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Efficient Low Dimensional Face Recognition Method based on Salient Features builtby GIST in Conjunction with DWT

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ABSTRACT

The wearable technologies coupled with biometrics, are used to detect human beings effectively and also address their health issues. In this research paper, we propose a novel face recognition scheme termed Discrete Wavelet Transform (DWT) multiscale GIST (DWT-GIST) feature extraction with fewer number of effective features to escalate speed of the biometric system. The original face images of various datasets with different sizes are converted into uniform size and DWT is used to convert spatial domain into frequency bands. The low frequency band of DWT, which is one fourth dimension of the original face image is considered and further processed by using GIST to derive final low dimensional salient features.The K-Nearest Neighbors (K-NN) algorithm through seven distance equations are used to test and authenticate the face recognition system. The recognition rates of the proposed method are very promising and betterlikened to current methods.
Keywords: Biometrics, DWT, Face Recognition, GIST, KNN

1.INTRODUCTION

Human recognition based on biometric identification uses the physiological and/or behavioral characteristics of human beings, which provides advantages over an existing traditional method such as password, PIN, and ID cards. The physiological biometric traits such as fingerprint, iris, face, palmprint, are almost constant at least for one decade. The behavioral traits such as gait, signature and voice, are not constant and depends on the mood of a person and surrounded environment. The biometric systems have been established their superiority in terms of recognition accuracy and robustness. Face recognition is anenergetic research area in machine vision for its incredible demands in biometrics. The deviations introduced by varying facial quality due to difference in illumination, expression disparities, emotional feelings, ageing, facial hair, image resolution, head pose, existence of noise etc., are vital and challenging problems in the face recognition research and may degrade the performance of a face recognition system significantly.

The effective face recognition is a step-by-stepprocess, including preprocessing, feature extraction and matching. The process of converting a color image to a grayscale image, image compression, image resize, noise removal is included in the preprocessing. Also preprocessing stage is vital and necessitates the proper selection of filters to improve the quality of face images. The spatial domain, transform domain and hybrid domain technics are used in feature extraction. The union of many features will improve the accurateness of face recognition systems in its placeby using only one kind of feature.Multiple feature sets are combined in a cascade or parallel to obtain effective features for the accurate face recognition system. However, this leads to high dimensional features, which intern increase delay in identification of human beings inthe larger size database. The better compression technics are required in feature extraction section to reduce the number of features to increase identification of human beings for the larger size database.In matching section, the distance formulae and classifiers are used.An advanced technology coupled with biometrics deployed face recognition technique in almost all electronics-based applications for security issues by authenticating face images of human beings. The real time applications are national safety, military safety, entree control, video surveillance, wireless mobile communication, video analytics, Bank transactions, cloud computing, big data analytics and human interaction with machines securely.

In this research paper, we proposed efficient face recognition system using features extracted by cascading DWT and GIST techniques. The dominant and effective LL band coefficients, which has one fourth dimension of the original face image are considered as initial features. The GIST technique is used on initial features to obtain final features with a smaller number of coefficients, which reduces delay in identification of human beings. In the matching section, the KNN technique is used to compute performance parameters on comparing test images with database images.

This paper is arranged as follows; section 2 briefly presents the literature survey on existing face recognition techniques. The proposed method and algorithm are discussed in sections 3 and 4. In section 5, the investigation results are discussed. Finally, section 6 presents the conclusion and future expansion.

