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Study and Analysis of a Hybrid Model for Fingerprint Based Gender Identification

Punam Pati[1], Sunita Dalai[2], Rupanita Das[3]
[1]*M.Tech Scholar, Dept. of ECE, Centurion University of Technology &Management, Odisha, INDIA*
[2]*Asst. Professor, Dept. of ECE, Centurion University of Technology &Management, Odisha, INDIA*
[3]*Asst. Professor, Dept. of ECE, Centurion University of Technology &Management, Odisha, INDIA*

Abstract: *In today's time fingerprint plays a very important role, whether it is to link the suspect in a crime scene or to find an unknown person. Fingerprints are one of the most mature biometric technologies use generally for Military code Transaction, Some secret operations at National Security system .The widespread development of Automated fingerprint identification system (AFIS) in Law enforcement and Border control applications are done by various methods like (Face, Iris, palm ,gait ,Voice ,Fingerprints , and Footprints) recognition .The main objective of this paper is to find a link between gender of a person and his/her fingerprint. The gender of an unknown fingerprint was found out by classifying the frequency and spatial domain vector of the input image. Gender identification from fingerprint is proposed based on a hybrid method that combines discrete wavelet transform, Singular value decomposition and Principal component analysis. Here maximum features were extracted from each of this method. The Discrete Wavelet Transformation (DWT) was used to find the frequency domain vector by calculating energy values; Singular Value Decomposition (SVD) was implemented in order to find the spatial feature of the non-zero singular values. The outputs of PCA, SVD and DWT are combined to form the feature vector. The K-nearest neighbor classifier is used to classify the fingerprint .The system will recognize whether the output is match with training data. Result obtained from these techniques show an encouraging performance graph in terms of classification accuracy.*
Keywords: *Biometrics, Gender classification, Fingerprint, SVD, PCA, DWT, AFIS, K- nearest neighbor*

I. Introduction

Now a day's accurate automatic personal identification by system is a very difficult task as various methods are invented to get fake identification. Biometric technology refers to one physiological or behavioral characteristic is inherently more reliable and more capable in differentiating between two people.[22] For recognizing gender of a person by taking his/her Fingerprint is easier than other biometric traits. Due to this distinguished uniqueness of fingerprint I have updated this method. A fingerprint is composed of various ridges and valleys.

Ridges are the upper skin layer segments of the finger and valleys are the lower segments. A ridge ending is defined as the point where a ridge ends abruptly. A ridge bifurcation is defined as the point where a ridge forks or diverges into branch ridges. Ridges are also known as Minutiae that are the local discontinuity in the fingerprint pattern, using which comparisons of one print with another can made. [3][18][21]There are five basic fingerprint patterns: arch, ten -ted arch, left loop, right loop and whorl. Loops. In case of fingerprint the primary dermal ridges are formed during the fetal period (12-19 weeks) [21] [22] and remain fixed permanently. Ridges and their patterns are varying between individuals even if our fingerprints of two hands are differing. Fingerprint does not change size or shape throughout a person life, except in case of serious injuries that scar the dermis. In this paper Gender classification is achieved by extracting different feature by combining three methods DWT, SVD and PCA .The identification and verification of person identity through fingerprint is totally based on Feature extraction. Feature extraction a type of dimensionality reduction that efficiently represents interesting parts of an image as a compact feature vector.[23][18] This approach is useful when image sizes are large and a reduced feature representation is required to quickly complete tasks such as image matching and retrieval. In biometrics feature plays a very important role ,before getting feature of a person for identity purpose various image processing steps are carried out like enhancement normalization ,Binarization , thinning, thresholding, resizing. There are five basic fingerprint patterns: arch, tented arch, left loop, right loop and whorl. The main technologies used to capture the fingerprint image with sufficient detail are optical, silicon, and ultrasound. The main goal of Feature extraction is to obtain the most relevant information from the original data and represents that information in a lower dimensionality space.[19][23] When the input data to an algorithm is large to be processed and it is suspected to be redundant then input data will be transformed into a reduced representation set of feature. Transforming the input data into the set of features is called feature extraction. Feature extraction is classified as Appearance Feature based(global) and Geometric feature based

