



ANALYSIS OF FINGERPRINT IMAGE FOR GENDER CLASSIFICATION USING SPATIAL AND FREQUENCY DOMAIN ANALYSIS

S. S. Gornale¹, Geetha C D², Kruthi R²,

¹Department of Computer Studies, Government College (Autonomous), Mandya-Karnataka-INDIA.

²Research Student, DOS in Computer Science, University of Mysore,
Mysore-Karnataka-INDIA

Abstract: Gender identification from fingerprints is an important step in forensic anthropology in order to identify the gender of a criminal and minimize the list of suspects search. Fingerprint identification and classification has been extensively researched in the literature however very few researchers have studied the fingerprint gender classification problem. In this paper, gender identification is carried out by using combined features like FFT, Eccentricity and Major Axis Length. Left thumb impression of each sample of the internal database of 450 male samples and 550 female samples of good quality are selected. An optimal threshold for each transform is chosen for better results. It is found that the proposed algorithm produces accurate decision of 80% of male and 78% of female. The overall performance of the system is found to be satisfactory and useful to forensic anthropology.

I. Introduction

The science of fingerprint has been used generally for the identification or verification of person and for official documentation. Based on the varieties of the information available from the fingerprint we are able to process its identity along with gender, age and ethnicity. The primary dermal ridges (ridge counts) are formed during the gestational weeks 12-19 and the resulting fingerprint ridge configuration (Fingerprint) is fixed permanently. Variations in ridge dimensions and sex differences in ridge breadth have been reported. Ridges and their patterns exhibit number of properties that reflect the biology of individuals. Dermatoglyphic features statistically differ between the sexes, ethnic groups and age categories. Studies so far carried out in gender determination have used the inked fingerprints and their findings are based on the spatial domain analysis of ridges. Generally ridge related parameters such as fingerprint ridge count, ridge density, ridge thickness to valley thickness ratio, ridge width and fingerprint patterns and pattern types were used for gender determination. All the methods proposed based on the fingerprint ridges have given insight about the ridge parameters mentioned about but fails to give accurate method of measuring the parameters. This may be due to the measurement made on the inked fingerprint impressions and manual measurements of the parameters where human error and recklessness is inevitable. Poor impressions are unavoidable due to one or more of the following reasons. Poor, thin or colored ink, poorly maintained inking apparatus, fingers of foreign substances, failure to roll fingers fully, smears and blurred fingerprint due to finger slip or twist while enrolling and poor cooperation of subject. Also, the ridge thickness depends on the pressure applied and may provide false results on gender identification. The traditional methods use ridge related parameters and frequency domain analysis to detect gender. But not much work has been done to detect gender using region properties of the image. Hence, an attempt has been made by proposing a method that utilizes both frequency domain analysis and spatial domain analysis for identification [1][2][3]

II. Related work

Ahmed Badawi, et al, (June, 2006) proposed a method for Gender classification from fingerprints. A dataset of 10-fingerprint images for 2200 persons of different ages and gender (1100 males and 1100 females) was analyzed. Features extracted were; ridge count, ridge thickness to valley thickness ratio (RTVTR), white lines count, and ridge count asymmetry, and pattern type concordance. Fuzzy- C Means (FCM), Linear Discriminate Analysis (LDA), and Neural Network (NN) were used for the classification using the most dominant features predicted results of 80.39%, 86.5%, and 88.5% using FCM, LDA, and NN, respectively. [4]

Manish Verma, et al, (2008) proposed a method for Gender classification from fingerprints. Features extracted were; ridge width, ridge thickness to valley thickness ratio (RTVTR), and ridge density. SVM is used for the

classification. This method is experimented with the internal database of 400 fingerprints in which 200 were male fingerprints and 200 were female fingerprints. They found male-female can be correctly classified up to 91%.[5]

Jen feng wang, et al, (2008) worked on gender determination using finger tip features. He obtained fingerprints from 115 normal healthy adults in which 57 were male fingerprints and 58 were female fingerprints. They have used ridge count, ridge density, and finger size features for classification. However, the ridge count and finger size features of left little fingers are used to achieve a classification. The best classification result of 86% accuracy is obtained by using ridge count and finger size feature together.[6]