2. LITERATURE SURVEY

The existing recent related research papers most connected to our work proposed by many authors are considered and their research work are briefly described. Several researchers have presented face recognition techniques by concentrating on feature extraction methods.
Nhat and Hoang [1] proposed canonical correlation analysis-based face recognition using concatenating different feature sources for coding a facial image. The techniques LBP, HOG, and GIST are examined for extracting facial features based on block division. Nguyen-Quoc and Hoang [2] employed fusion of HOG and GIST descriptors forfeature extractionfrom facial images.The canonical correlation analysis is used to combine two sets of features into a single feature set. The Fisher ranking is used to eliminate unrelated and noisy features. Siqi Yang et al., [3] proposed a cascaded face alignment based on global image descriptor GIST supervised initialization scheme. An additional training steps are notrequired, hence making the method low computational and easy to extract features. Kumar et al., [4] aimedSavitzky-GolayFilter (SGF), Discrete Wavelet Transform (DWT) and median filters to remove noise from facial images. The datasets used from extended Cohn-Kanade (CK+) database, ruined by several noises with fluctuating noise altitudes. Alobaidi and Mikhael [5] presented a sparse representation technique for face recognitionthrough ℓ 2 rule (SRFI). The featuresoftwo non-orthogonal domains viz., Discrete Cosine Transform (DCT), and DWT, were usedindependently or combined to obtain face recognition systems. A combined SRFI system isweight-based selected coefficients from the two domains, such as 2D DCT and 2D DWT. The highest recognition accuracy is obtained incombined SRFI compared to SRFI while amazinglydecreasing the storingdesires, and the computational trouble. Lahaw et al., [6] proposed the 2D-DWT for the image compression concept in the preprocessingsection. The ICA, PCA, and LDA techniques are used for feature extraction from LL sub-band.The SVM algorithms is used in matching section.
Saikia and Kandali [7] presented a frontal and non-frontal faces recognition in different illumination conditions and facial expressions. The symmetric Elliptical Local Binary Pattern (ELBP) and DWT areused for features extraction. The algorithm is validated using K-NN classifier.Kiani and Rezaeirad [8] usedDWT technique for face recognition algorithm, which compresses the face image.In matching section, the ergodic Hidden Markov Model (HMM) classifier is used for comparison of features.Zohra and Gavrilova [9] proposed an adaptive DWT based face recognition method.The Contrast Limited Adaptive Histogram Equalization (CLAHE) and Discrete Cosine Transform (DCT) are used to normalize regional illumination distortion.The low and high frequency facial features are extracted with the help of DWT at different scales. A fusion of the low and high frequency sub bandsis fusedwith weighted concept to increase the identification accurateness under fluctuatingilluminationcircumstances. The fuzzy membership function is used to select the fusion parameters.Fahima Tabassum etal., [10] proposed face recognition algorithm with the mixture of DWT and machine learning. The features are extracted based on the coherence of DWT shared with four algorithms viz., error vectors ofPCA, eigenvectors of PCA, eigenvectors ofLinear Discriminant Analysis and Convolutional Neural Network.The obtained fourresults are combined using entropy of detection probability and Fuzzy system.Vishwakarma et al., [11] proposed face recognition system by extracting the normalized face images features byusing DWT and DCT techniques. The DWT and DCT Combination is used to avoid redundancy and extracting the global features of the face images.

3. PROPOSED METHOD

The face identification system authenticates the given probe face image by comparing the features of probe image with features of millions of facial images in the stored face database. The efficiency of the system depends upon effective features and the speed of the system depends on a number of features. The number of features may increase the recognition rate;however, the speed of the system reduces, hence the system has to be developed keeping number of features in control. The main objective of this research is to introduce an approach of lower dimensional features for the efficient face recognition system to enhance recognition speed of computation using DWT and GIST techniques.

3.1 Face image Datasets

The benchmarkedface databases such as YALE, ORL and JAFFE are used to experiment and authenticate the projected model.

3.1.1 YALE Dataset:

This dataset has face images of fifteen peoples with eleven face image samples per individual. Face image samples of everyindividualwere captured withdifferent expressions overspectacles, without spectacles, center-light, left-light, right-light, having moments of happy, sad, normal, sleepy, surprised, wink. The face images of a single person are given in Figure1 andthe dimensions of each face image are320x243 with the GIF format.

Figure1 Face Image samples of Yale database [12]

3.1.2 Olivetti Research Laboratory (ORL) Dataset:

The face image database was created between 1992 and 1994. The dataset has 40 persons and ten face image samples per individualwith the facial image format of PGM and each image dimension of 92x112. Ten image samples of every individual are given in Figure 2.The unrelatedfacial expressions such as open/shut eyes, laughing/not laughing, with/without glasses, changing lightening conditions of single people are captured. A shady background with upright frontal and slight tilt of the head positions are considered while capturing every image.

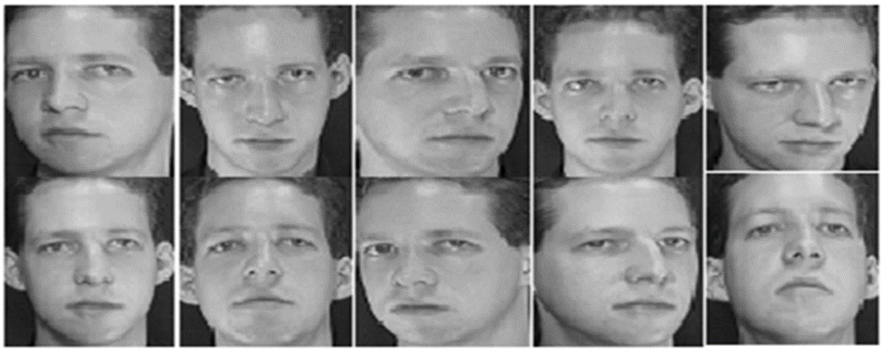

Figure2. ORL face image samples of single people [13]

3.1.3 Japanese Female Face Expression (JAFFE):

This dataset has ten people withtwenty distinctive pictures per individual.Seven enthusiastic facial emotions of every individual with an upright, frontal positions are captured as shown in Figure 3. The measure of each picture is of grayscale with 256 x 256 and tiff image format.