(local).It has been used in many application such as character recognition, document verification, reading bank deposit slips, applications for credit cards, health insurance ,loan ,tax forms, data entry, postal, Address reading, check sorting, tax reading, script recognition etc. Now a day's feature extraction methods are Template Matching, Deformable templates, Unitary image transforms, Graph description, Projection histograms, Contour profiles ,Zoning, Geometric moment invariants, Zernike moments, Spine curve approximation, Fourier descriptors, Gradient feature and Gabor features. Feature extraction is done after the pre-processing phase in character recognition system. The primary task of pattern recognition is to take an input pattern and correctly match with output. This purposed method is totally work on Gender classification by human- computer interaction such as personal identification.

II. Background And Literature Review

S. Yu, T. Tan, K. Huang, K. Jia and X. Wu, "A Study on Gait-Based Gender Classification", IEEE Transactions on Image Processing, vol. 18, no. 8, (2009), pp. 1905-1910.] and its automatic classification in the digital world has gained much popularity. Gender classification from fingerprints is an important step in forensic anthropology in order to identify the gender of a criminal and minimize the list of suspects search**.** Gender and age classification can be me made using the spatial parameters or frequency domain parameters or using the combination of both. Most of the findings are based on the spatial domain analysis and few were based on the frequency domain**..**

In [1]S.Selvarani, S.Jebapriya, R.Smeeta Mary has proposed a new method for Automatic Identification and Detection of Altered Fingerprints that refers to the deliberate alternation of the fingerprints pattern by a person for masking his/her identity. It is possible to remove, alter or even fake fingerprints(made of Glue,Latex,Silicone) by burning the fingertip skin(fire, acid) by using plastic surgery(changing the skin completely, causing change in pattern portions of skin are removed from a finger and grafted back in different position, like other fingers, palms ,toes ,soles)based on estimation of orientation field and computation of the reliability was tested with real altered fingerprint obtained from natural fingerprint image.

In [2] The Enhancement of Low Quality Fingerprint Based on Fingerprint Based on Fractional Calculus Mask By XunqiangTao,Xin Yang, YaliZang , JieTian proposed an algorithm that improvise the low quality fingerprint image enhancement .The quality of fingerprint image degrades due to the factors such as scars, non-uniform contact with sensors and the environmental condition during the capturing process. Compared with tradition frequency filtering technology of image processing, this method has many advantages, such as not requiring estimation of the ridge frequency component and Gaussian parameters, simple and easy application, high performance and good practicality. First an 8-directions image is obtained in a convenient way. Then based on Fractional calculus, a mask has been got on 8-directions. Then the mask is used to filter and enhance fingerprint image according to 8-directions image. The proposed algorithm is match with the stored data base for matching.

In [3]Fingerprint identification system based on Neural Network proposed by Mr.Lokhande S.K. Prof.Mrs.DhongdeV.S.they propose a method that design and develop a pattern recognition system using Artificial Neural Network that can recognize the type of image based on feature extraction. They develop a system to recognize the exact thumb impressions from the match with images that has already stored, the main task before are, to make the system activate through Artificial Neural Network. The main objective was to produce a computation system that work like human brain, to understand the physiology and psychological functioning of human neural system. Using Mat lab the system will recognize and will produce a kind of graph that describes the feature of data which is same as training data.

In [4] An Advance Technique For User Identification Using Partial Fingerprint by V.Conti,G.Vitello and S.Vitabile they proposed a method that used to identify a person by taking a small part of fingerprint based on fingerprint local analysis and micro-feature, endpoints and bifurcation, extraction that is minutiae extraction. Then, at the end final matching was done between pairs of fingerprints. In case of Partial Fingerprint samples, the amount of data in the database shall be decreased so, faster processing for fingerprint identification through Hardware and Software was possible.

In [5] Fingerprint image synthesis based on statistical Feature Models by Qijun Zhao, Anil K.Jain, Nicholas G.Paulter Jr., Melissa Taylor they proposed a method to synthesize fingerprint images that retain prespecified features such as (singular points, orientation field, and minutiae) .Here feature are sampled from appropriate statistical models which are trained by using real fingerprints in public domain databases. A master fingerprint containing the specified features is then generated by using a fingerprint reconstruction algorithm. Multiple impressions are generated by applying nonlinear plastic distortion and global ridge transformation to the master fingerprint. Finally, image rendering is performed on the impressions, which simulates finger dryness and noise. From the result features in different fingerprint impressions are traced during the synthesis.

