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Study of Spatial Domain and Frequency Domain Approach for Fingerprint Based Gender Classification

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Abstract— Each person's fingerprint structure is unique and is developed for biometric authentication systems than others because fingerprints have advantages such as: feasible, differ from each other (distinct), permanent, accurate, reliable and acceptable all over the world for security and person identity. Fingerprints are considered legitimate proofs of evidence in courts of law all over the world.
Fingerprint based gender classification can be studied using spatial domain and frequency domain approach. Spatial domain approach uses ridge related parameters like ridge count, ridge density, ridge width, ridge thickness to valley thickness ratio. Frequency domain approach do not work on physical parameters related to ridge, but work on measuring parameters like frequency and region parameters of an image. This paper compares one method of spatial domain approach and one method of frequency domain approach in terms of processing time, accuracy, simplicity in calculations and compatibility with other methods.

Keywords- Fingerprint, gender classification, spatial domain, frequency domain, ridge parameters, measuring parameters

I. INTRODUCTION

Fingerprints are one of the most mature biometric technologies and are considered legitimate proofs of evidence in courts of law all over the world. Based on the varieties of the information available from the fingerprint we are able to process its identity along with gender, age and ethnicity [1]. Within today's environment of increased importance of security and organization, identification and authentication methods have developed into a key technology. Such requirement for reliable personal identification in computerized access control has resulted in the increased interest in biometrics [2].

A Fingerprint is the representation of the epidermis of a finger, it consists of a pattern of interleaved ridges and valleys. Fingertip ridges evolved over the years to allow humans to grasp and grip objects. Like everything in the human body, fingerprint ridges form through a combination of genetic and environmental factors. This is the reason why even the fingerprint of identical twins is different. Fingerprint analysis plays a role in convicting the person responsible for an audacious 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 [3]. Existing methods for gender classification have limited use for crime scene investigation because they depend on the availability of teeth, bones, or other identifiable body parts having physical features. Gender determination of unknown can guide investigators to the correct identity among the large number of possible matches, means reduces the search space.

Spatial domain approach

There are variations in ridge dimensions and sex differences in ridge breadth of every person. 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. These features help in classifying a person [4].

Ridge based 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 as feature for gender determination. The ridge thickness depends on the pressure applied and may provide false results on gender identification [4,5]. 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. Also the feature vectors obtained in these methods is of varying length and makes the calculations difficult.

Frequency domain approach

Image based gender determination uses digital fingerprint images and utilizes both frequency domain analysis and spatial domain analysis and work on region properties of the image. Here, features are extracted using different methods, like Discrete Wavelet Transform, Discrete Cosine Transform, Fast Fourier Transform and Region Properties [6,7]. Fourier transform plays a vital role in image processing applications. It contains most of the information of the spatial domain image. DCT transforms an image from the spatial domain to the frequency domain and provide better approximation of image. DCT transforms a set of data which is sampled at a given sampling rate to its frequency components. Whereas dwt works on wavelets, a waveform of effectively limited duration that has an average value of zero. In mathematical term wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. Here the fundamental frequency is used for gender Classification [13]. These methods give feature vectors of fixed length which makes calculations easier, and can be mapped with other methods easily.

II. ANALYSIS OF THESE METHODS

Spatial domain approach for gender classification

Ridge density based approach

Fingerprint patterns of dermal ridges can be classified into three major groups: arches, loops and whorls (figure1). 60% of people have loops, 35% have whorls, and 5% have arches. Arches are the simplest type of fingerprints that are formed by ridges that enter on one side of the print and exit on the other. No deltas are present. It may be sub classified as "plain" when the ridges rise slightly over the middle of the finger or "tented" when the ridges rise to a point. Loops must have one delta and one or more ridges that enter and leave on the same side, the loop pattern has a tri-radius and a core. A tri-radius is a point at which three groups of ridges coming from three directions meet at angles of about 120 degrees. The core is essentially a ridge that is surrounded by fields of ridges which turn back on themselves at 180degrees (figure2). Loops can be either radial or ulnar. A finger possesses a radial loop if its tri-radius is on the side of the little finger for the hand in question and the loop opens toward the thumb. A finger has an ulnar loop if its tri-radius is on the side of the thumb for that hand and the loop opens toward the little finger. Whorls have at least one ridge that makes (or tends to make) a complete circuit, the whorl pattern has two tri-radii with the ridges forming various patterns inside.