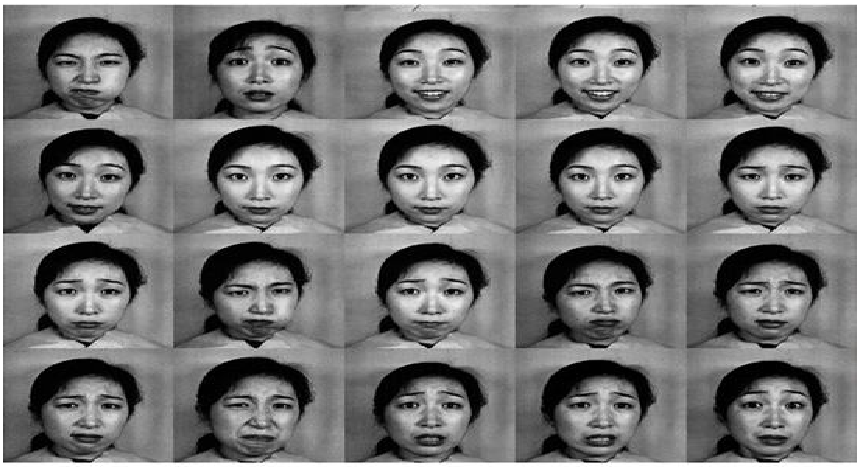

Figure3. Face Image samples of JAFFE dataset [14]

3.2 Preprocessing

The face images of several datasets with dissimilar sizes are rehabilitated into even dimensions of 90x110 and also color images are changed into grayscale images.

3.3 Discrete Wavelet Transform (DWT)

This is a transform domain technique used to reduce noise and compress face image dimensions based on frequency bands. An image parallelly passed throughlow and high pass filters recursively to derive bands with frequencies of low and high values.The original face image is converted into four image bands and are belongs to the approximation and the detailed bandimages. Only one sub-band image corresponding to approximation band is formed after passing through two low pass filters and is named as Low-Low (LL) band, which has substantial information about the original face image. The detailed bands of an original image have 3 bands consists of insignificant edge information of the original image and are named as Low-High (LH), High-Low (HL), High-High (HH). The LH band is formed after passing the original image through low and high pass filters, which has the vertical edge information. The HL band is formed after passing the original image through high and low pass filters, which has the horizontal edge information. The HH band is formed after passing the original image through two high pass filters, which has the diagonal edge information.

The transformationpermits an investigation in both spatial and frequency domains, giving an evidence on the development of the frequency content of animage over spatial domain. More likely, thenoise presentin high-frequency bands of DWT [15] and the noise is eliminated by discarding high frequency bands [16].The two-dimensional DWT is used on preprocessed face images of size 90x110 for de-noising and decrease the dimensionality of face images to decline computation time in extraction of features. The DWT algorithm separated the image into four bands of sizes 45x55, which is one fourth the size of the original face image as given in the Figure 4.

