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Haralick Feature Descriptors for Gender Classification Using Fingerprints: A Machine Learning Approach

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Abstract— This Gender classification is a key task for human beings, as many social interactions are gender-based. The research carried out so for on gender classification techniques can be vigorously estimated from the face image with relatively more complex resulting in high accuracy. Fingerprint biometric trait is another technique which is used for the estimation of gender information and classification. It is a significant step in anthropology in order to identify the femininity of a criminal and shorten the list of suspects search. In this work, Haralick texture features are used to extract the gender information from fingerprints for classification of male and female. The experiment is conducted on fingerprints collected from different age groups of rural and urban people. According to the experimental observations a 92% and 94% classification rate is achieved for linear discriminant analysis (LDA) and quadratic discriminant analysis (QDA) classifiers respectively. The work has been analyzed and the results reported in this are found to be satisfactory and more competitive.

General Terms- Image Processing, Pattern Recognition.

Index Terms—Gender classification, Image-based methods, Minutia based methods, Haralick Texture, Linear Discriminant Analysis (LDA) and Quadratic Discriminant Analysis (QDA).

I. INTRODUCTION

This Gender classification is a key task for human beings, as many social interactions are gender-based. The problem of gender classification has been investigated from both psychological and computational perspectives. It plays a vital role in many applications such as human-computer inter-action, surveillance, context-based indexing and searching, demographic studies and biometrics. In the context of biometrics, gender can be viewed as a soft biometric trait that can be used to index databases or enhance the recognition accuracy of primary biometric traits [36]. The problem of automated gender assessment is typically treated as a two-class classification problem in which features extracted from a set of images corresponding to male and female subjects are used to train a two-class classier. The reviews of different classification techniques based on face have been used for gender classification discloses that accuracy is high but time consuming [1]. Existing methods of face based gender classification have limited use for crime scene investigation because they depend on the availability of huge global features i.e. appearance based approach that uses whole face image containing thousands of pixels which is reduced to handful number of pixels by dimensionally reduction schemes. Fingerprint analysis plays a role in convicting the person responsible for a rude crime. Fingerprint has been used as a biometric for the gender and age identification because of its unique nature and do not change throughout the life of an individual. An inadequate number of studies have investigated the estimation of gender information from fingerprint images which will increase the accuracy level with a lesser amount of computer complexity [40].

Fingerprint based gender classification algorithms/methods can be classified into two categories: image-based and minutiae-based. The minutia- based fingerprint identification contains orientation, segmentation and core point detection [2]-[5]. The minutia like intersecting points, number of blobs, ridge counts and terminating points etc., were extracted and classified accordingly. It is still significant in research field and a few researchers have worked on fingerprints for gender classification using minutia extractions and have achieved competitive results [6]-[7],[9]-[12].[14-16]. Image-based methods include optical correlation and transform-based features [17]-[30]. Several methods have been proposed for each and every category and there are several approaches so for suggested in the literature for transform-based features. In this work, the Haralick texture features are used to extract the gender information for classification of male and female using fingerprints. The Haralick features were extracted and classified using linear discriminant analysis (LDA) and quadratic discriminant analysis (QDA) classifiers [41]. The rest of the paper is organized as follows: the section-2 gives the outline of the related work. Section-3 gives the proposed methodology and algorithm. Section-4 will gives an analysis and discussion of the experimental work followed by the conclusion and future work in section-5.

II. RELATED WORK

In [18], a comparative study on feature extraction for fingerprint classification and performance improvements using rank-level fusion. The features were extracted like Gabor features, OM (Orientation Maps), MM (minutia Maps) and OC

(orientation co-linearity). In MMs, the total rejection rate was 1.77% with 36 training samples and 35 testing samples rejected. Using OM the total rejection rate was 1.75% with 37 training images and 33 testing images rejected. Using OC the top-class accuracy was close to 77%, while the top-two classes' accuracy was 93.7%. Using Gabor features the top-class accuracy was 83.86% while the top-two-classes accuracy was 96.1%. With processing time in sec for Gabor features 5.6, OM 0.03, MM 0.30 and OC 2.29 respectively

In [19], authors have focused on male and female identification using fingerprint through frequency domain analysis to estimate male and female by analysing fingerprints. FFT, DCT and PSD are sued to extract features on a database of 400 persons of different age and gender. An optimal threshold is used to classify the gender. A 92.88 % and 94.85 % for male and female accuracy rate is obtained.