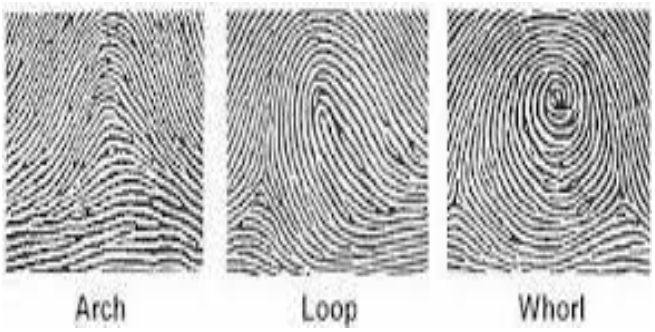

Fig1. Types of fingerprint

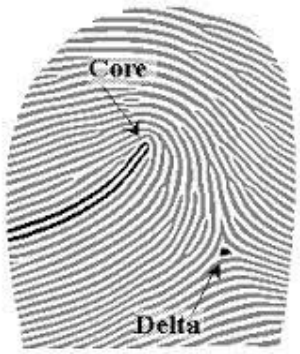

Fig2. Core and Delta

Total ridge count (TRC) is the sum of the ridge counts for all 10 fingers. The average TRC for males is 145 and for females, 126. The ridge count on a finger with a loop is determined by counting the number of ridges between the tri-radius and the center or core of the pattern. For an arch, the ridge count is O. For a whorl a ridge count is made from each tri-radius to the center of the fingerprint, but only the higher of the two possible counts is used (Fig 3).


Fig3. Ridge Count of fingerprint

Fig4. Counting dermal ridges

Inked fingerprints of ten fingers of some males and females are collected. Epidermal ridges of each fingerprint sample are counted within a 5 mm*5 mm square drawn on fingerprint. This value represents the epidermal ridge density. For fingerprints from the right hand, this square is placed directly at the upper left of the central core region. Likewise, for fingerprints from the left hand, the square is placed at the upper right of the central core area. This sampling method is useful in the case of arches, where the ridge count is zero as per the traditional method of ridge counting. Furthermore, the ridge counts were not analyzed in central core regions due to the variability of pattern shapes and re-curving ridges, which are sometimes counted more than once in these regions. Mean value for ten fingers is then calculated. The fingerprint ridge of < 13 ridges/25 mm2 is more likely of male origin and finger print ridge of > 14 ridges/25 mm2 is more likely of female origin. Women tend to have a statistically significant greater ridge density than men.

Frequency domain approach for gender classification

DWT based approach

Frequency domain approach uses 2D Discrete Wavelet Transform for extracting the features of the fingerprint image. A wavelet is a waveform of effectively limited duration that has an average value of zero (figure4). In mathematical term wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale.

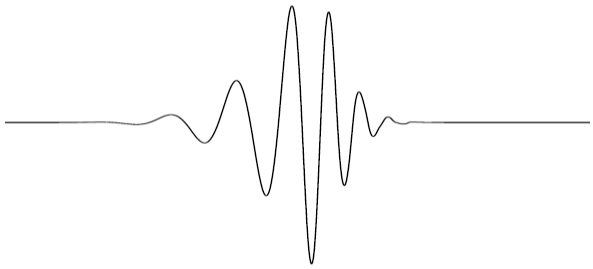

Fig5. Wavelet

In 1D Discrete wavelet transform a signal is decomposed into two parts, high frequency part & low frequency part. 1d dwt is applied on 1D signal and as image is 2D data 2d dwt is used for image decomposition.

Two dimensional DWT decomposes an image into sub-bands that are localized in frequency and orientation (Horizontal, vertical, diagonal). The decomposition of images into different frequency ranges permits the isolation of the frequency components and helps in identifying small changes in image to study fine details of the image.

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.

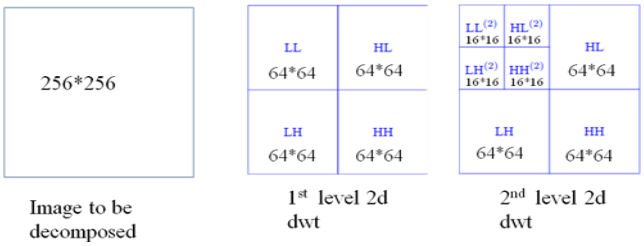

Fig6. 2D DWT decomposition

Many signals or images contain features at various levels of detail (i.e., scales) and multi-resolution helps in studying that details. Small size objects should be examined at a high resolution. Large size objects should be examined at a low resolution.

