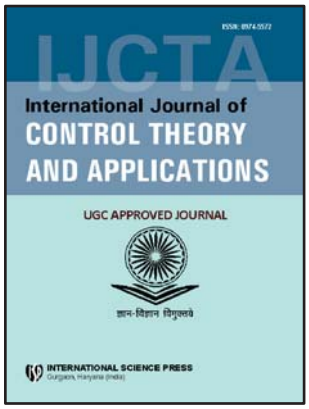

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Fingerprint Based Gender Estimation using 2D Discrete Wavelet Transform and Independent Component Analysis

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Abstract: Fingerprints are used for over a decade, and moreover it has been generally accepted form of biometric identification. Estimating the Gender of the fingerprints is a developing field and numerous methods using the fingerprint physical features like the ridge count and the ridge breadth have been used so far. In this paper, a novel technique for gender classification using fingerprints has been implemented. The first method is the discrete wavelet transformation (DWT) which is employed to extract fingerprint, and the second method Independent Component Analysis (ICA) is used to estimate a Gender using an extracted fingerprint. The above said methods are combined and used for gender classifications. The Multi Class Support Vector Machine (Multi-class SVM) was used as a classifier. The method is experimented with the internal database of 500 fingerprints of left hand index finger, 250 males & 250 females belonging to same age group. The experimental results show good for trained list of fingerprints. It was found that increasing the Quality of the image improves the performance of the system.

Keywords: *Enhancement, Discrete Wavelet Transform (DWT), Independent Component Analysis (ICA), Multiclass SVM.*

1. INTRODUCTION

Fingerprint is one of the unique identity of any person in the world. It takes place in pregnancy and lives for entire duration of life of a person. Even though finger of a person is injured, burned, the prints damages for small period of time after getting fine, it occurs as normal. Means there is no changes in the fingerprints. So fingerprints are unique id of person [2]. Biometric recognition technique is based on the main physical feature that lends itself to biometric identification. Fingerprint biometric performs better as compared to other obtainable traits due to its accuracy, reliability and simplicity [1]. The main reason at the back the use of fingerprint biometric is that it is the most established technique to identify the individual. Fingerprints are permanent morphological characteristics and criminal recognition based on the fingerprints is based on the theory that no two people can have identical fingerprints.

Fingerprints have been broadly and universally used in forensic examinations as positive proof of identity by different law enforcing agencies for more than a century now. Gender of a person can be accepted using different biometric personality such as face of a person, iris, retina, speech, gait, hand geometry and fingerprint of the human [4]. Fingerprint is one of the most universal traits of human and can be easily obtained. Fingerprint ridge density is another characteristic feature of enormous importance in fingerprints. Fingerprint ridge density of the human is defined as the fingerprint ridge count corresponding to a defined fingerprint area[3]. It is determined by two parameters; ridge width and distance between ridges.

2. RELATED WORKS

2.1. Basics of finger prints

Fingerprint ridges are developed during the third to fourth month period of fetal development. The ridges begin to develop on the skin of the thumbs and fingers. The friction ridges on the finger prints place themselves in more or less standard patterns with ridge characteristics. All the fingerprints of human have been unique combination and arrangement of patterns and ridge characteristics

A finger print is a human being characteristic. No two prints have always been found to be exactly identical. Even though identical twins are different, fingerprints are not inherited. The general pattern may be the similar in families but the level 2 and 3 details will get differ. After the arrangement of the finger print patterns, the growing fingerprint ridges are increase evenly in all directions while development is occurring so the finger print pattern never changes for life long duration. There are three main fingerprint patterns like arches, loops and whorls [2].

Arches are found around 5% of fingerprint patterns encountered. The ridges enter from one side of the finger rise in the center and exit to the other of the pattern, making no toward the back turn. Loops pattern is occur around 60-70 % of fingerprint images. One or more ridges enters into any side of the impression, and exit from same side, touches or crosses the line in a row from the delta to the core and terminate on or in the direction of the side where the ridge or ridges entered. Whorls are seen around 25-35 % of fingerprint patterns. In a whorl, various of the ridges make a turn through at least one circuit. Any of the fingerprint patterns which consist of 2 or more deltas will be a whorl pattern.

