observed RD given that the fingerprint image come from female (B)}} \quad (4)$$

EXPERIMENTAL RESULTS

In this section, all the results in this study are tabulated for comparison. Table-1 show that the numbers of ridge count and the percentages of the ridge count of male and female. The result shows that the male respondents tends to have lower number of ridges density with a maximum number of 14 ridges density compared to female respondents with maximum of 16 ridges density. In terms of percentage, 40% of the male respondents tend to have 11 ridges while for female respondent, majority of the group have 16 ridges, which accumulate 40%.

Table-1. No of ridges against male and female participant.

	Male		Female	
Number of Ridge	No of Participant	Percentages (%)	No of Participant	Percentages (%)
10	4	16	-	
11	10	40	-	
12	9	36	-	
13	1	4	1	4
14	1	4	6	24
15	-		8	32
16	-		10	40
Total:	25	100	25	100

The data visualization of the respondents and its ridge count is shown in Figure-3.

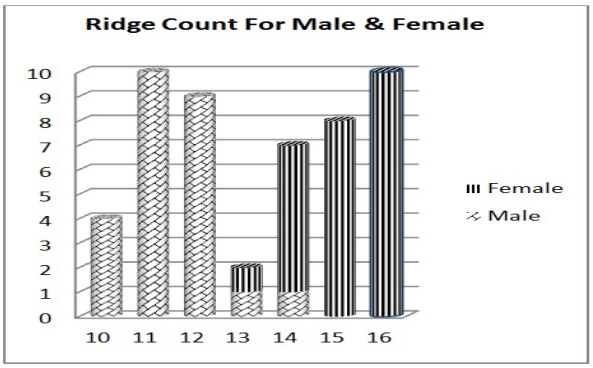

Figure-3. Histogram of ridges count in both male and female.

Figure-3 shows the histogram of ridges count in both genders. It is shown that the male respondents tends to have a lower number of ridges densities with maximum of 14 ridges compared to female respondents with maximum of 16 ridges. On the other hand, there is no female respondents was found to have number of ridge of 10,11 and 12 and no male respondents to have ridge count of 15 and 16.

In Table-2, it is shown that mean for male and female in Malaysia is around 11.4 and 15.1 each with the standard deviation of 1.3822 and 0.9496. The median for each gender is 12 for male and 14.5 for female.

Table-2. Statistical of ridges density in both male and female.

	Male	Female
Minimum	10	13
Maximum	14	16
Median	12	14.5
Mean	11.4	15.1
Standard Deviation	1.3822	0.9496

The frequency distribution of ridge density is shown in Figure-4.We can observe that there are an escalating number of female respondents having more ridges when the number of ridge increases from 13 to 16. While for male respondents, we can see that the pattern is totally contrary when the number of ridges increases after 11.

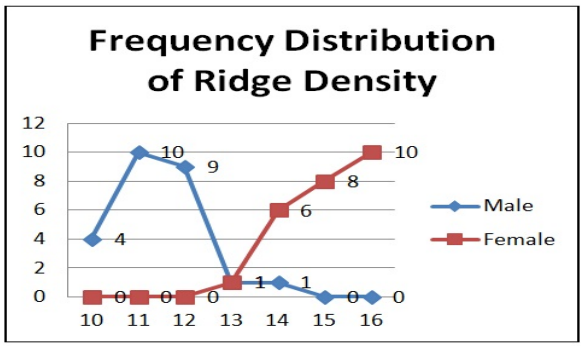

Figure-4. Frequency distribution of ridge density observed from male and female respondents

In Table-3, we show the value of the probability density and the Likelihood ratio of male and female from the ridge density aspects. The likelihood ratio (LR) was computed to obtain the probability inferences of sex, based on RD values [10]. The favoured Odd male female will show the probability of each gender for every ridge density.

Table-3. Ridge density (RD), probability Density, likelihood ratio and favoured Odd.

