

Study of different methods for Gender Identification using Fingerprints

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ABSTRACT

Fingerprint evidence is undoubtedly the most reliable and acceptable evidence till date in the court of law. Fingerprints are obtained at the site of crime and in many old monuments and in excavated things. Estimating the gender of fingerprints is an emerging field and many methods using the fingerprint physical features like the ridge count and the ridge thickness have been used so far. 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. There are different methods to identification of gender using fingerprints like- DWT&SVD method, Spatial & Frequency domain analysis, 2D discrete wavelet and PCA, DNA fingerprinting method. In this paper we are going to explain first three methods which are mentioned above.

Keywords:- DWT, SVD, PCA, Spatial & Frequency Analysis, Gender Classification.

1. INTRODUCTION

Gender information is important to provide investigative leads for finding unknown persons. In this paper, gender of a person is identified from fingerprints using different methods. The science of fingerprint has been used generally for the identification or verification of person and for official documentation. Fingerprint analysis plays a role in investigation of crime. There are different methods to identify gender of human which are listed below and explain one by one in next part of paper.

1. DWT and SVD Method.
2. Spatial and Frequency Domain Analysis.
3. 2D Discrete Wavelet and PCA.
4. DNA Fingerprinting method.

In DWT & SVD method DWT stands for Discrete Wavelet Transform and SVD stands for Singular value Decomposition [1]. In this approach Wavelet transform is a popular tool in image processing and computer vision because of its complete theoretical framework, the great flexibility for choosing bases and the low computational complexity. As wavelet features has been popularized by the research community for wide range of applications including fingerprint recognition, face recognition. The SVD approach is selected for the gender discrimination because of its good information packing characteristics and potential strengths in demonstrating results. The SVD method is considered as an information-oriented technique since it uses principal components analysis procedures (PCA), a form of factor analysis, to concentrate information before examining the primary analytic issues of interest. K-nearest neighbors (KNN) [2] gives very strong consistent results. It uses the database which was generated in the learning stage of the proposed system and it classifies genders of the fingerprints. It is 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)[3]. In 2D Discrete Wavelet and PCA method Fingerprints are acquired real time and from the database sources. A fingerprint gender identification system constitutes of digital images of fingerprint as its input which is then transformed. The algorithm can be developed using MATLAB programming language. We use 2D- Discrete Wavelet PCA Transform (DWT) and Principal Component Analysis [4].

2. DIFFERENT METHODS FOR GENDER IDENTIFICATION IN DETAIL

DWT and SVD Method Gender and age information is important to provide investigative leads for finding unknown persons. Existing methods for gender classification have limited use for crime investigation because that depends on the availability of teeth, bones or other body parts but other number of methods has been used to do same work which are

based on biometric method by using different human body parts such as face iris, hand shape, speech etc. In this method, gender and age of a person is identified using DWT and SVD. This is explained in detail in following context.

2.1 DWT and SVD based Propose Gender Classification

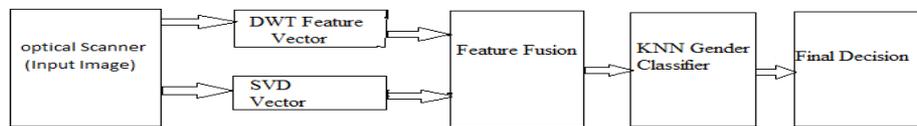


Fig no-1- Gender Classification Using DWT and SVD

2.1.1 Fingerprint feature extraction

Feature extraction is a fundamental pre-processing step for pattern recognition and machine learning problems. In the proposed method, the energy of all DWT sub-bands and non-zero singular values obtained from the SVD of fingerprint image are used as features for the classification of gender. In this section, DWT and SVD based finger print feature extractions are described.