2.2. Recent researches in gender classification

An identification and classification of Fingerprint has been mostly researched for past long durations. However very few researchers have been studied the fingerprint gender classification and identification problem.(Acree 1999) From the ridge density of the finger print, it is possible to calculate the number of ridges are present in a certain space. From the above calculation, it was observed that the female finger prints have higher ridge density (Acree1999). (Kralik 2003) which also been showed that the males have higher ridge breadth, than females. So far studies about the finger print undergoing to determine the sex, which uses the inked fingerprints and their findings are based on the spatial domain investigation of ridges [3]. Generally ridge associated parameters such as, ridge density, ridge count from the finger print images, ridge thickness to valley thickness ratio and ridge width of the finger and fingerprint patterns were used for gender determination.

Earlier work on gender estimation based on the ridge density shows that the ridge density of the finger is greater for female than male and analyzed fingerprints of a tribal population of Andhra Pradesh (India) and showed the obvious that the males viewing higher mean ridge counts than females [6] . M.D. Nithin et al has applied baye's theorem on the rolled fingerprint images belongs to south Indian population and establish fingerprint possessing ridge density <13 ridges/25 mm2 is most likely to be of male origin and ridge count > 14 ridges/25mm2 are most likely to be of female finger print[10]. Female finger print have more ridge count than male finger print.

E.O.OMIDIORA et al [7] has proposed a method of Analysis, Design and Implementation of Human Fingerprint Patterns System in the direction of Age & Gender Determination, Ridge Thickness to Valley Thickness Ratio (RTVTR) & Ridge Count on Gender Detection. He found that obtained result for Age and Gender, Ridge thickness to valley thickness ratio and ridge count for all 10 fingers. He observed that females have higher Ridge thickness to valley thickness ratio compare to males. Males has a slightly higher ridge count than females[16].

In these methods they are finding the Gender by using minutiae points and some drawbacks of these methods are: Point pattern matching problem, Minutiae set suffer from false, missed and displaced minutia caused by poor finger print, When finger prints are translated ,rotated and scaled ,fingers may extract an unevenly distributed pressure due to elasticity of skin and If we take partial finger prints , no. of minutia points available in such prints is few and it has loss of singular points (core ,delta) and Uncontrolled impressions environment results in unspecified orientation of partial finger prints.

Dr. Sudesh gungadin et al and Ramanjith Kaur ,Rakesh K Garg et al both proposed novel method of gender classification from Both of them conducted a study to establish relationship between sex and Ridge Density[10]. Ridges were counted in upper portion of the radial border of each finger print all 10 finger prints and mean value was calculated. They found that finger print ridge of <13 ridges/25mm2 is more likely of male origin and finger print ridge of >14 ridges/25mm2 for female origin. Female finger print have more ridge density than male [11].

Gnanasivam P. et al. [20], [21] proposed the method of gender classification using fingerprint based on discrete wavelet transform (DWT) with one spatial domain technique singular value decomposition (SVD). System is used to calculate all the sub bands of DWT and combined with spatial features of non-zero singular values of the finger prints which are obtained from SVD. The classifier used in this gender estimation method is K nearest neighbor (KNN).System has 1980 male fingerprint and 1590 female fingerprints were taken for analysis which is stored in internal database. Spatial domain technique and Frequency domain technique are used. Some drawbacks of the System are if Age group >36 ,the achieved result is 54.14%.It uses only the energy of the individual bands, Fails to use other Spatial parameters of Fingerprint and not specifically taken finger print above age of 36.

Rijo Jackson Tom, et al, [19] (2013) have proposed a Novel method for Fingerprint Based Gender Classification through frequency domain analysis and some spatial domain techniques to estimate gender. To analyzing fingerprints using 2D DWT and Principal Component Analysis (PCA) combined vectors are used to classify the Gender of the person. A dataset is created for 400 persons of different age and gender is collected as internal database. The minimum distance method is used for classification and achieve overall success rate in gender classification of around 70%. In this method achieved performance result is around only 70% .To improve the performance of the result. Some good techniques and good quality database finger prints should be used.

3. PROPOSED METHOD FOR FINGERPRINT FEATURE EXTRACTION

Feature extraction is a basic Preliminary processing step for pattern recognition and machine learning problems [14]. In the proposed method, it is possible to combine DWT sub-bands and Independent component analysis to analyze the classification of gender. In this section, DWT and Independent component analysis based fingerprint feature extractions are illustrated.

3.1. DWT Feature Extraction

The fingerprint image goes through discrete wavelet transformation after pre-processing for attaining the feature vector. Wavelets have been used repeatedly in image processing for feature generation, de-noising, compression and image super-resolution. Two dimensional DWT go off the given image into sub-bands that are restricted in

frequency and orientation. The diverse frequencies obtained from image decomposition permits the segregation of the frequency components introduced by intrinsic warps or extrinsic factors into definite number of sub-bands [18]. This process results in segregating small variations in an image generally in high frequency sub-band images. Hence discrete wavelet transform (DWT) is an appropriate technique to be used as a classification system designer [12],[13].

