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Age Determination from Obtained Fingerprint Using 2D Discrete Wavelet Transforms and Support Vector Machine

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Abstract*— Fingerprints are obtained at the site of crime and in many old monuments and in excavated things. Estimating the age of the 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 age of an individual using frequency domain technique and a pattern recognition technique. The combined processing has provided better results. This paper aims in using 2D- Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA) combined to estimate a person's age using an obtained fingerprint. The Support Vector Machine (SVM) was used as a classifier. 300 Fingerprints belonging to the various ages in between 1 – 80 were taken for analysis. The experimental results show good for trained database. It was found that increasing the database population in each category improves the performance of the system.

Keywords: Discrete Wavelet Transforms, Principal Component Analysis, Ridge count, Support Vector Machine

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 [5].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 [4]. 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 fingerprints of identical twins are

different (Maltoni and Cappelli, 2006). The concept of fingerprint pattern being studied has been of significant use over time, when scanning it involves the conversion of fingerprint by small portion of light solid-state devices into alphanumeric formula (Galton, 1982).

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 estimate the age from an obtained fingerprint. This is helpful for anthropologists for estimating the age from the fingerprints they obtain from excavated articles and for crime investigators for minimizing the rage of the suspects. The age of the person can be judged using the fingerprint of that concern person based upon the count or breadth of the ridges of the fingerprint. Ridge breadths differ more between regional populations than between males and females from the same population. 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 [1].

The paper is aimed in developing an algorithm for estimating the age through fingerprint obtained using 2D- Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA) combined. Fingerprints are acquired real time and from the database sources. A fingerprint age estimating system constitutes of digital images of fingerprint as its input which is then transformed. Figure1 shows the generalized block diagram of the proposed system. The algorithm can be developed using MATLAB programming language. We use 2D- Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA) combined to estimate a person's age using his/her fingerprint. The obtained fingerprint goes through preprocessing stage for enhancement and removing the noise. After preprocessing the fingerprint goes through two levels of feature extraction, one is frequency domain feature vector obtaining by undergoing Wavelet decomposition and second is by spatial level undergoing PCA. The next step is to combine the two vectors and this is compared with the database using Support Vector Machine to classify the fingerprint as to which class it lies.