2.1.2 DWT Based Fingerprint Feature extraction

Wavelets have been used frequently in image processing and used for feature extraction, de-noising, compression, face recognition, and image super-resolution. Two dimensional DWT decomposes an image into sub-bands that are localized in frequency and orientation. The decomposition of images into different frequency ranges permits the isolation of the frequency components introduced by “intrinsic deformations” or “extrinsic factors” into certain sub-bands. This process results in isolating small changes in an image mainly in high frequency sub band images. Hence, DWT is a suitable tool to be used for designing a classification system. The 2-D wavelet decomposition of an image is results in four decomposed sub-band images referred to as low–low (LL), low–high (LH), high–low (HL), and high–high (HH) [5]. Each of these sub bands represents different image properties. Typically, most of the energy in images is in the low frequencies and hence decomposition is generally repeated on the LL sub band only (dyadicdecomposition). For k level DWT, there are (3*k) + 1 sub-bands available. The energy of all the sub-band coefficients is used as feature vectors individually which is called as sub-band energy vector (E). The energy of each sub-band is calculated by using the equation

$$E_k = \frac{1}{RC} \sum_{i=1}^R \sum_{j=1}^C |x_k(i,j)| \tag{Equation(1)}$$

Where $x_k(i,j)$ is the pixel value of the k th sub-band and R,C is width and height of the sub-band respectively.

2.1.3 SVD based Fingerprint Feature extraction

The Singular Value Decomposition (SVD) is an algebraic technique for factoring any rectangular matrix into the product of three other matrices. Mathematically and historically, it is closely related to Principal Components Analysis (PCA). In addition it provides insight into the geometric interpretation of PCA. As noted previously, the SVD has long been considered fundamental to the understanding of PCA. The SVD is the factorization of any K x p matrix into three matrices, each of which has important properties [6]. That is, any rectangular matrix A of k rows by p column scan is factored into U, S and V by using the equation.

$$A = U S V^T \tag{Equation(2)}$$

Where

$$U = A A^T \ \& \ V = A^T A$$

And S is a k X p diagonal matrix with r non-zero singular values on the diagonal, where r is the rank of A. Each singular value is the square root of one of the Eigen values of both $A[A]^T$ and $A^T A$. The singular values are ordered so that the largest singular values are at the top left and the smallest singular values are at the bottom right, i.e., $S_{1,1} \geq S_{2,2} \geq S_{3,3}$ etc. Among the three rectangular matrices, S is a diagonal matrix which contains the square root Eigen values from U or V in descending order. These values are stored in a vector called Eigen vector (V). As the internal database contains images of size 260x300 pixels, the feature vector of SVD is of the size 1x260.

2.1.4 KNN Classifier

In pattern recognition, the k-nearest neighbor algorithm (K-NN) is the generally used method for classifying objects based on closest training examples in the feature space. KNN is a type of instance- based learning where the function

is only approximated locally and all computation is deferred until classification. In K-NN, an object is classified by a majority vote of its neighbors, with object being assigned to the class most common amongst its k nearest neighbors (k is a positive integer, typically small). If k = 1, then the object is simply assigned to the class of its nearest neighbors. The neighbors are taken from a set of objects for which the correct classification is known. This can be thought of as the training set for the algorithm, though no explicit training step is required.

2.1.5 Algorithms Used for this method-

Algorithm (I): (Learning)

[Input] all samples of fingerprint with known class (Gender)

[Output] the feature vector of all samples as database

- 1) Decompose the fingerprint with 6 level decomposition of DWT.
- 2) Calculate the sub-band energy vector (E) using (1).
- 3) calculate the Eigen vector (V) using (2).
- 4) Fuse the vectors E and V to form the feature vector for the particular fingerprint.
- 5) Insert this feature vector and the known class into the database.
- 6) Repeat the above steps for all the samples.

Algorithm (II): (Classification)

[Input] unknown fingerprint and the feature database

[Output] the class of the fingerprint to which this unknown fingerprint is assigned

- 1) Decompose the given unknown fingerprint with 6 level decomposition of DWT.
- 2) Calculate the sub-band energy vector (E) using (2).
- 3) calculate the Eigen vector (V) using (1).
- 4) Fuse the vectors E and V to form the feature vector for the given unknown fingerprint.
- 5) Apply KNN classifier and find the class of the unknown fingerprint by using the database generated in the learning phase.

2.2 Spatial and Frequency Domain Analysis

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 pattern 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 ration, 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.