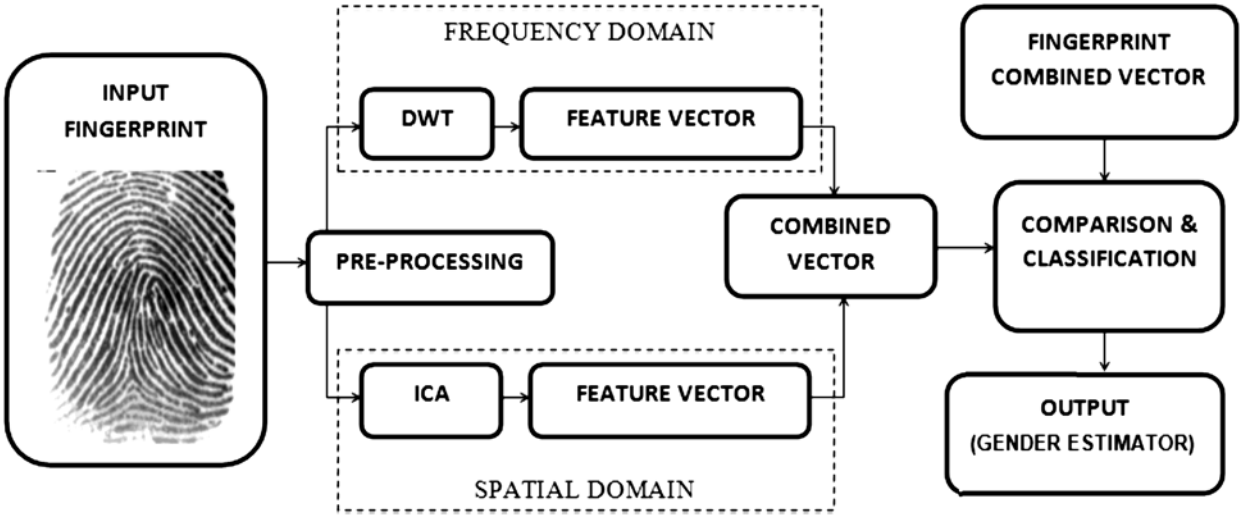

Figure 1: Generalized block diagram for Gender estimation

$$E_k = \frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}|X_k(i,j)| \quad (1)$$

Where

$X_k(i,j)$ – Pixel value of the K^{th} sub band

M, N – Width & height of the sub band respectively

3.2. ICA Feature Extraction

ICA algorithms are normally employed for pattern recognition techniques. Independent Component Analysis [8] is a computing process of splitting a multivariate signal into additive subcomponents. This can be done by assuming that the subcomponents which are non-Gaussian signals and they are statistically independent from each other. In general, ICA cannot recognize the definite number of source signals, a solely correct assembling of the source signals, nor the proper scaling of the source signals.ICA is a special case of blind source separation. A familiar example for ICA technique is cocktail party crisis which gives awareness to one person's speech in a noisy area.

3.3. Combined Feature Vector

After undergoing 2D-DWT and ICA feature vector extraction, the feature vectors are stored separately. The following step is to combine both the feature vectors into a single vector that stores the frequency domain and spatial domain information of a fingerprint. The 19 feature vector from the DWT and the 512 feature vector from ICA are combined to form 1 x 531 feature vectors for a single fingerprint image . For all the fingerprints in the database, this procedure is followed as the identical and a database feature vector is created. This database feature vector contains all the feature vectors of the images in the database. If there are *k* fingerprints in the database then the size of the database feature vector will be *k*x 531.A graph was plotted after finding the combined feature vector. Till date spatial features were used for analysis and are well established. We propose this system for the use of frequency domain analysis to acquire an individual's age.

4. GENDER CLASSIFICATION

We have used 250 male fingerprints and 250 female fingerprints downloaded from the database of Department of Biometric research, University of Ilorin [5]. All these fingerprints are obtained by means of optical scanner. For gender Classification the database contains only two classes Male and Female [15]. The fingerprints of both classes are grouped and kept as the database fingerprints. Once the preferred database is formed all the fingerprint in the data base is undergoes the feature vector extraction as dealt in the last section.

The following steps are used for Gender classification using the query fingerprint:

1. The fingerprint undergoes pre processing and is resized to 512x512.
2. All the fingerprints undergoes Wavelet Decomposition and the 19 feature vector is obtained from each finger print.
3. The fingerprint from the pre processing stage also undergoes ICA Eigen vector feature extraction. This provides the Eigen vector of 512 sizes.
4. Now the features vectors are integrated 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.