In [6] On the Principal Component Based Fingerprint Classification Using Directional Images by Meltem Ballan and Fikret Gurgen they used PCA method to compress fingerprint data. The compressed data are

then used for Directional image representation. After the compressed data are obtained, the process continues with directional image formation, directional image block representation, and fingerprint matching. This method was help full in determining direction of pixel, process the images in blocks and uses directional histograms, thus, remove the need of thinning also reduces computation time.

III. Implemented Work

Gender classification system consists of feature extraction and classifier module. In this phase feature extraction reduces the data by measuring certain features or properties of training fingerprint images. Then, the extracted features are stored in the database. The resultant data's are used by classifier to classify the images with the help of previously stored database and make the final decision. Here the classifier is trained and tested which can classify input vector as a male or female. Gender Classification is a typical binary classification problem.[2]The gender classification framework generally consists of five procedures, which is demonstrated in Fig. 1 including sensing, pre-processing, feature extraction, classification, and evaluation.

3.1. Sensing

The first step for gender classification is to obtain the effective raw data using specific sensors, including camera (images, videos) [8], recorder (voice), physiological measurements (EEG, ECG), social network-based information (e.g., facebook posts, tweet, blog). Based on the acquired features, various approaches are employed to perform gender classification.

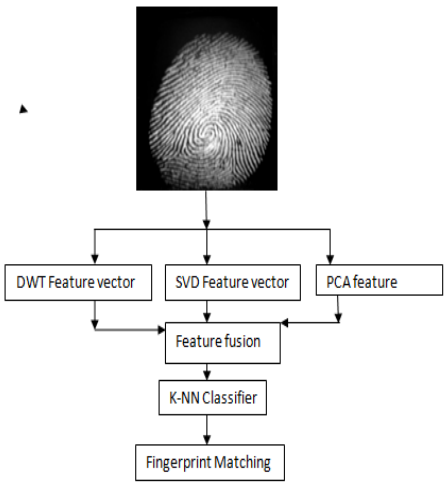

Figure 1 Histogram equalization

3.2. Preprocessing

Pre-processing is a necessary procedure to improve the quality of raw data, which includes the normalization of the main signal detection, the extraction of the informative area, and the correction of imperfections such as filling holes, noise removal, face detection, etc. With appropriate .Signal pre-processing procedure, the undesired information are eliminated from the raw information and has few affect on quality of the feature extraction, leading to a improvement on the identification accuracy rate. This step include image enhancement i.e, done through Histogram equalization.

Histogram is the basis for spatial domain processing .It is a technique t hat is used for adjusting image intensities to enhance contrast**.** In case of data that is represented by close contrast value using histogram equalization the intensities can be better distributed on the histogram. So, in this case contrast will increase from lower gain to higher gain. This method is useful in images with backgrounds and fore grounds that are both bright or both dark. Histogram equalization is to expand the pixel value distribution of an image so as to increase the perceptional information Minutiae extraction.

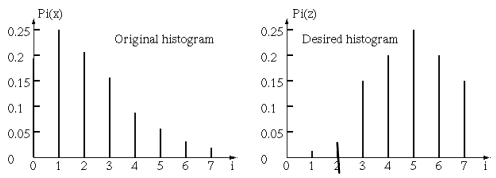

Figure 2 Intensity variation of Histogram between original and desired out put

To find Histogram equalization transformation for the input image

$$s = T(r) = (L-1)\int_0^r p_r(w)dw = (L-1)\int_0^r \frac{2w}{(L-1)^2}dw = \frac{r^2}{L-1}$$

For the specified histogram

$$G(z) = (L-1)\int_0^z P_z(t)\,dt = (L-1)\int_0^z \frac{3t^2}{(L-1)^3}dt = \frac{z^3}{(L-1)^2} = s$$

The transformation function

$$z = [(L-1)^2 s]^{1/3} = \left[(L-1)^2 \frac{r^2}{L-1}\right]^{1/3} = [(L-1)r^2]^{1/3}$$