2.2.1 Proposed methods for fingerprint based gender classification using spatial and frequency analysis

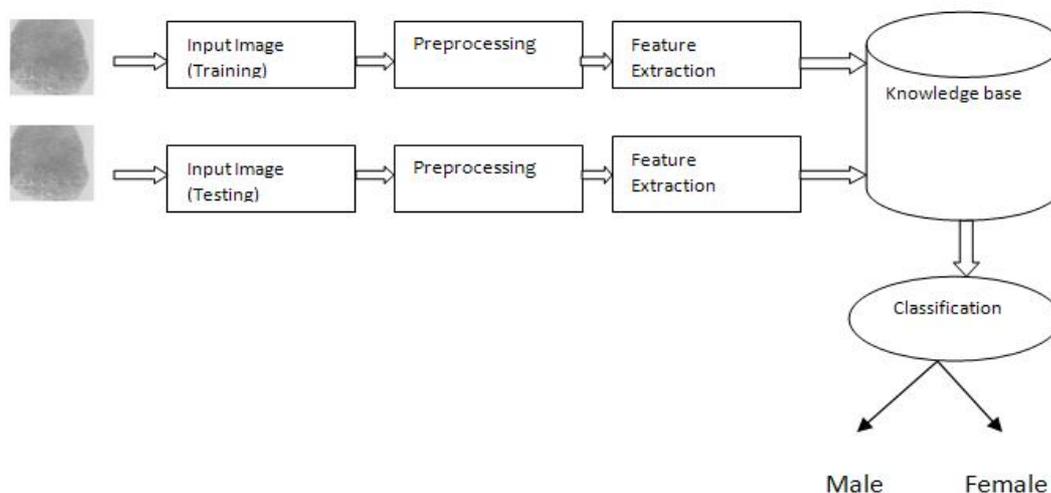


Fig no-2 - Gender classification using spatial and frequency analysis

2.2.2 Fingerprint Image Acquisition:

The fingerprint images of internal database were collected from a finger key hamster 2nd scanner [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.

2.2.3 Pre -processing.

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.

2.2.4 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 [7]. Output from this step given to classifier which compare these images with already store knowledge database and give the results.

2.2.5 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.

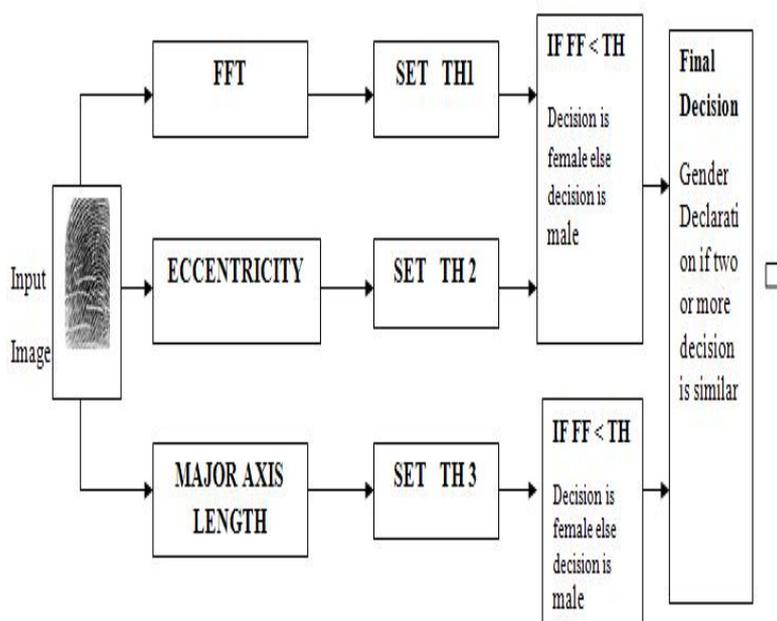


Fig no-3 Processing Algorithm for Gender classification using spatial and frequency analysis

2.3 Fingerprint based gender classification using 2D discrete wavelet Transform and PCA

Fingerprint identification algorithms are well established and are being implemented all over the world for security and person identity. Very few attempts have been made to classify the gender from an obtained fingerprint. This is helpful for anthropologists for classifying gender from the finger prints they obtain from excavated articles and for crime investigators for minimizing the rage of the suspects. The gender of the person can be judged using the fingerprint of that concern person based upon the count of the ridges of the fingerprint. The average ridge count is slightly higher in males than in females, with high standard deviation among subjects of both genders. Epidermal ridges and their

arrangement (dermatoglyphic patterns) exhibit a number of properties that reflect the biology of an individual. Dermatoglyphic features statistically differ between the sexes, ethnic groups and age categories.

