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ENHANCED FINGERPRINT CLASSIFICATION BASED ON COMPRESSED GIST ON DWT

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Abstract*:* In this paper, we propose enhanced fingerprint recognition based on compressed GIST concept on DWT. The fingerprint database of FVC 2004 is considered to test the proposed algorithm and only fingerprint part in an image is cropped and Histogram Equalization (HE) is applied. The cropped HE image is resized to 400 x 400 and Discrete Wavelet Transform (DWT) is used to convert spatial domain to transform domain with low and high frequency bands. The low-frequency LL-band of size 200 x 200 is considered by discarding the high frequency bands of LH, HL and HH of each size 200 x 200 to enhance image quality with reduced dimensionality. The GIST concept is used on LL band to obtain final features. The Support Vector Machine (SV M) is used to classify images in the database. It is seen that the recognition rate of proposed method is better compared to the existing methods.

Keywords – Biometrics, fingerprint, DWT, GIST, SVM

I. INTRODUCTION

The progress of biometric system is to improve the security aspects in genuine real time applications. Biometrics is the method of identification and verification of an human beings built on the physiological and behavioral characteristics, which are unique that distinguish individuals effectively. Physiological traits are the badly attached parts of human beings, such as fingerprint, palm print, facial pattern, deoxyribonucleic acid (DNA), Iris. These traits are extensively used because of the uniqueness, permanence, and inexpensive stable characteristics. The behavioral traits are the characteristics related to the actions of and individual, and examples are, speech, keystroke, signature, handwriting and gait. These traits are dependent on the environments and attitude of an individual hence unstable and lack of precession. The biometric systems have abundant benefits over old styled schemes such as ID cards and password but there are several limitations of the biometric systems. An attacker accesses the stored database to take the data and bluffing the uniqueness of an individual, an attacker intersects the data communicated between the matcher and the stored template to alter genuine person, an attacker may replace the data in the stored template based on the demand of required one from criminals [1].

Biometric recognition systems have become more common for the progress of many beneficial, exciting and broadly accepted applications viz., sanctuary issues, investigation, legal inquiries, fake skills, self-access administration and entrée regulator. The systems can be manufactured either using single modality or multiple modalities [2]. The result of the single modality system is significantly deteriorate by the noisy data, small sample size and with physically challenged persons. However biometric system employ two or more biometric traits (multimodal biometric systems) are more secure from the attacks, extremely trustworthy and robust under an active atmosphere. The multimodal biometric systems are established with the combinations on the several stages, such as feature stage fusion, decision stage fusion and score stage fusion. The biometric applications are in two modes viz., verification and identification modes. In verification mode, the authentication of an individual is verified by likening the test biometric trait with the deposited sample one ie., one to one comparison (1:1). In identification mode, the authentication of an individual is identified by likening the test biometric trait with the all samples deposited in the dataset ie., one to many comparison (1:N).

Fingerprints of human being is a biological feature, have dissimilar among people, have attracted the attention of several research scholars due to their high consistency. The biometric features of biometric traits comprise a lot of detailed information, which is uniqueness for human beings compared to traditional methods of identification. The low budget of collection of fingerprint images through very less complicated device and its high consistency in recognition process, been normally used in search of human beings. Most fingerprint classification approaches are built on the features by image orientation, ridgeline flow, minutia points and Gabor filter responses [3]. The capture of good fingerprint image using sensor from oily, dirty, and moisture, on finger is challenging leads to lack in performance. Hence it is required to develop robust fingerprint recognition system to verify/identify human beings.

Contribution: In this paper fingerprint recognition based on DWT, GIST and SVM is proposed. The fingerprint images are cropped and HE is used to enhance the contrast and DWT is applied. The GIST features are computed from LL band of DWT to recognize fingerprint based on SVM.

Organization: The paper is prepared as the literature survey on existing fingerprint recognition technique is explained in section 2. The proposed method is deliberated in detail in section 3. In section 4, the experimental result is deliberated and compared results of proposed methods with existing methods. The research paper is concluded in section 5 along with future work.

II. LITERATURE SURVERY

The signature of human identity based on fingerprint identification approaches have been developed by several researchers using various techniques are revealed in this section.