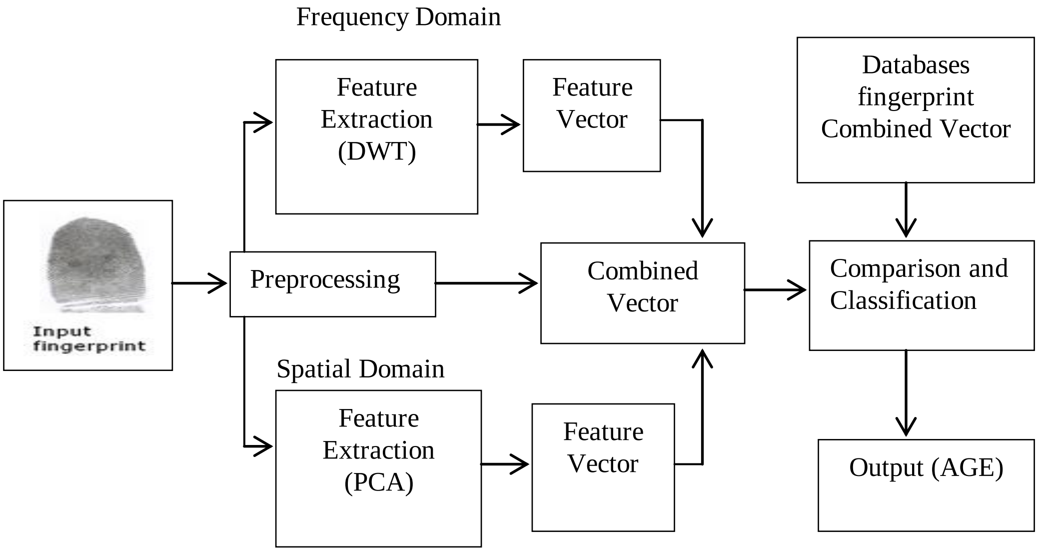

Figure1.1: Generalized Block Diagram

II. LITERATURE SURVEY

***E.O. Omidiora, O. Ojo, N.A. Yekini, and T.O. Tubi*:** They proposed Analysis, design and implementation of human fingerprint patterns system "towards age &gender determination, ridge thickness to valley thickness ratio & ridge count on gender detection. The aim of their research is to analyze humans fingerprint texture in order to determine their Age & Gender, and correlation of RTVTR and Ridge Count on gender detection. The study is to analyze the effectiveness of physical biometrics in order to determine age and gender in humans. An application system was designed to capture the finger prints of sampled population through a fingerprint scanner device interfaced to the computer system via Universal Serial Bus, and stored in Microsoft SQL Server database, while back-propagation neural network will be used to train the stored fingerprint.

***K. Thaiyalnayaki, S. A. Karim, and P. V. Parmar*:** They proposed Finger print Recognition Using Discrete Wavelet Transform [2]. The most common approach for fingerprint analysis is using minutiae that identifies corresponding features and evaluates the resemblance between two fingerprint impressions. Although many minutiae point pattern matching algorithms have been proposed, Finger print recognition can be done effectively using texture classification approach. Important aspect here is appropriate selection of features that recognize the finger print. The features include standard deviation, kurtosis, and skewness. We apply the method by analyzing the finger prints with discrete wavelet transforms. We used Canberra distance metric for similarity comparison between the texture classes

***Manish Verma and Suneeta Agarwal*:** They proposed the Fingerprint Based Male-Female Classification. Male-female classification from a fingerprint is an important step in forensic science, anthropological and medical studies to reduce the efforts required for searching a person. The aim of this research is to establish a relationship between gender and the fingerprint using some special features such as ridge density, ridge thickness to valley thickness ratio and ridge width. RTVTR & ridge count using Neural Network as Classifier. We have used RTVTR, ridge width and ridge density for classification and SVM as classifier [3].

III. EXISTING SYSTEM

The most common approach for fingerprint analysis is using minutiae that identifies corresponding features and evaluates the resemblance between two fingerprint impressions. Although many minutiae point pattern matching algorithms have been proposed, reliable automatic fingerprint verification remains as a challenging problem. Finger print recognition can be done effectively using texture classification approach. Important aspect here is appropriate selection of features that recognize the finger print. We propose an effective combination of features for multi-scale and multi-directional recognition of fingerprints. The features include standard deviation, kurtosis, and skewness. We apply the method by analyzing the finger prints with discrete wavelet transform (DWT) [5]. We used Canberra distance metric for similarity comparison between the texture classes. We trained 30 images and obtained an overall performance up to 95%.

IV. PROPOSED SYSTEM

The following paper aims in creating a system that is used to estimate the age from an obtained fingerprint. Fingerprints are acquired real time and from the database sources. A fingerprint age estimating 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 Transform (DWT) and Principal Component Analysis (PCA) combined to estimate a person's age using his/her fingerprint. The obtained fingerprint goes through preprocessing stage for enhancement and removing the noise. After preprocessing the fingerprint goes through two levels of feature extraction, one is frequency domain feature vector obtaining by undergoing Wavelet decomposition and second is by spatial level undergoing PCA. The next step is to combine the two vectors and this is compared with the database using Support Vector Machine for the classification of the fingerprint as to which class it lies.

The database for our analysis is done on 300 individual fingerprints of male and female of different ages between 1-80. The database fingerprints goes through the process and the feature vectors are stored in the database and is used for classification.

A. 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, biniarization, thinning and inverting are used as per the requirement of the image to be enhanced. The fingerprint is resized to 512x512. The fingerprint image obtained undergoes image enhancement for improving quality of the ridges and valleys. The input image which is gray scale is converted into binary. The output of preprocessing is shown in Figure4.1.