DWT is basically used for edge detection in images. LL (low low) frequency sub-band is upper left block which consists of all the coefficients and represents the approximated version of original image at half the resolution. LL preserves essential visional features for the original image. LL corresponds to low frequency rows and low frequency columns of original image. HL (high low) frequency sub-band shows horizontal edges of original image very clearly. HL corresponds to high frequency rows and low frequency columns of the original image. LH (low high) frequency sub-band shows vertical edges of the image clearly where HL corresponds to high frequency rows and low frequency columns of the image. HH (high high) frequency sub-band shows the edges in diagonal direction where HH corresponds to high frequency rows and high frequency columns. All these sub-bands helps in studying fine details of the image.

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 (Ek). The level which gives optimal result is selected. The energy of each sub-band is calculated by using the equation.

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

Following fig7 shows the overall process, before classification process all the training sample images are pre-processed. Training sample contains the fingerprints of various males and females belonging to different age groups. Using 2D DWT method features of fingerprint are extracted. After extracting features of all fingerprint images we get feature vector for each image and is stored in database. This database is used as lookup table.

Testing fingerprint which is to be classified as male or female fingerprint is taken as input. This image is pre-processed and features are extracted using the same method used for training sample to get feature vector. This testing fingerprint feature vector is compared with all the feature vectors of training sample using minimum distance classifier, which uses Euclidean distance measure for classifying testing fingerprint as male or female fingerprint.

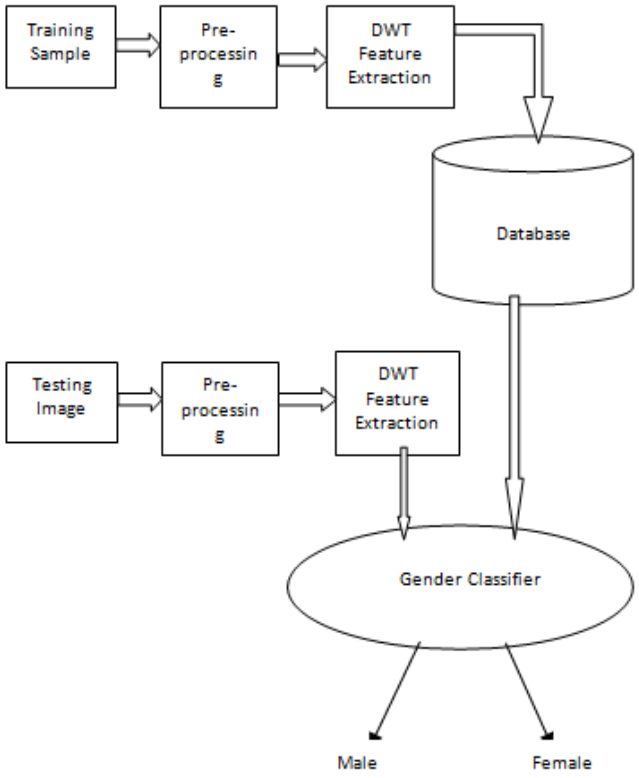

Fig7. Image based dwt method for fingerprint classification

In this section, the author describes the previous research works in the form of title, problem statement, objectives, not repeat the information discussed in Introduction [2].

III. CONCLUSION AND FUTURE SCOPE

This paper compares fingerprint based gender classification using two approaches; ridge based approach and image based approach based on processing time, accuracy, simplicity in calculations and compatibility with other methods.

In Ridge based approach the extraction of ridges from fingerprint and finding distance between them is tedious and require more time, also the feature vector obtained in this methods is of varying length and make the calculations difficult. Image based approach takes less time and fixed length feature vector make the calculations easier.

Table-1 Comparison of two approaches

Sr. No.	Spatial domain approach	Frequency domain approach
1.	Works on physical parameters of fingerprint. (Parameters related to ridge and valley).	Works on measuring parameters of an image like frequency and region properties of the image.
2.	Some parameters like ridge thickness provide false results.	Provide more accuracy as it study fine details of the image.
3.	Ridge parameters are the features and can be of varying length.	Energy of the image is used as features and is of fixed length.
4.	Varying length make the calculations difficult.	Fixed length makes the calculations easier.
5.	Can't be mapped with other methods easily as features vectors are of varying length.	Can be mapped with other methods as feature vectors are of fixed length.
6.	Require more processing time.	Less processing time is required.

In future, the work will be extended by combining spatial domain and frequency domain approaches to find different parameters like age, rural, urban people. Also different features which will help in gender classification which will be more accurate and suitable for all types of application.

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