Dale and Joshi [4] presented a fingerprint system using Discrete Cosine Transform (DCT), Fast Fourier Transform (FFT) and Discrete Wavelet Transform (DWT). The fingerprint image of size 64x64 is collected around the core point. The transforms are used on the collected image and factors are organized in specific way to get the feature vector in terms of standard deviation. The fingerprint equivalent is based on the Euclidian distance. Singh and Girdhar [5] proposed a technique of fingerprint augmentation based on DWT, PDE and SVM. The DWT is used to obtain LL, HL, LH and HH bands of fingerprint. The minutiae of fingerprint are extracted by selection of the local point of each ridge using a 3x3 window. The PDE algorithm gets the better features through minutiae technique. The SVM is used for classification of unique features. Shinde and annadate [6] analyzed association of an individual with gender based on DWT and singular value decomposition (SVD). The classification based on gender is attained by mining the energy calculated from all the bands of DWT pooled with the spatial features of non-zero singular values gained from the SVD. The matching is done by K Nearest Neighbor (KNN).

Tekade and Shende [7] proposed a personal identification using multimodal biometric system with three modalities viz., face, fingerprint and palm vein. The Local Binary Pattern (LBP) procedure, DWT and minutiae process are used to extract features from face, palm vein and fingerprint. The feature level fusion is adopted to gat final features to test the algorithm. Rezaei and Abaei [8] explored fingerprint recognition built on hybrid features using DCT, DWT, and moment methods. Back propagation neural network is employed for classification. Cevik et al., [9] examined the Gray Level Co-occurrence Matrix (GLCM) and DWT techniques on fingerprint images. The DWT is used to compress the size of features.

Zhao and Liu [10] described a building recognition model using multi scale GIST feature illustration idea to captures a holistic and low-dimensional depiction of the building image. Yangyang Wang et al., [11] projected GIST descriptor which imprisonments the structure information of achievement and its trajectories indicate the position connection of local grids. The GIST features are separated into four sectors, and word phrases are constructed using bag of words technique. The SVM classifier is used. Ende et al., [12] presented a system for human behavior in still images based on LLC and GIST features. The GIST features are evaluated by dividing the image into blocks and constructed the Gabor filter collection of 32 different scales and directions. The features from each block are fused and normalized for the GIST features. The SVM is used for classification. Vinay et al., [13] proposed a double filtered GIST based descriptor for face recognition using edge detection through Prewitt technique, DCT and IDCT conversion to decrease noise prior to extraction of feature from GIST descriptor.

III.PROPOSED MODEL

The fingerprint identification system has mainly three sections viz., enrolment section, and test section with two stages in each section namely image enhancement stage, and feature extraction stage to extract final effective. The final features of enrolment section and test section are classified using SVM to verify the performance of the system. The proposed fingerprint system is displayed in the figure 1.

3.1 Enrolment Section:

The db3 fingerprint images of different persons are considered and created a database. The fingerprint contrast is enhanced using Histogram Equalization (HE) and resized in preprocessing unit. The initial features are mined from 400x400 fingerprint images by using DWT and considered the compressed significant LL band fingerprint image of size 200x200 for further processing. The final features are extracted using GIST concept on LL band of DWT to obtain less number of features for fast computation.