Ridges Density (RD)	Probability Density		Likelihood Ratio (LR)		Favoured Odd	
	Male (A)	Female (B)	LR (A/B)	LR (B/A)	Male (A/A+B)	Female (B/B+A)
10	0.16	0.001	160	0.006	0.994	0.006
11	0.40	0.001	400	0.002	0.998	0.002
12	0.36	0.001	360	0.002	0.997	0.003
13	0.04	0.04	1	1	0.5	0.5
14	0.04	0.24	0.167	6	0.143	0.857
15	0.001	0.32	0.003	320	0.003	0.997
16	0.001	0.40	0.002	400	0.002	0.998

It is shown that the ridge density and the probability density is smaller in males compared to females as it might be as a reason of the less coarseness of ridges in female. The statistical analysis of Likelihood Ratio and the odds ration shows that a ridge density of less than and equal to 12 per 25mm^{2}is more likely to be from a male respondent from the higher probability (p = 0.997), whereas a ridge density of more than and equal to 15 will definitely indicate a female respondent with higher probability. The ridge density of 14 is likely to be from a female respondent with the probability value of p = 0.857 and it will be a 50 % chance of both genders if the ridge density is 13.

DISCUSSIONS

Many studies have been done by researchers on global structure of fingerprint which is ridge structure, ridge count, ridge thickness and ridge density for identification purpose. The existing study shows that male tends to have a lesser ridge count compared to female. This study have been conducted to prove and validate the statement of existing studies about the relationship of ridges density with the gender of a person in Malaysia. The main objective of this study is to test the truth of the relationship between the fingerprint ridge densities and the gender of a person born and lives in Malaysia as until now, no work on such study has been reported among the population. From the results, it shows that women have a significantly higher ridge count (mean = 15.1) when compared to men (mean = 11.4). The result obtained in this study is similar to study obtain by Vinod [10] and higher values obtained by Acree [12]. Table-4 shows the result obtained from the existing studies that show similar trends in the gender difference which it can strengthen the fact that women tend to have higher ridges density compared to a man.

Table-4. Gender differentiation by ridge count among various studies.

Author	Participant	Mean	
		Male	Female
Sudesh Gunggadin [8]	India	12.8	14.5
Nayak et al.[10]	India	11.05	14.2
Acree [12]	Africa	10.90	12.0
Kumar et al. [14]	Uttarakhand	11.9	14.1
Cumins and Midlo [15]	America	20.7	23.4
Ping et al. [16]	China	14.5	15
Sam et al. [17]	Indian	12.79	14.81

The result of this study is very helpful for classifying the gender in Forensics or Law Enforcement field. The result of the study will minimize the time taken in recognizing the gender of a person. The study will be continued by using 10 different fingerprint of each person and add other fingerprint features like fingerprint pattern types, ridge thickness to valley thickness ratio, white lines count and no pattern types.

Further experiment will enhance the classification part, which is to find the best method of classification that helps to increase the accuracy and speed of gender classification system. It is noted that in Figure-3, that some men and women have the same ridge and this will sparks more explanation why this happen.

CONCLUSIONS

The results will inspire for further study in classification techniques/methods of gender classification by using different characteristics or features. This study was conducted to test the hypothesis that claimed women tends to have a greater ridge density compared to a man in several countries. Since all the previous studies happened in overseas, it is such an opportunity to test the hypothesis in Malaysia population and from the results gained, we know that we can accepted the hypothesis. Another contribution of this paper is the introduction of the binarization technique in the fingerprint image preprocessing. The objective is to convert the grayscale finger print image to bi-level image before any ridge lines can be count as from the literature review, the greyscale image is known to be unstable in fingerprint recognition. Before this, all the ridge counting process is done to the raw image without have been gone through any image preprocessing technique.

ACKNOWLEDGEMENTS

This work was supported by research grants RAGS/2013/FTMK/ICT02/01/B00039 under Ministry of Higher Education ofMalaysia for financial support.

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