4.1. Estimation of Gender

Query fingerprint whose gender has to be classified also undergoes the feature extraction and 1 x 531 feature vector is obtained. This query feature vector is compared with all the database feature vector of both the classes.

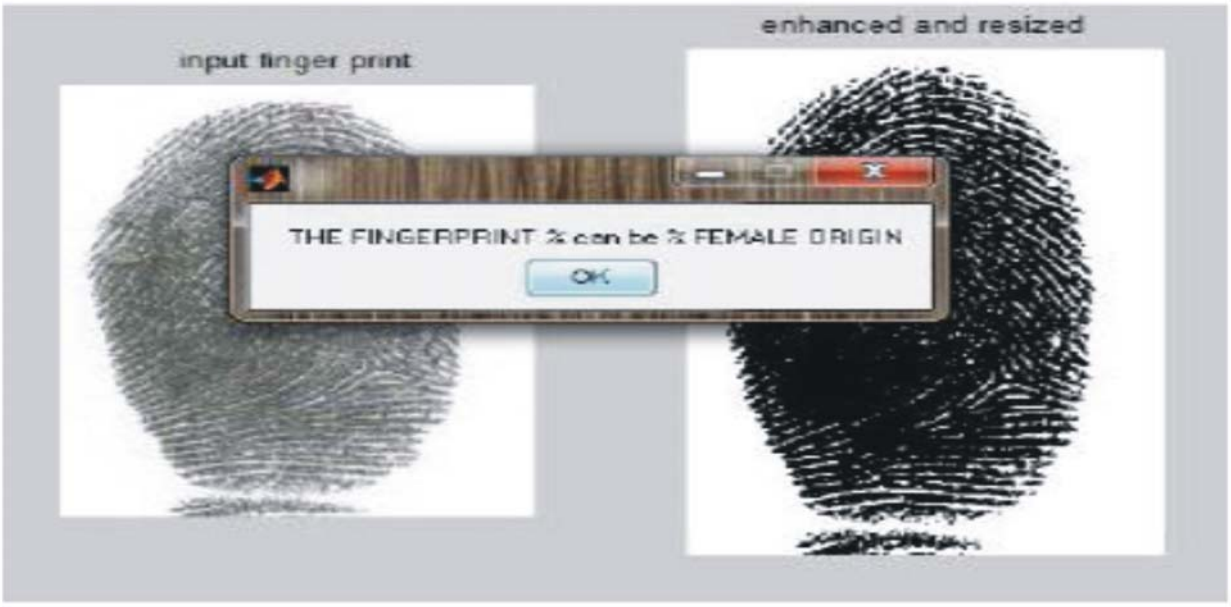

Figure 2: Result of Gender estimation

In this approach, the classifier used as Multiclass SVM which uses the Euclidian distance measure for finding the distance between the query and the database [9]. Once the distance is found between the query and the database, classification comes into picture. We analyze to see as to which class does the following query fingerprint lies closest. The gender classification algorithm was implemented and the output was tested.