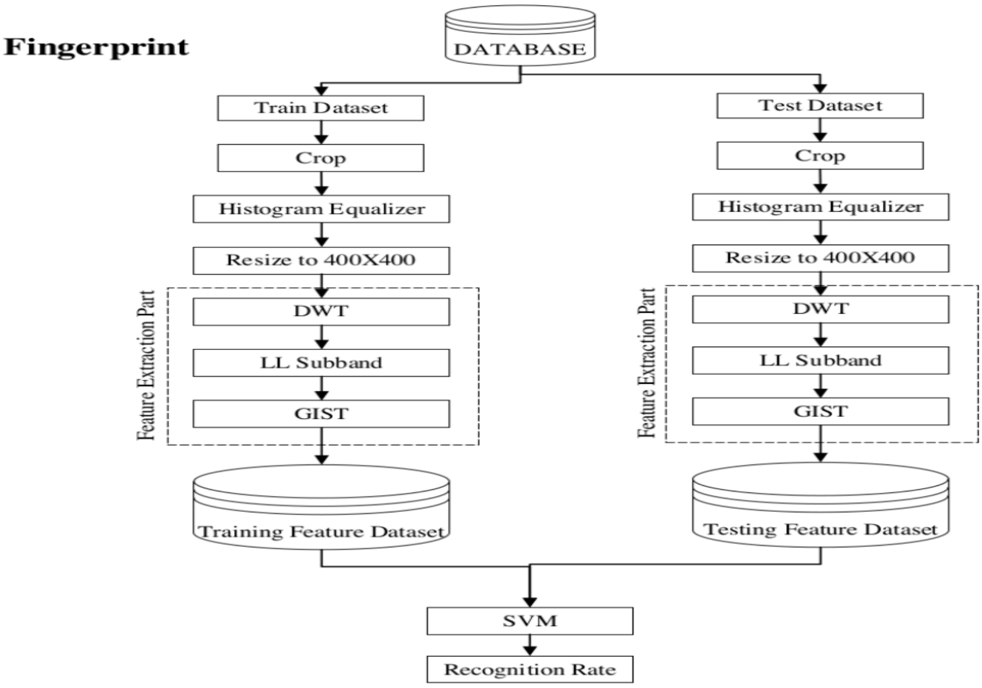

Figure 1. Block diagram of Proposed Model

3.1.1 Fingerprint Database: The FVC 2004 database of fingerprint is the third International Fingerprint Verification Competition database [14] after FVC2000 [15] and FVC2002 [16]. FVC2004 is divided into four dissimilar sub-datasets as DB1, DB2, DB3, and DB4 which were collected by using the different sensors database [14] after FVC2000 [15] and FVC2002 [16]. FVC2004 is divided into four dissimilar sub-datasets as DB1, DB2, DB3, and DB4 which were collected by using the different sensors/technologies.

(i) DB1 has totally 80 grayscale images with .TIF format from 8 distinct images of each of 10 different persons. It was collected by using optical sensor module V300 by Cross Match. Each fingerprint image in the database has a size of 640x480 pixels. The first fingerprint images of 10 different persons and eight images of a person for DB1 are as shown in the figures 2 and 3.

Figure 2. First image of 10 persons for DB1

Figure 3. All 8 images of first person for DB1

(ii) DB2 has totally 80 grayscale images with .TIF format from 8 distinct images of each of 10 different persons. It was collected by using optical sensor module. Each fingerprint image in the database has a size 328x364 pixels. The first fingerprint images of ten different persons and eight images of a person for DB2 are as shown in the figures 4 and 5.

Figure 4. First images of 10 persons for DB2

Figure 5. All 8 images of first person for DB2

(iii) DB3 has totally 80 grayscale images with .TIF format from 8 distinct images of each 10 different persons. It was collected by using thermal sweeping sensor module, Finger Chip FCD4B14CB by Atmel. Each fingerprint image in the database has a size 300x480 pixels. The first fingerprint images of ten different persons and eight images of a person for DB3 are as shown in the figure 6 and 7.

Figure 6. First image of 10 persons for DB3

Figure 7. All 8 images of first person for DB3

(iv) DB4 has totally 80 grayscale images with .TIF format from 8 distinct images of each of 10 different persons. It was collected by using synthetic fingerprint generation ersion3.0. Each fingerprint image in the database has a size 288x384 pixels. The first fingerprint images of ten different persons and eight images of a person for DB4 are as shown in the figures 8 and 9.

Figure 8. First image of 10 persons for DB4

Figure 9. All 8 images of first person for DB4

3.1.2 Preprocessing: The fingerprint image is cropped, and HE is used to enhance contrast, finally resized.

(i) Crop fingerprint image: The lone part of fingerprint from original fingerprint image of size 640x480 is considered and cropped it to obtain reduced size of 202x435 for further processing as shown in the figure 10.

10.a: Original image with Size 640x480

10.b: Cropped image with size 202x435

Figure 10. Fingerprint image cropping

(ii) Histogram Equalization (HE): It is used to enhance contrast in an images for better viewing by effectually scattering out the most frequent intensity values, i.e. widening out the intensity range of the image. The HE images of original and cropped images with their corresponding histograms are shown in figures 11 and 12.

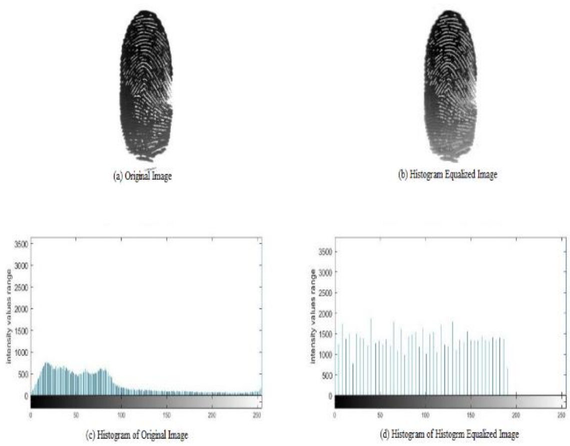

Figure 11. Histogram Equalization on original image (640x480)