Angela Bell proposed a method in contrast to Acree's method of comparing ridge densities. He compared fingerprint loop ridge counts from 40 male and 40 female subjects. His analysis revealed no significant mean difference in the loop ridge counts across gender represented by these eighty subjects, $F(1, 78) = .308$, $p > .05$, $MSE = 7.946$. There is no difference in the number of loop ridge counts that males have (13.18, $SD = 2.735$) then did females (13.53, $SD = 2.900$). He concluded there are no significant differences in loop ridge counts between genders.[7]

Dr. Prateek Rastogi, et al, have presented that there is an association between distribution of fingerprint patterns, blood group and gender. A dataset of 200 persons were analyzed (100 male & 100 female) belonging to the age group 18- 25. Results show that each finger print is unique; loops are the most commonly occurring fingerprint pattern while arches are the least common. Males have a higher incidence of whorls and females have a higher incidence of loops. Loops are predominant in blood group A, B, AB and O in both Rh positive and Rh negative individuals except in O negative where whorls are more common. Thus, they concluded that there is an association between distribution of fingerprint patterns, blood group and gender and thus prediction of gender and blood group of a person is possible based on his fingerprint pattern.[8]

Gnanaswami P, et al, (2011) have proposed a method for Gender Identification Using Fingerprint through Frequency Domain Analysis to estimate gender by analyzing fingerprints using fast Fourier transform (FFT), discrete cosine transform (DCT) and power spectral density (PSD). A dataset of 400 persons of different age and gender is collected as internal database. Frequency domain calculations are compared with predetermined threshold and gender is determined. They obtained the results of 92.88 % and 78 % for male and female respectively.[9]

Gnanaswami P, et al, (2012) proposed a method for Gender Classification from Fingerprint based on discrete wavelet transform (DWT) and singular value decomposition (SVD). The classification is achieved by extracting the energy computed from all the sub-bands of DWT combined with the spatial features of non-zero singular values obtained from the SVD of fingerprint images. K nearest neighbor (KNN) is used as a classifier. This method is experimented with the internal database of 3570 fingerprints finger prints in which 1980 were male fingerprints and 1590 were female fingerprints. They have obtained Finger wise gender classification which is 94.32% for the left hand little fingers of female persons and 95.46% for the left hand index finger of male persons. Gender classification for any finger of male persons tested is obtained as 91.67% and 84.69% for female persons respectively. Overall classification rate of 88.28% has been obtained [10]

Ritu Kaur et.al, (2012) have worked on fingerprint based gender identification using frequency domain analysis. The classification is achieved by analyzing fingerprints using Fast Fourier transform (FFT), Discrete Cosine Transform (DCT) and Power Spectral Density (PSD). A dataset of 220 persons of different age and gender is collected as internal database. Frequency domain calculations are compared with predetermined threshold and gender is determined. They obtained results of 90%, and 79.07% for female and male samples respectively.[11][12]

Rijo Jackson Tom, et al, (2013) have proposed a method for Fingerprint Based Gender Classification through frequency domain analysis to estimate gender by analyzing fingerprints using 2D Discrete Wavelet Transforms (DWT) and Principal Component Analysis (PCA). A dataset of 400 persons of different age and gender is collected as internal database. They have used minimum distance method for classification and achieve overall success rate in gender classification of around 70%.

III. Proposed Methodology

The Proposed method for classification of fingerprint image for gender classification is shown figure-1 it carries four major steps as the functioning blocks of gender identification.