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.

Original image Inverted image Enhanced image

Figure4.1: Enhanced Fingerprint

B. 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, denoising, 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 are separated as shown in the Figure4.2.

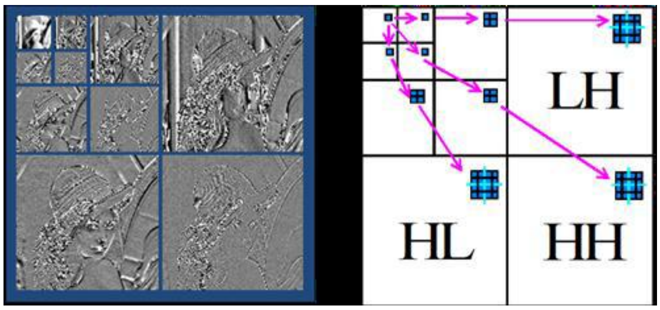

Figure4.2: Wavelet Decomposition

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). 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_k).

Each fingerprint undergoes six level decomposition after preprocessing as shown in Figure4.3. At each level we get sub bands and their energy is calculated. We get a total of 19 sub bands and the energy vector E_k will be 1x19 vectors at the end of the six level decomposition for each fingerprint. All fingerprints in the database undergo the decomposition and the energy vector of all the images is stored.

Haar Wavelet:

The wavelet that was considered for DWT for this paper is Haar wavelet. In mathematics, the Haar wavelet is a sequence of rescaled "square-shaped" functions which together form a wavelet family or basis. Wavelet analysis is similar to Fourier analysis in that it allows a target function over an interval to be represented in terms of an orthonormal basis. The Haar sequence is now recognized as the first known wavelet basis and extensively used as a teaching example.

The Haar sequence was proposed in 1909 by Alfréd Haar. Haar used these functions to give an example of an orthonormal system for the space of square-integrable functions on the unit interval [0, 1]. The study of wavelets, and even the term "wavelet", did not come until much later. As a special case of the Daubechies wavelet, the Haar wavelet is also known as Db1.

The Haar wavelet is also the simplest possible wavelet. The technical disadvantage of the Haar wavelet is that it is not continuous, and therefore not differentiable. This property can, however, be an advantage for the analysis of signals with sudden transitions, such as monitoring of tool failure in machines.

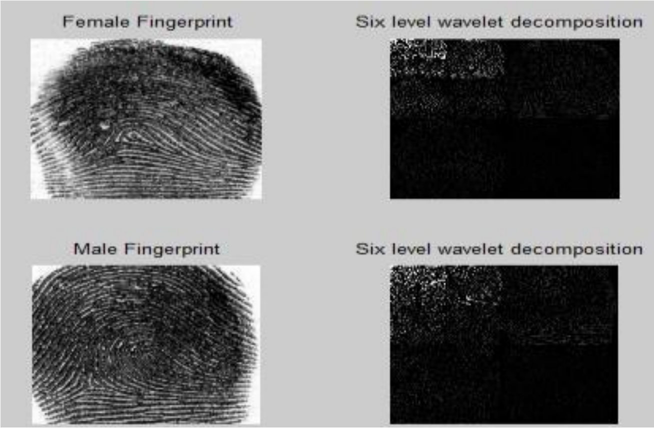

Figure4.3: Six level decomposition of fingerprint

C. PCA Feature Vector generation

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. It is also named as the Karhunen–Loeve transform which is also called as (KLT) the Hoteling transform.

PCA involves the calculation of the Eigen value decomposition of a data covariance matrix or singular value decomposition of a data matrix, usually after mean centering the data for each attribute. The results of a PCA are usually discussed in terms of component scores and loadings. An Eigen vector of a given linear transformation is a vector which is multiplied by a constant called the Eigen value as a result of that transformation. The direction of the eigenvector is either unchanged by that transformation (for positive Eigen values) or reversed (for negative Eigen values).Every fingerprint in the database undergoes the PCA for obtaining the eigenvector. The eigenvector is 512 x 1 size and is stored as another feature vector of the fingerprint.