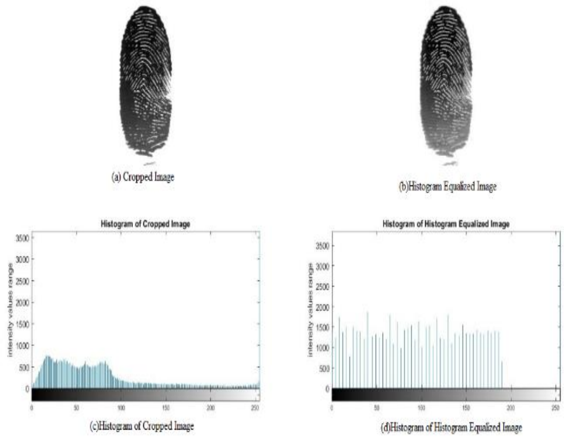

Figure 12. Histogram Equalization on cropped image (202x435)

(iii) Resize of fingerprint image: The histogram equalized cropped image of size 202x435 is considered and resized to 400x400 as shown in figure 13.

13.a: HE copied image of size 202x435

13.b: Resized fingerprint images with size 400x400

Figure 13. Resized HE fingerprint image

3.1.3 Feature Extraction:

(i) DWT on resized HE fingerprint image: The transformation is discretely sampled to bag both frequency and time domain information simultaneously. It decomposes the image into four different sub band images based on mixture of wavelet filter and scaling filters [17]. The DWT is applied on resized HE fingerprint image of size 400x400 to reduce noise and compress fingerprint image dimension by considering LL sub band of DWT with size 200x200 as shown in the figure 14.

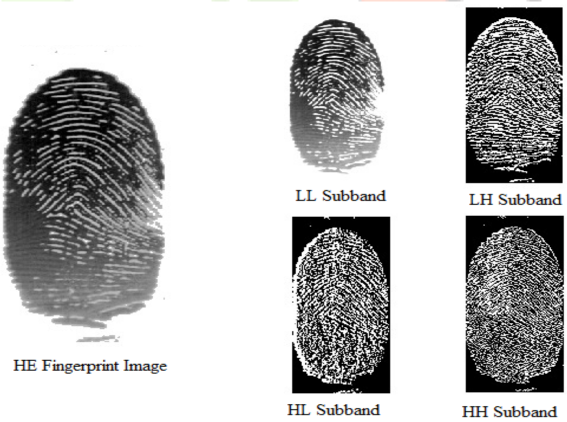

Figure 14. DWT on resized HE image

(ii) GIST on LL sub band: The image processing research has established that persons can grasp the *GIST* [18,19,20] of an image by looking at it for just a limited seconds and it is a descriptor of a overall image. It attains a description of the image through the control of overall features of an image. The image is divided into non-overlap 4x4 image blocks with the same size to yield 16 coefficients. The Gabor filter has four dimensions and eight directions to build 32 dissimilar scales and directions. A low dimensional representation of the image is developed using GIST concept which is calculated by the following steps.

1. Convolve the LL sub band fingerprint image with 32 Gabor filters at 4 scales with 8 orientations, producing 32 features.
2. Each feature matrix is divided into 16 regions of a 4x4 grid, and compute average feature values of every region.
3. Concentrate the 16 averaged values resulting in 16x32=512 GIST descriptors as shown in figure 15.

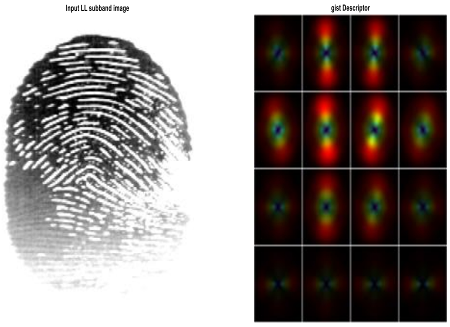

Figure 15. LL sub band image and its GIST descriptors

3.2 Test Section:

The fingerprint image to be tested are considered in test section to identify human beings. The procedure adapted in this section is same as enrolment section.