In [20], authors have focused on a method for gender classification from fingerprint based on Discrete Wavelet Transform and Singular Value Decomposition. DWT and SVD is used extract the feature set. This method is experimented with the internal database of 3570 fingerprints. They 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.

In [21], authors have extracted the feature set from FFT, DCT and PSD are used to extract the features for gender classification. A dataset of 220 persons of different age and gender is collected as internal database. An optimal threshold is used to classify the gender. They obtained a 90%, and 79.07% for female and male samples respectively.

In [26], authors have used the 2D-Discrete Wavelet Transformation (DWT) was used to find the frequency domain vector and Singular Value Decomposition (SVD) are used to find the spatial feature of the non-zero singular values. The K-NN classifier is used to classify the fingerprint. The method is experimented on the internal database of 100 fingerprints of left hand index finger, 50 males and 50 females belonging to the same age group and achieved the success rate of classification that is more than 80%.

In [31], authors have extracted the features through 2D Discrete Wavelet Transforms and Principal Component Analysis. A dataset of 400 fingerprints of the age of 12-60 was collected and the overall success rate of classification in age estimation was around 68%.

In [24], authors have focused method for fingerprint based gender classification through frequency domain analysis to estimate gender by analysing fingerprints using 2D Discrete Wavelet Transforms and Principal Component Analysis. A dataset of 400 persons of different age and gender is collected as internal database. Their overall success rate in gender classification is around 70%.

In [25], a male and female identification that is carried out using frequency and spatial domain by combined features using FFT, Eccentricity and Major Axis Length. A database of 450 male and 550 female samples of left thumb impression of each sample were considered. An optimal threshold is chosen to achieve results. The algorithm produces accurate classification of 80% of male and 78% of female.

In [27], authors have focused on RVA and DCT coefficients for gender classification based on age and gender determination from fingerprints. The age and gender fingerprints are classified on the basis of ridge to valley area, entropy and RMS value of DCT coefficients. The novelty of the method lies in the fact that the identification of age and sex is independent of the pressure i.e. finger prints thickness or ridge/valley thickness. And they have achieved competitive results.

In [28], authors have worked on DWT based gender classification. The features were extracted using Discrete Wavelet Transform Using 5-level Haar Wavelet Transform; the directional images of fingerprints are obtained. The Neural Networks are used to classify it and they achieved classification rate of 91.30% of an internal database of 300 images.

In [29], authors have proposed a method of fingerprint based gender classification using discrete wavelet transform & artificial neural network. The two methods are combined for gender classification. The first method is the wavelet transformation employed to extract fingerprint characteristics/features by doing decomposition up to 5 levels. The second method is the back propagation artificial neural network algorithm used for the process of male and female identification. This method is experimented with the internal database of 550 fingerprints in which 275 were male fingerprints and 275 were female fingerprints. The overall classification rate of 91.45% has been achieved.

In [30], authors have focused on a method of male and female identification through fingerprint biometric using Discrete Curvelet Transform and back propagation with feed forward neural network classifier. These features were extracted from the fingerprint database utilized for learning stage of neural network. The trained network acts as automatic classifier to identify the gender from input image features. The Fast Discrete Curvelet Transform decomposes an image into different orientation wedges, details of which provide texture pattern and frequent occurrences of intensities. The orientation image represents an intrinsic property of the fingerprint images and defines invariant coordinates for ridges and valleys in a local neighbourhood. These patterns will be estimated using haralick or glcm features and can achieve better classification accuracy and low complexity in performance.