Figure-3 (a) Original finger print (b) After Histogram equalization

3.3 Feature Extraction

Feature extraction captures the main characters of the pre-processed signal as the input parameter for the classification algorithm. The feature extraction module minimizes the size of data by extracting the features of the pre-processed information that are useful for classification. Thedesired features should be easily computed, robust, distinctive, and insensitive in various conditions. In the next phase, the classifier will process these extracted features and conduct the classificationPCA is that once you have found these patterns in the data, and you compress the data, i.e. by reducing the number of dimensions, without much loss of information. Here Eigen vectors and Eigen values are calculated.Feature extraction is done in three ways of DWT, SVD, and PCA.

3.3.1 Feature Extraction by Discrete Wavelet Transform

A weakness shared by most of the texture analysis schemes is that the image is analyzed at one single-scale; a limitation that can be lifted by employing a multi-scale representation of the textures such as the one offered by the wavelet transform. Wavelets have been shown to be useful for texture analysis in literature, possibly due to their finite duration, which provides both frequency and spatial locality. Wavelets have been used for feature extraction, de-noising, compression, face recognition, fingerprint recognition and image super-resolution.

The measure advantage of using DWT is it captures both frequency and location information.DWT is a transform based on frequency domain the distributions of the frequency is transformed in each step of DWT, where L represents Low frequency band, H represents High frequency band and subscript behind them represents the number of layers of transforms. LL sub graph represents the lower resolution estimate of the original video, while mid-frequency and high-frequency details sub graph HL, LH and HH represents horizontal edge, vertical edge and diagonal edge details. Most of the energy is concentrated in low frequency sub-band.

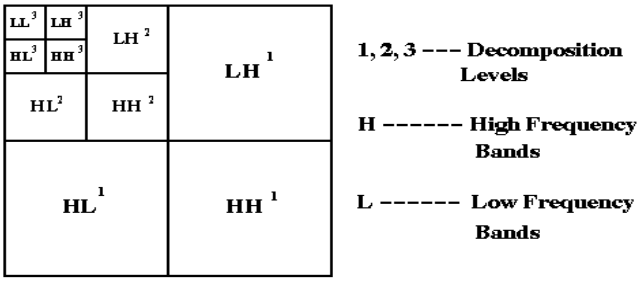

Figure 4: Discrete Wavelet Transform

The decomposition of images into different frequency ranges permits the isolation of frequency components introduced by ‘’intrinsic deformation” or ‘’extrinsic factors” into certain sub-band. This process results in isolating small changes in an image mainly in High frequency sub-band image. So, DWT generally used for designing a classification system. This shows one level DWT.

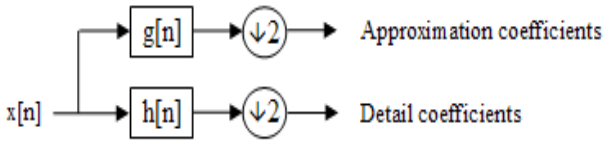

Figure 5: 1-Level of Decomposition

At every iteration of the DWT, the lines of the input image (obtained at the end of the previous iteration) are low-pass filtered and high pass filtered. Then the lines of the two images obtained at the output of the two filters are decimated with a factor of 2. Next, the columns of the two images obtained are low and high pass filtered. The columns of those four images are also decimated with a factor of 2.Four new sub-images (representing the result of the current iteration) are generated. The first one, obtained after two low-passes filtering, is named approximation sub-image (or LL image). The others three are named detail sub-images: LH, HL and HH. The LL image represents the input for the next iteration. For k level DWT, there are * [(3*k) +1] sub-bands available. We propose a combination of three texture descriptors namely Standard Deviation, Kurtosis and Skewness.

***i. Standard deviation*:** The standard deviation of the image gives a measure of the amount of detail in that sub-band.