3.3 Classification:

The supervised machine learning Support Vector Machine (SVM) algorithm is used matching section. An algorithm automatically creates linear decision boundaries to classify multiple classes. A hyperplane in high-dimensional feature space is used for classification between two classes. The kernel trick technique is used to transform the data to discover an optimal boundary between the possible outputs. The support vectors describe the hyperplane for classification between the two classes.

IV EXPERIMENTAL RESULTS

Experiments have been conducted to authenticate the performance of the proposed methodology on the MATLAB R2016a platform and the performance is compared with existing approaches. The proposed method is tested using FVC2004 fingerprint database which has 4 sub datasets as DB1_B, DB2_B, DB3_B, and DB4_B and each sub dataset consists of 80 images from 10 different people with 8 different images per person.

4.1 Performance variations with test image locations:

The table 1 symbolize the recognition rate with the seven images in training and one image for testing by changing the test image locations from one to eight. The recognition rate with seventh fingerprint image as test image gives best result of 100% compared to first and second images at test images having only 30% using DB1 fingerprint database. The recognition rate with third fingerprint image as test image gives the best result of 80% compared to first and fourth images as test images having only 30% using DB2 fingerprint database. The recognition rate with 2nd, 3rd and 4th fingerprint images as test images gives best result of 100% compared to 5th and 7th images as test images having only 80% using DB3 fingerprint database. The recognition rate with first fingerprint image as test image gives the best result of 80% compared to fourth, sixth and eighth images as test images having only 50% using DB4 fingerprint database. Hence, the recognition rate depends on the test fingerprint images selected from the fingerprint database.

Table 1. Percentage Recognition Rate with Different Test Image Location in the Database

Data base	Test @ 1	Test @ 2	Test @ 3	Test @ 4	Test @ 5	Test @ 6	Test @ 7		Test @ 8
DB 1_B	30	30	40	50	70	80	100		70
DB 2_B	30	40	80	30	50	40	60		60
DB 3_B	90	100	100	100	80	90	80		90
DB 4_B	80	70	60	50	70	50	60		50

The Percentage Recognition Rate (PRR) variations with different test fingerprint image locations using DB1_B, DB2_B, DB3_B, and DB4_B are shown in figure 16. The PRR values are with DB_3 are better compared to other databases, as the quality of fingerprints are good. The PRR value is better with test image location 7 for DB_1 database. The PRR value is better with test image location 3 for DB_2 database. The PRR values are better with test image location 2, 3 and 4 for DB_3 database. The PRR value is better with test image location 1 for DB_4 database. Hence, the performance of the fingerprint recognition system is dependent on test fingerprints.

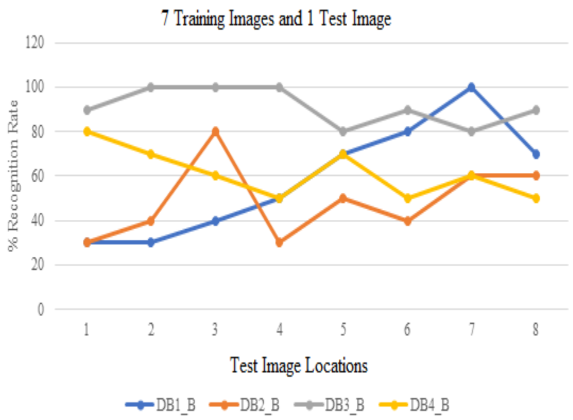

Figure 16. Variations in Percentage Recognition Rate with test image location

4.2 Performance variations with diverse combinations of train and test images:

The PRR values with dissimilar combinations of train and test images with best test image in the databases are as shown Table 2. It is detected that the values of PRR increases with increase in number of training images. The PRR value is computed and found 100% with best test image location at 7 for DB_1 fingerprint database. The PRR value is computed and found 80% with best test image location at 3 for DB_2 fingerprint database. The PRR values is computed and found 100% with best test image locations at 2, 3, and 4 for DB_3 fingerprint database. The PRR value is computed and found 80% with best test image location at 1 for DB_4 fingerprint database.

Table 2. The PRR Deviations with Dissimilar Combinations of Train and Test Images with Best Test Image Locations

Train :Test	**7:1**	**6:2**	**5:3**	**4:4**	**3:5**	**2:6**	**1:7**
DB1_B	100	85.00	73.33	70.00	48.00	43.33	41.67
DB2_B	80.00	60.00	56.67	50.00	46.00	38.33	31.43
DB3_B	100	100	97.50	96.67	86.00	66.67	62.86
DB4_B	80.00	60.00	63.33	55.00	44.00	35.00	32.86

The variations of PRR with different combinations of train and test images with DB_1, DB_2, DB_3 and DB_4 fingerprint databases are shown in figure 17. It is noticed that the PRR values are better with DB_3 fingerprint database for all combinations of train and test images compared to other databases. The PRR values are poorer with DB_2 and DB_4 fingerprint database for all combinations of train and test images as the quality of fingerprint images are poor.