In [1], authors have proposed the study to explore the use of classical texture descriptors - Local Binary Pattern (LBP), Local Phase Quantization (LPQ), Binarized Statistical Image Features (BSIF) and Local Ternary Pattern (LTP) - to estimate gender from fingerprint images and predicted that LBP descriptor is efficient in encoding gender information from high quality fingerprint images in comparison to LPQ, BSIF and LTP.

In [32], authors have proposed the method of fusion of fingerprint and age biometrics for gender classification. The real fingerprints were collected from different age groups such as 15-20 years and 20- 60 years of the rural and urban people. Features are extracted through DWT, DCT, FFT and Region Properties like major axis length, area, eccentricity, minor

axis length, convex area, solidity, perimeter, extent, Euler number and filled area. The overall performance of the proposed method is found to be satisfactory and more competitive.

In [38], authors have proposed the use of machine learning to determine the differences between fingerprints. The database was represented by a feature vector consisting of ridge thickness to valley thickness ratio (RTVTR) and the ridge density values. By using a support vector machine trained on a set of 150 male and 125 female images and obtained an accuracy of 96%.

From the literature it is observed that a good number of researchers have worked on gender classification using different approaches and forecasted some promising results with their own datasets. But still there is a scope for developing a robust algorithm using different parameters like age group, demographic characterization based on rural and urban people. Different robust features are required to be extracted for gender classification which will be more accurate and suitable for all types of datasets to increase the gender classification rate [32]-[33].

III. PROPOSED METHODOLOGY FOR GENDER ESTIMATION FROM FINGERPRINTS

The general steps involved in the gender estimation from the fingerprints are as shown in below figure-1 [25],[32],[33].

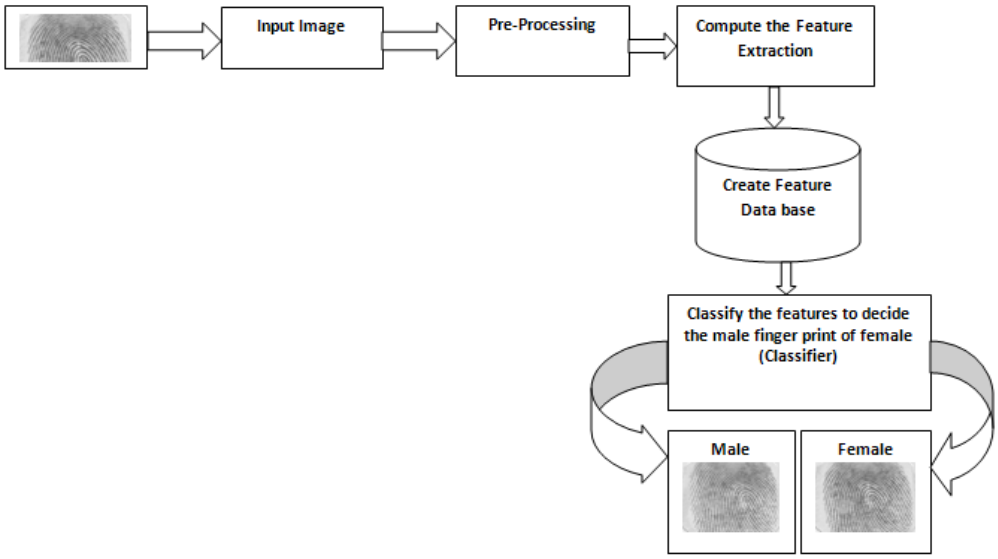

Figure-1: General steps for gender estimation from the fingerprints

3.1 Fingerprint acquisition:

As per the study there is no separate standard database for male and female fingerprints. In view of this we have created our own database for gender classification based on fingerprints. The dataset is collected from different age groups and these were chosen from urban and rural area. The acquisition of the fingerprint was made by "Fingkey hamster 2nd scanner manufacture by nitgen biometric solution [30 with interface USB 2.0]". The resolution of the captured images is of 512 DPI in gray scale of 200x200 pixels by the researchers for better accuracy and performance [25],[32],[33].