***ii. Kurtosis*:** It measures the peaked ness or flatness of the distribution and is given

$$k = \frac{1}{N}\sum_{I=1}^{N}\left(\frac{x_i-\mu}{\sigma}^4\right) \qquad (1)$$

Where μ is the sample mean of the *N* pixels within the image and σ is standard deviation.

iii. Skewness: Skewness is a measure of the asymmetry of the data around the sample mean.

$$g_1 = \frac{m_3}{m_2^{\frac{3}{2}}} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i-\overline{x})}{(\frac{1}{n}\sum_{i=1}^{n}(x_i-\overline{x})^3/_2} \qquad (2)$$

The energy of each sub –band energy vector (E).The energy of each sub-band is calculated by using equation (1)

$$E_K = \frac{1}{RC}\sum_{I=1}^{R}\sum_{J=1}^{C}(X_I Y_J) \qquad (3)$$

Where x (i, j) is the pixel value of thek^{th} sub-band and R,C is width and height of the sub-band .The DWT of a signal x is calculated by passing it through a series of filters.

3.3.2. Examples of Discrete wavelet transform

Haar wavelet transform, Daubechies wavelet transform, The dual-tree complex wavelet transform (DCWT) etc.

1. ***Haar wavelet:*** The Haar wavelet is a sequence of rescaled (square shaped) functions .For an input represented by a list of $\mathbf{2^n}$ numbers, the Haar wavelet transform transform may be considered to pair up input values, storing the difference and passing the sum .This process is repeated recursively, pairing up the sums to provide the next scale ,which leads to$\mathbf{2^n - 1}$ differences and a final sum.TheHaar wavelet is also the simplest possible wavelet. The technical disadvantage of the Haarwavelet is that it is notcontinuous, 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.The Haar wavelet transform has a number of advantages (1)It is conceptually simple.(2)It is fast. (3)It is memory efficient, since it can be calculated in place without a temporary array.(4)It is exactly reversible without the edge effects that are a problem with other wavelet transforms.

3.3.3. Implementation of DWT Algorithm

[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.

3.3.4. Feature Extraction By Singular Value Decomposition

Singular value decomposition is a numerical technique used to diagonalizable matrices in numerical analysis. It is an algorithm developed for a variety of applications. The singular value decomposition (SVD) technique has been successfully used in a variety of applications, such as data compression, pattern analysis and signal processing. It has been scientifically proved that slight variation in the singular values does not change the visual perception of the image. Also, the singular values are robust to the common image processing attacks and do not change much after their application to the image. From the linear algebra viewpoint, the SVD decomposition of any discrete image matrix A of size mxn can be represented as:

$$A=U\,S\,V^T$$

Where U and V are orthogonal matrices (UU^T =1,VV^T =I) of size mxm and nxn respectively [5, 6]. The horizontal and vertical details in an image are given by the columns of U and V matrices called as left and right singular vectors respectively. The diagonal matrix S with size m x n, has nonzero element scalled singular values of the matrix. They represent the luminance values of the image layers and as arranged in decreasing order from the first SV to the last one. The above decomposition is termed as Singular Value Decomposition. The increased robustness is due to the stability of singular values. Singular values exhibit some more properties like rotation invariance, translation invariance, transposition invariance, etc.

3.3.5 Implementation of SVD Algorithm: Householder reduction to bi-diagonal form

Input: m, n, A where A is m×n.

Output: B, U, V so that B is upper bidiagonal, U and V are products of Householder matrices, and A=UBV^T

1. B← A
2. U=$I_{m\times n}$.
3. V=$I_{n\times n}$
4. For k=1,…..,n

a. Determine Householder matrix Q_k with the property that:

- Left multiplication by Q_k leaves components1,…..,k-1 unaltered ,and
- $$Q_k\begin{bmatrix}0\\ \vdots\\ b_{k-1,k}\\ b_{k,k}\\ \vdots\\ b_{k+1,k}\\ \vdots\\ b_{m,k}\end{bmatrix}=\begin{bmatrix}0\\ \vdots\\ b_{k-1,k}\\ s\\ \vdots\\ 0\\ 0\end{bmatrix},$$

  Where s = $\pm\sqrt{\sum_{i=k}^{m} b_{i,k}^2}$

  b.B← $Q_K B$.