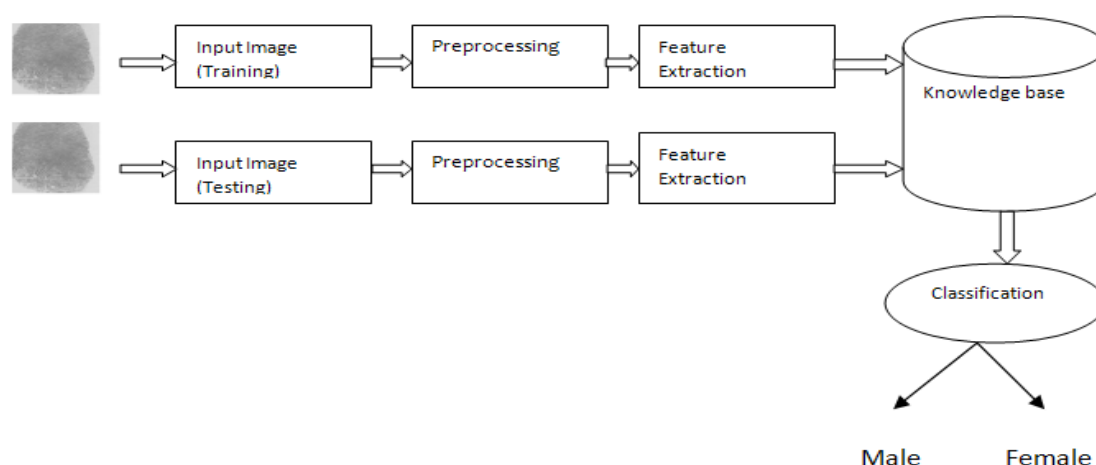


Figure 1. Proposed methods for fingerprint classification

3.1. Fingerprint Image Acquisition:

The fingerprint images of internal database were collected from a finkkey hamster 2nd scanner manufactured by nitgen biometric solution [30 with interface USB 2.0] The images were captured with a resolution of 512. For this work a database with 1000 images of left thumb fingerprints was created which correspond to 80 different people

3.2 Preprocessing.

After collecting fingerprint samples, some preprocessing work such as background elimination, cropping, etc. have been carried out All collected fingerprints are resized [200x200] in the bitmap format of same dimensionality. Primarily it is a color image. For computer efficiency, the color image having high dimensionality was converted these color image to binary image, so for this binary image the calculation/recognition time is less and dimensionality will be reduced and it saves the memory.

3.3 Feature Extraction:

Feature extraction is a fundamental preprocessing step for pattern recognition and machine learning problems. Various experiments were carried out to extract features using different methods, namely discrete wavelet Transform, Discrete Cosine Transform, Fast Fourier Transform and Region Properties. The promising results are obtained using FFT and Region properties. The experimental analysis, results and conclusion are discussed in sections 4 and section 5 respectively.

IV. Experimental Analysis.

The various experiments are conducted using DCT, FFT and spatial features like (area, major axis length, minor axis length, eccentricity, orientation, convex area, filled area, Euler number, equivalent diameter, solidity, extent and perimeter) and promising results are obtained and the results have predicted only some dominant features like eccentricity, Major axis length and FFT, which are used to classify the gender (male or female.)

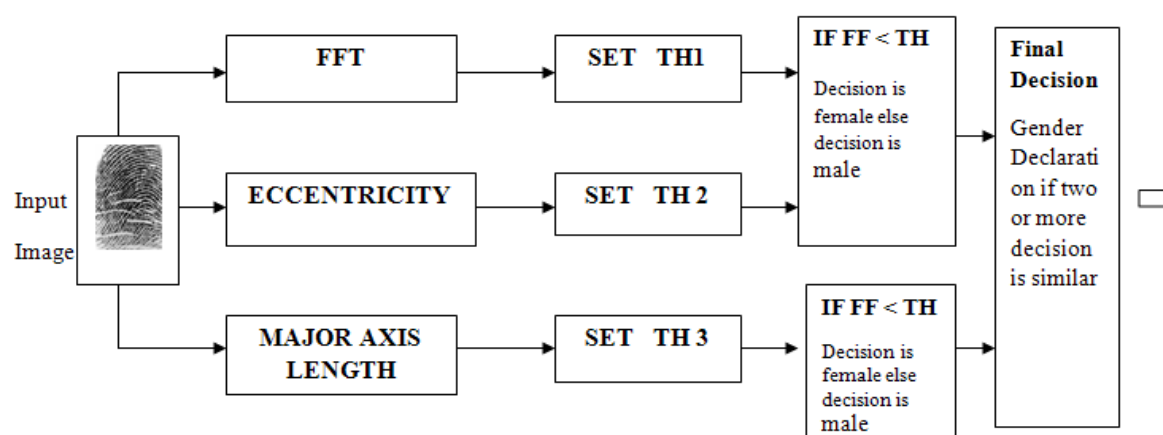


Figure -2 Analysis of algorithm.