2.3.1 Proposed-system

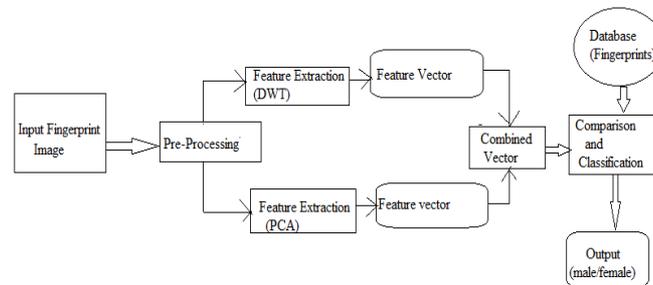


Fig no-4- Fingerprint based gender classification using 2D Discrete wavelet Transform and PCA

2.3.2 Preprocessing

Image enhancement processes consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or a machine. Enhancements techniques like contrast enhancement, histogram equalization, binarization, thinning and inverting are used as per the requirement of the image to be enhanced. The fingerprint is resized to 512x512[8]. The fingerprint image obtained undergoes image enhancement for improving quality of the ridges and valleys. The input image which is grayscale is converted into binary. The output of preprocessing is shown in Fig After preprocessing the fingerprints undergo further processing. Enhancement methods changes from fingerprint to fingerprint and for different databases. Poor quality fingerprints obtained can be enhanced for the betterment of the algorithms.

2.3.3 DWT Feature Vector generation

The fingerprint image undergoes discrete wavelet transformation for obtaining the feature vector. Wavelets have been used frequently in image processing and used for feature extraction, de-noising, compression, face recognition, and image super-resolution. Two dimensional DWT decomposes an image into sub-bands that are localized in frequency and orientation. The decomposition of images into different frequency ranges permits the isolation of the frequency components introduced by “intrinsic deformations” or “extrinsic factors” into certain sub bands. This process results in isolating small changes in an image mainly in high frequency sub band images. Hence, discrete wavelet transform (DWT) is a suitable tool to be used for designing a classification system. The obtained image is decomposed using the analysis filter bank and the low frequency and the high frequency bands. The 2-D wavelet decomposition of an image is results in four decomposed sub-band images referred to as low–low (LL), low–high (LH), high–low (HL), and high–high (HH). Each of these sub-bands represents different image properties. Typically, most of the energy in images is in the low. Frequencies and hence decomposition is generally repeated on the LL sub band only (dyadic decomposition).

2.3.4 PCA Feature Vector generation

The preprocessed fingerprint also undergoes PCA algorithm for obtaining the feature vector in spatial domain. PCA algorithms are generally implemented for pattern recognition systems. Principal component analysis involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible [9]. It is also named as the Karhunen–Loeve transform which is also called as (KLT) the Hostelling transform.

2.3.5 Combined Feature Vector

After undergoing DWT and PCA the feature vectors are stored separately. The next step is to combine both the feature vector into a single vector which stores the frequency domain and spatial domain information of a fingerprint. The 19 feature vector from the DWT and the 512featurevector from PCA are combined to form 1 x 531 feature vector for a single fingerprint. Similarly for all the fingerprints in the database this procedure is followed and a database feature vector is created which contains all the feature vector of the images in the database. If there are n fingerprints in the database then the size of the database feature vector will be n x 531[10].

2.3.6 Steps to be followed for Gender classification using the fingerprint

1. The fingerprint undergoes pre processing and is resized to512x512.
2. The fingerprint undergoes Wavelet Decomposition and the 19 feature vectors are obtained.

3. The fingerprint from the pre processing stage also undergoes PCA Eigen vector feature extraction. This provides the Eigen vector of 512 sizes.
4. Now the features vectors are combined in total $19+512=531$ vectors are obtained from the fingerprint.
5. This fingerprint feature vector is classified using the minimum distance classifier and this undergoes the gender classification

3.CONCLUSION AND FUTURE WORK

In this paper, we have studied and proposed different methods for gender classification using fingerprint images based on DWT, SVD, FFT, PCA etc. after study of this methods we have conclude that Gender classification is depend on qualities of finger print images and maximum number of image should be taken so as obtain good result or reach high efficiency of result. and also common factor that is included in this all methods is wavelet transform weather work is in frequency domain or any other domain by considering all above methods we can obtain good result about gender identification. And also The level 6 DWT is selected as optimum level for the gender classification by analyzing the results obtained for the database used for training and testing and the data base used other than the training and testing.

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