D. 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 512 feature vector 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.A graph was plotted after obtaining the combined feature vector. Till date spatial features where used for analysis and is well established. We propose this system for the use of frequency domain analysis for the purpose.

E. Classification

The extraction of relevant features of a pattern is not a trivial task. For the particular case of the feature extraction from fingerprint images several approaches have been developed, most of them based on special characteristics from the fingerprint patterns, such as ridge orientation and minutia detection. The ridge orientation pattern of fingerprints is used to obtain feature vectors, which were used as inputs to statistical and neural networks classifiers. Several neural network models have been considered for the implementation of the fingerprint classifier. Depending up on the decision rule, all pixels are classified in a single class. Support Vector Machine (SVM) is used for classification of fingerprint into their respective class

Support Vector Machines:

In machine learning, Support Vector Machines (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis. Given a set of training examples, each marked for belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other, making it a non-probabilistic binary linear classifier. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall on.

In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces.

When data are not labeled, supervised learning is not possible, and an unsupervised learning approach is required, which attempts to find natural clustering of the data to groups, and then map new data to these formed groups. The clustering algorithm which provides an improvement to the support vector machines is called support vector clustering and is often used in industrial applications either when data is not labeled or when only some data is labeled as a preprocessing for a classification pass.

V. Age Estimation

All the fingerprints used for our algorithm was taken from the database of Department of Biometric research, University of Ilorin. These fingerprints are optical scanned images. For Age estimation we divide the database into different age groups like 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70 and 71-80. The fingerprints of different age group are grouped and kept as the database fingerprints .Once the desired database is formed all the fingerprints in it undergoes the feature vector extraction as explained in the previous section.

Steps to be followed for Age estimation using the query fingerprint:

1. The fingerprint undergoes preprocessing and is resized to 512x512.
2. The fingerprint undergoes Wavelet Decomposition and the 19 feature vector is obtained.
3. The fingerprint from the preprocessing 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 Support Vector Machine.

VI. RESULTS

The algorithm is developed based on MATLAB programming language. Algorithm executed and result obtained using MATLAB R2013a 8.1.0.430.