  C.U← UQ_K.

  d.If k≤ $n-2$,determine Householder matrixP_{K+1} with the property that:

- Right multiplication by P_{K+1} leaves components1,….,k unaltered ,and
- [0…0 $b_{k,k}b_{k,k+1}b_{k,k+2}\dots\dots b_{k,n}$]$P_{K+1}$=[0….0 $b_{k,k}$ s 0…….0] where s = $\pm\sqrt{\sum_{i=k}^{m} b_{i,k}^2}$

  e.B← BP_{K+1}

  f.V ← $P_{K+1}V$.

3.3.6. Feature Extraction by Principal component analysis

The stem performance. The PCA method tries to find the projection of the feature vector on a set of base Vectors.

Let X= { *xt*, *t*=1, 2… *M* } be a set of *M* ,*n*-dimensional feature vectors. Hence, the covariance matrix C of X can be found as follows:

$$C=\frac{1}{M}\sum_{i=1}^{M}(x_i-\bar{x})(x_i-\bar{x})^T$$

Where

$$\bar{x} = \frac{1}{M}\sum_{i=1}^{M}(x_i)$$

And *M* is the number of n-dimensional feature vectors. The projection vector,Ω $\{\omega_1, \omega_2, \ldots\ldots \omega_n\}$ describes the distribution of eigenvectors on m-dimensional linear subspace (eigen space). This weight is used to represent the input minutiae image and can be obtained as follows:

Where $\phi_k$is the eigen vector. The transformation matrix $\phi$is formed by the principle eigenvectors $\phi_1, \phi_2, \ldots\ldots \phi_m$(m < M) of the covariance matrix C,m is the number of projection bases, and the Eigenvectors $\phi_k$are organized in ϕin such a waythat all eigenvectors indices are in a descending order corresponding to their respective eigen values($\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_m$).

Implementation of PCA Algorithm
1) All training set images are resized and converted in to a single vector.
2) The test image is resized and converted in to a single vector.
3) The mean image of all training set images plus test image is calculated.
4) Then the mean image is subtracted from each image of the training set as well as from the test image.
After subtraction we will get new images called as difference images.
5) Then using covariance matrix the eigenvector and Eigen values are calculated. Each eigenvector belongs to one of the Eigen image.
6) Using product of each eigen images with the difference images will get the weight vector of each class as well as the weight Vector of the test image.
7) Then the weight of the test image is subtracted from each weight vector of the difference image.
8) Then the distance of each class of the images in the database is calculated.
9) The class having the least distance, the input test image belongs to that class.

3.7. Classification Algorithm

The classification algorithm is the core for gender identify. Generally, the classification approaches can be divided into two categories: appearance based approaches and non-E aigsor an animate video to conduct gender classification. The nonappearance based approaches classify the gender by analysing persons physical, biometric, or social network-based information. Among these two approaches, several types of classifiers have been utilized for gender classification, such as support vector machine (SVM) [28], k-nearest neighbours (KNN) [29] and Gaussian mixture models (GMM) [30]. The choice of classification algorithm is crucial depends on case by case in order to achieve a higher identification accuracy.

3.8. Classification Algorithm

[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.

3.9 Evaluation

Evaluation measures the performance of the gender classification system. Basically, the system is tested in terms of accuracy, trustworthiness, invasiveness, etc. One of the most important standards is accuracy, which refers to the probability of correct recognition of a person as a male or a female. In the evaluation, several databases are used for the evaluation such as Multiple Biometric Grand Challenge database and the Face Recognition Grand Challenge database to verify the gender classification approach.

IV. Conclusion

As we know that Gender Identification becomes a real challenge in image processing, we have used fingerprints (only Thumb) of male and female for gender identification. In this work we have applied different feature extraction methods like PCA, DWT and SVD for the feature extraction of fingerprint images. In first case we have used only PCA and in second case we have used all PCA, DWT and SVD combiningly. Then we compare the identification results for both male and female. In first case we got 85% of correct identification for Male and 75% of correct identification for Female. But in second case for Male we got 90% of correct

identification where 72.5% of correct identification for SS Female. Some fingerprints which are wrongly identified in 1st case but these are correctly identified in 2nd case.

In future we have planned to apply these methods for the individuals of different age groups and also improve the database by taking fingerprints of all 10 numbers of fingers. So that we can improve the percentage of correct identification. Also we can implement this work in real-time application.

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