3.1.1. Data set used in this work:

According to the Henry [42] there are eight different classes of fingerprints irrespective of gender. However left loops, right loops and whorls and arch are the major and most popular fingerprint classes [43]. As such there is no standard database is available based on gender. In view of this we have created our own database male and female separately. Fingerprints from different age groups and were chosen from urban and rural area. A 45 samples of Male and 46 samples of female for rural and 65 Samples of Male and 60 samples of female for rural for the age group 15-20 years and for the age group 21-60 years respectively. The samples of fingerprints for the same age groups from the urban areas are collected and the overall data set is near about 4320 fingerprint samples (10 samples of each person). It is clearly understood that there is an intra and inter-class variations in the fingerprint images. This intra and inter class variability makes the data set is very challenging and competitive.

3.2. Pre-processing:

After acquiring the images, the initial task is to do pre-processing and the pre-processing techniques are application dependent. In our case we are pre-processed the fingerprint images such as background elimination, cropping, converting colour image into binary image etc., to increase the computer efficiency [25],[32],[33],[37].

3.3. Feature Extraction and Computation:

A Textured area in an image is characterized by a non-uniform spatial distribution of image intensities. A Colour image also contains the textures. We limit ourselves to grey scale images. The texture descriptor models are classified into three main classes [32]-[35], [39].

- Pixel based models: In this model texture is described by statistics of the distribution of grey levels of intensities in the texture.

- Local feature based model: In this model statistics are computed with respect to the distribution of local features such as edges or lines.
- Region based model: In this model the texture is segmented into the regions and then statistics on the shape and spatial arrangement of regions are used to characterize the texture [25],[32],[33].

In this paper, we used pixel based statistical measures in which texture is described by statistics of the distribution of grey level of intensities. The Haralick texture features are used to extract the gender information for classification of male and female from the fingerprint images [13]. We have fingerprint image f(x,y) as the square image of size 64*64 and we define the co-occurrence matrix for Image f as :

$$C(i,j) = \sum_{x=1}^{N}\sum_{y=1}^{N} \begin{cases} 1 \; if \; f(x,y) = i \; and \; f(x+dx, y+dy) \\ 0 \; otherwise \end{cases}$$

The distance between co-efficient of interest and its neighbours is specified by offset (dx, dy). We have $\{[0\ 1], [-1\ 1], [-1\ 0], [-1\ -1]\}$ level of offsets which are representing the directions D as 0^0 , 45^0 , 90^0, 135^0 respectively. From this co-occurrence matrix, we computed the thirteen statistical features such as Angular Second Moment (ASM), Contrast(C), Correlation, Variance (CV), Inverse Difference Moment (IDM), Sum Average (SA), Sum Variance (SV), Sum Entropy (SE), Entropy Difference Variance (EDV), Difference Entropy (DE), and Information Measure of Correlation-1(IMC-1) and Information Measure of correlation-2(IMC-2). For more details on co-occurrence matrix based statistical texture descriptors are given in [13]. Further we compute 13 features from each co-occurrence matrix and formed feature vector of size 13*4 = 52 dimensions.

3.4. Feature Classification:

Several approaches have been developed for automatic fingerprint classification and these approaches broadly put into four main categories: [25],[32],[33].

- Knowledge-based: This technique that uses the locations of singular points (core and delta) for classification.
- Structure-based: This technique uses the estimated orientation field in a fingerprint image for classification.
- Frequency-based: This technique uses the frequency spectrum of the fingerprints for classification.
- Syntactic: This technique uses a formal grammar to represent and classify fingerprints.

In our work we used the structured based classification techniques such as linear discriminant analysis (LDA) and quadratic discriminant analysis (QDA) classifiers for classification [41].

IV. EXPERIMENT ANALYSIS

The experiment is carried out on fingerprints which are collected from different age groups of the rural and urban population. A real 600 fingerprints were collected from different age groups and the experiments are conducted on datasets of 600 samples. (300 male and 300 female) The Haralick texture descriptors are used to compute the extract features. For analysis 300 male and 300 female fingerprints are trained and tested. The linear discriminant analysis (LDA) and quadratic discriminant analysis (QDA) classifiers are used to classify the gender by using below algorithm.