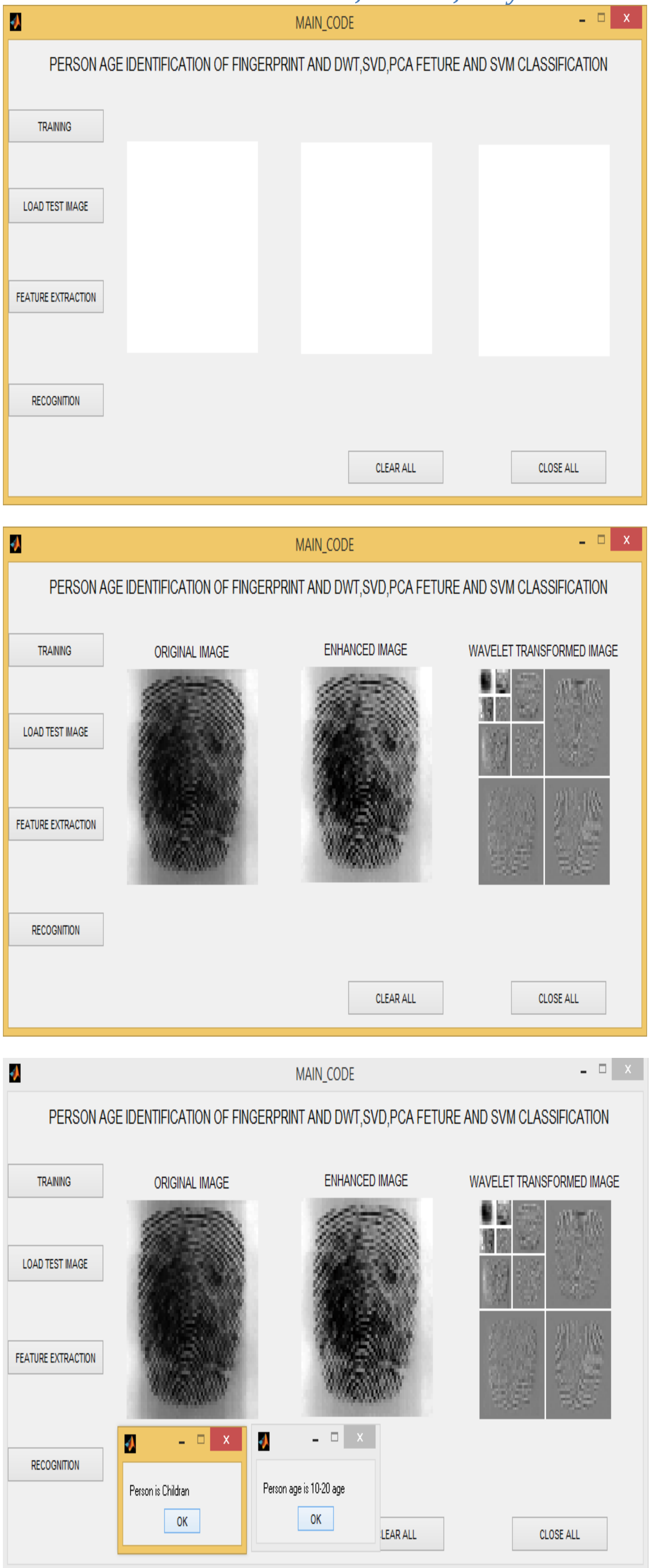

Figure6.1: Results at diferent phases of operation

The algorithm was implemented only on optical scanned prints. With optical scanned prints in database and ink prints as query the algorithm was not much efficient because of the lack of training. It has been found that changing the database also improves the estimation process. The number of database prints is an important criterion.

Increasing the population of fingerprints in the database, considering 600 fingerprints instead of 300 for this paper, has led to increased accuracy in the results produced. Also increased database population can decrease the width of classes considered. So instead of classes of width 10 (1-10, 11-20 etc.), age can be classified into groups having lesser width (1-5, 6-10, 11-15 etc.).

VII. Conclusion

In this work, we have proposed a new method of age estimation from fingerprint obtained based on 2D-DWT and PCA. The database fingerprints are grouped on the basis of the ages. Different age groups are formed for training 1- 10, 11-20, 21-30, 31-40, 41-50, 50-60, 60-70,70-80. For our experiment we made eight groups and the fingerprints of these ages are made to undergo the feature vector extraction steps. The query fingerprint also undergoes the feature extraction and the feature vector is obtained. The feature vectors of the query fingerprint are then initiated for the classification process. After the extraction the classification is done by means of Support Vector Machine. The query vector is compared with all the eight classes and the class which forms the close relation with the given fingerprint is taken for the age group of the Query Print. The proposed method has given high degree of accurate results and can play important role in many important fields like investigation, biometric authentication and in anthropology.

VIII. Future Works

The algorithm that was developed was simple which was to study how well frequency domain analysis help in the classification. In future the algorithm has to be improved with a good classification algorithm like neural networks. It has been found that improving the database is an important criterion for good classification and estimation. Ink prints, optical scanned prints and prints from artifacts all can be used in the database. In future fingerprints from different ethnic groups have to be collected for a large scale study.

Experimental results show an overlap between the different age group fingerprints in some cases. Fingerprint size depends on the growth of the human body. Persons of smaller age group with a body structure bigger than their normal growth have fingerprints bigger than their group. The fingerprints of different age groups vary in size and patterns and thickness of ridges and valleys. The fingerprints of people from various ethnic groups vary. An algorithm for compressing the huge database of fingerprints has to be developed and the database of the feature vectors have to be coded to provide a simpler database structure to reduce the complexity in calculations.

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