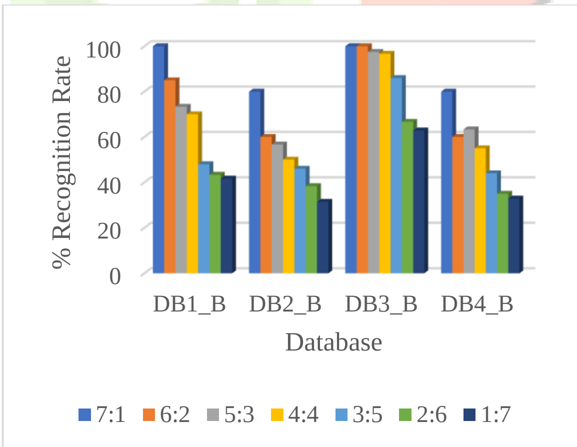

Fig 17. The variations of PRR with different combinations of train and test image.

The variations of PRR with four fingerprint databases for different combinations of train and test images are shown in bar chart of figure 18. The PRR values are better with DB_3 for all mixtures of train and test images. The fingerprint database DB_2 performs very poorly for all combinations of train and test images.

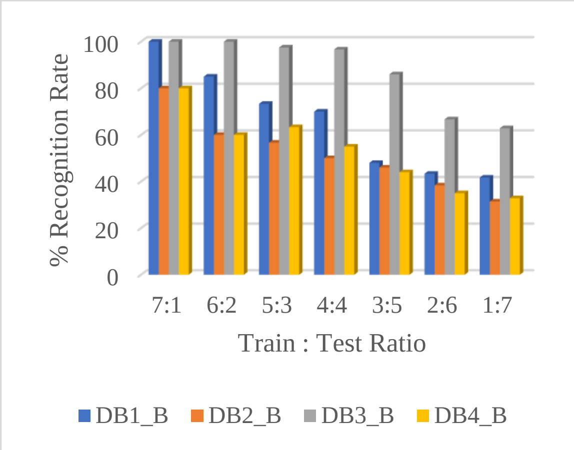

Figure 18. Variations of PRR with fingerprint databases for different combinations of train and test images

4.3 Proposed method performance comparison with existing approach:

The result of proposed method is compared with the existing methods presented by Uttam U et al., [21], Yanglin Tu et al., [22], Kittiya Khongkraphan [22], and Shan Juan Xie and Yanshuang Zhang [23] based on PRR given in Table 3. The value of PRR is high in the case of proposed method compared to existing methods since the feature extraction technique is the combination of HE, DWT and GIST.

Table 3. The PRR comparison of proposed method with current methods

Sl No.	Authors	Year	Technique	PRR
1	Uttam U et. al., [20]	2020	local minutia-based Convolution Neural Network	85.00
2	Yanglin Tu et. al., [21]	2020	Fingerprint ridges with cubic Bezier curve fitting	92.77
3	Kittiya Khongkraphan [22]	2019	Multiple minutia Points and ridge orientation features	96.88
4	Shan Juan Xie and Yanshuang Zhang [23]	2016	Pixel-based precision in determining the position of reference point without complex enhancement	98.63
5	Proposed Method	2021	Histogram Equalization in preprocessing, DWT and GIST for features	100

The advantages of the proposed method are as follows

(i) Histogram Equalization on fingerprint image enhances the quality of an image.

(ii) The DWT is used to separate out high and low frequencies. The high frequency component bands, which may have, consists of noise are ignored and considered only low frequency band with less dimensionality.

The GIST concept is used to obtain less number of final features to increase speed of computation.

V. CONCLUSION

In this paper fingerprint recognition based DWT and GIST features is proposed. The HE technique is used to enhance contest level of fingerprint images. The DWT is used on HE image to obtain low and high frequency bands. The low-frequency LL band with significant information is considered. The GIST concept is used to obtain features to classify fingerprint images using SVM for fingerprint recognition. It is discovered that the performance of the proposed method is better than the current methods. In future the deep learning technique is used for large fingerprint database in place of SVM.

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