Input: Fingerprint image.

Output: Male or female finger print images.

Step-1: Pre-processing i.e. removal noise, images resize, etc and Convert it into grayscale.

Step-2: Normalize gray scale image to size 64x64 and define the co-occurrence matrix.

Step-3: From the co-occurrence matrix compute the thirteen statistical features [13].

Step-4: Further compute 13 features from each co-occurrence matrix and formed feature vector of size 13*4 = 52 dimensions (Extract the 52 Haralick texture features from each input finger print image.)

Step-5: Apply LDA classifier and test the accuracy using 10 fold cross validation.

Step-6: Apply QDA classifier and test the accuracy using 10 fold cross validation.

End of the algorithm.

The performance/results of the algorithm for showed in Table-1 and Table-2. The Table-1 gives the confusion matrix of the data set and Table-2 gives the classification rate using Linear Discriminant Analysis (LDA) and Quadratic Discriminant Analysis (QDA). Table-3 gives qualitative comparison with other well known methods of gender classification using fingerprints

Table-1: Confusion matrix

Quadratic Discriminant Analysis (QDA)		Linear Discriminant Analysis (LDA)	
Male	Female	Male	Female
288	12	270	30
24	286	18	282

Table-2 gives the classification rate using LDA and QDA.

Classifier	Over All Accuracy
Quadratic Discriminant Analysis (QDA)	94 %
Linear Discriminant Analysis (LDA)	92 %

V. CONCLUSIONS

In this paper we have proposed a texture based gender classification method. In this work we have considered Haralick texture features and linear discriminant analysis (LDA) and quadratic discriminant analysis (QDA) classifiers for classification. We have tested gray level co-occurrence based statistical features for male and female identification using 600 fingerprint images. According to the experimental observation a 92% and 94% classification rate is achieved for linear discriminant analysis (LDA) and quadratic discriminant analysis (QDA) classifiers respectively. The significant thing in this work is that Haralick texture features have given good classification accuracy and more competitive when compared to other results available in the literature.

Sample of Male Fingerprints

Sample of Female Fingerprints

Title	**Data size**	**Features**	**Classifiers**	**Accuracy in %**
Gender Identification Using Fingerprint through Frequency Domain analysis[19]	400	FFT, DCT and PSD	Optimal threshold	A 92.88 % male and 94.85 % female
Fingerprint Gender Classification Using Wavelet Transform and Singular Value Decomposition [20]	3570	DWT and SVD	Optimal threshold	91.67% male and 84.69% for female
Fingerprint Based Gender Identification using Frequency Domain Analysis[21]	220	FFT, DCT and PSD	Optimal threshold	90%, male and 79.07% for female.
A Novel Method for Gender Classification Using DWT and SVD Techniques [26]	100	DWT and SVD	K-NN classifier	80%.
Fingerprint Based Age Estimation Using 2D Discrete Wavelet Transforms and Principal Component Analysis [31]	400	DWT and PCA	Optimal threshold	68%.
Fingerprint Based Gender Classification Using 2D Discrete Wavelet Transforms and Principal Component Analysis [24]	400	DWT and PCA	Optimal threshold	70%.
Analysis of fingerprint image for gender classification using spatial and frequency domain analysis[25]	1000	FFT, Eccentricity and Major Axis Length.	Optimal threshold	80% of male and 78% of female.
DWT-Neural Network based Gender Classification [28]	300	DWT Using 5-level Haar Wavelet	Neural Networks	91.30%
Fingerprint Based Gender Classification Using Discrete Wavelet Transform & Artificial Neural Network[29]	550	DWT	Neural network	91.45%
Haralick Feature Descriptors for Male And Female Classification Using Fingerprints: A Machine Learning Approach [Proposed Method]	600	Haralick texture features	Linear Discriminant Analysis (LDA)	92%
			Quadratic Discriminant Analysis (QDA)	94%

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