1. Input from the database is given to the gender identification system.
2. FFT transforms the given input and generates the output. Threshold is set to TH1. Rule is set in such a way that if the fundamental frequency (FF) is greater than TH1 the decision is female and if the FF is less than TH1 the decision will be male.
3. Eccentricity of the given input is computed and generates the output. Threshold is set to TH2. Rule is set in such a way that if the fundamental frequency (FF) is greater than TH2 the decision is female and if the FF is less than TH2 the decision will be male.
4. Major Axis Length of the given input is computed and generates the output. Threshold is set to TH3. Rule is set in such a way that if the fundamental frequency (FF) is greater than TH3 the decision is female and if the FF is less than TH2 the decision will be male.
5. Comparing the decision by all the transforms, if two decisions are male, the result is announced as male and if two decisions are female, the result is announced as female.

An optimal threshold set for each transform is an important part of the gender identification process. Initially 1000 fingerprints of both male and female are examined with FFT, Eccentricity and Major Axis Length were obtained for each case. For FFT, the threshold is set as 500000 and the samples having the fundamental frequency (FF) less than the threshold is identified as male and the samples with FF greater than the threshold is identified as female. For Eccentricity, the threshold is set to 0.6 and the samples having FF less than the threshold is identified as male and the samples with FF greater than the threshold is identified as female. For Major Axis Length, the threshold is set as 250 and the samples having FF less than the threshold are identified as male and the samples with FF greater than the threshold are identified as female as per the figure 2 the analysis of algorithm and the results for combined features are shown in Table-1 and Table-2.

FINGERPRINT SAMPLE	FFT THRESHOLD > 5000000	ECCENTRICITY THRESHOLD >0.6	MAJOR AXIS LENGTH YHRESHOLD >250
1	5075181.8	0.8495	269.22541
2	5910150.3	0.84051	261.21347
3	8010071.3	0.66843	277.39943
4	6269623.5	0.60265	253.10256
5	6831938.5	0.77789	273.74287
6	5668126.2	0.6764	256.03259
7	5946901	0.6764	257.11555
8	7562407.3	0.88811	250.47639
9	4968828.4	0.59602	246.66551
10	5795622.3	0.86555	273.17137

Table -1: Results of FFT, Eccentricity, Major Axis Length for female samples

FINGERPRINT SAMPLE	FFT THRESHOLD > 5000000	ECCENTRICITY THRESHOLD >0.6	MAJOR AXIS LENGTH THRESHOLD >250
1	4733106.5	0.5356	249.15157
2	1996323.8	0.28955	244.83074
3	4845580.2	.25252	244.98633
4	2570111.5	0.26499	239.58606
5	4844242.1	0.44792	247.83936
6	4535371.9	0.19157	129.75999
7	5337723.4	0.81617	260.24727
8	4054619.6	0.09282	240.87762
9	4626589	0.19163	245.95536
10	5325927.6	0.50575	240.83456

Table-2: Results of FFT, Eccentricity, Major Axis Length for male samples

V. Conclusion and Future Work

Fingerprint evidence is undoubtedly the most reliable and acceptable evidence till date in the court of law. Due to the immense potential of fingerprints as an effective method of identification, an attempt has been made in the present work to analyze their correlation with gender of an individual. In this work gender identification is carried out by combined features using FFT, Eccentricity and Major Axis Length for 450 male samples and 550 female samples of good quality. Left thumb impression of each sample of the internal database is tested. An optimal threshold is chosen to achieve better results. It is found that the proposed algorithm produces accurate decision of 80% of male and 78 % of female.

In future, the work will be extended to build robust algorithm for frequency domain and region properties to find different parameters (like age group, Rural, Urban people) and different features it can be applied in gender classification which will be more accurate and suitable for all types of applications.

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