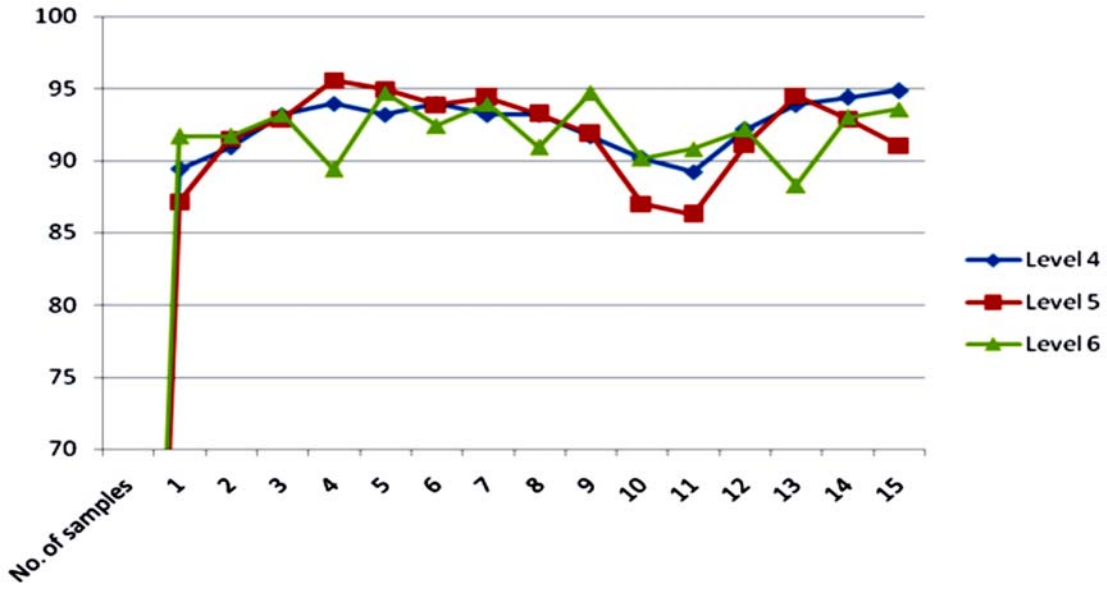

Figure 3: Success rate of male gender classification

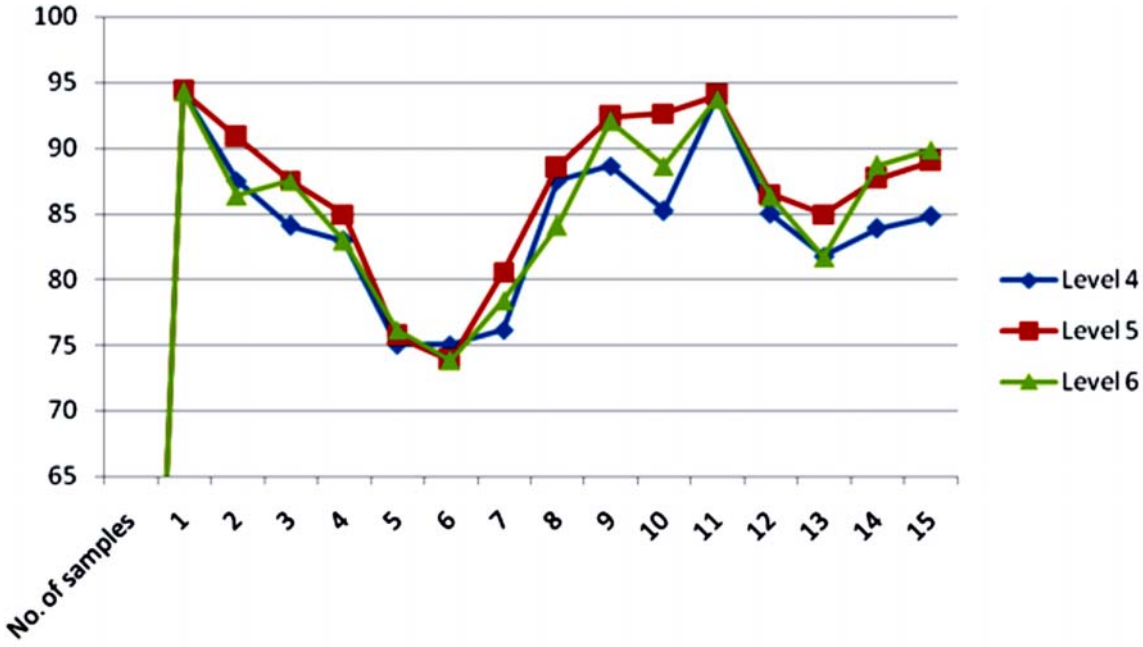

Figure 4: Success rate of Female gender classification

5. CONCLUSION

In this research work, we have projected a new technique for gender classification of fingerprint images based on level 6 decomposition using frequency domain technique DWT and combined with one spatial domain technique ICA. This method measured the frequency features of the wavelet domain and the non- zero spatial feature values from the Independent Component Analysis decomposition. The spatial features include the internal structure of the fingerprint images and the fusion with the frequency features produces enhanced

performance in gender classification. The 6 level DWT is selected as optimum level for estimating the gender classification by analyzing the results obtained. Finger print images are used for training and testing which is stored in the database and the database used other than the training and testing. The proposed method is tested with the internal database of 500 fingerprints of left hand index finger, 250 males & 250 females belonging to same age group. In this among 250 male finger print images, only 125 finger print images was taken for training and remaining 125 finger print images was taken for testing purpose and same procedure is repeated to find female finger print. The simulation results show that good for trained list of fingerprints. By this proposed method, the gender classification rate achieved is 93.87% for male and 94.89% for female.

In future good quality fingerprints have to be collected for large scale study. Our future work is to extend the gender categorization by using the spatial parameters. Also, it is aimed to use various other techniques to increase the success rate.

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