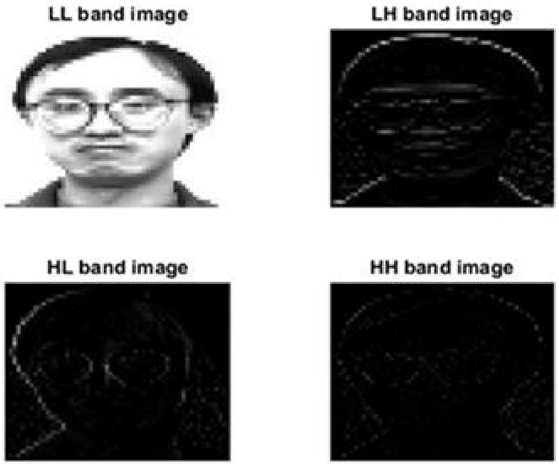

Figure 4. DWT Decomposition of face image

3.4 GIST descriptor

The storage of high dimensional face image featuresof billions of face images is impractical with an uncompressed manner. The technique of GIST [17, 18, 19] recently received growing attention in the framework of a face recognition system with a few numbers of features in the compressed manner. Theperceptual research has confirmed that human beings can grasp the *gist*of any image by looking at it for a littletime [20], which leads to GIST technique. Siagian and Itti's [21] proposed Context-based approaches for a whole image and extract a low-dimensional feature that compactly summarizes the statistics of an image. The GIST feature extraction method is visual salience feature map construction and are created based on visual features such as intensities, colors, and orientations [22]. Oliva and Torralba [23]proposed envelope of spatial domain as a low dimensional representation of scene images. The dominant spatial structures of face images which are meaningful to human observers considered are five perceptual dimensions such as naturalness, openness, roughness, expansion, ruggedness. The GIST features in our method are computed by convolving the LL band of DWT with 8 orientations at 4 different scales of 32 Gabor filters to produce 32 transfer functions.The imageis divided into a 4x4 grid and calculate the average energy of each division resulting in 32x16 = 512 features. The GIST concept improves the recognition rate of face recognition systems with significantly reducing the number of features.

3.5*K-Nearest Neighbors (K-NN) algorithm*

This issupervised machine learning (ML) algorithm which is used to decide both classification and regression problems [24, 25]. It is trained with the final GIST features of face image datasets. The value of *K* is an integer of nearest data points of face dataset features stored from the query face image features. In our algorithm,the value of *K* is initialized as oneand compute the distance between query face images and each stored dataset face image using the distance methods like Euclidean, Manhattan, Correlation, Minkowski (order = 0.5), Sum of squared distance (SSD), Cosine, and Spearman as given in equations 2-8.

1. Euclidean (a,b) = $\sqrt{\sum_{i=1}^{n}(ai-bi)^2}$ -- (2)
2. Manhattan (a,b) = $\sum_{i=1}^{n}|ai-bi|$-- (3)
3. Minkowski (a,b) = $(\sum_{i=1}^{n}|ai-bi|^p)^{\frac{1}{p}}$ --- (4)

where *p* is order

4. Correlation (a, b) = $\frac{Cov\,(a,b)}{\sigma a\ \ \sigma b}$ ---(5)

where Cov is Covariance matrix and σ is standard deviation

5. Sum of squared difference (SSD) (a,b) = $\sum_{i=1}^{n}(ai-bi)^2$ -------------------------(6)
6. Cosine distance (a,b) = $1-\frac{\sum_{i=1}^{n}ai\times bi}{\sqrt{\sum_{i=1}^{n}ai^2}\times\sqrt{\sum_{i=1}^{n}bi^2}}$ -------------------------------------(7)
7. Speareman distance (a,b) = $1-\frac{6\sum_{i=1}^{n}(rank(ai)-rank(bi))^2}{n(n^2-)}$ ----------------------- (8)

4. PROJECTED ALGORITHM

Problem definition: The biometric system is developed to identify effectively human beings based on face images with the lower dimensional GIST technique on DWT features is given in table 1 to decreasethe complication of an algorithm and computation time.

Objectives: The biometric face recognition system is developed using salient features with the objectives of decreasing number of the final features and increasing recognition rate using the DWT, GIST and KNN classifier for different amalgamations of training and testing face image ratios using various distance methods.

Table 1. Projected Algorithm

Input: Face image datasets **Output:**Recognition rate of face identification biometric system 1. Various benchmarked face image datasets are considered to validate the algorithm. 2. The pre-processing method is used to convert RGB face images to grayscale images and dissimilarface image dimensions are converted into a uniform dimension of 90x110. 3. The DWT is appliedto pre-processed face images to de-noise and compress to one fourth size of an original face image by considering the LL band of size 45x55. 4. The GIST features are calculated by convolving the LL band image with 8 orientations at 4 diverse scales of 32 Gabor filters to produce 32 transfer functions. 5. The image is divided into a 4x4 grid and calculate the average energy of each division resulting in 32x16 = 512 features. 6. The stored face image dataset features compare with query image featuresusing a KNN algorithm to identify human beings.

5. Experimental Result Analysis

The percentage Recognition Rate (RR) is the performance measure metric and is defined as the ratio of total number peoples matched appropriately to the total number of people in the training dataset, which is used to validate the proposed method for benchmarked face datasets viz., YALE, ORL and JAFFE. The %RR is calculated with the help of KNN classification technique using seven distance equations viz., Euclidean, Manhattan, Correlation, Minkowski (order = 0.5), Sum of Squared Distance (SSD), Cosine, and Spearman.

5.1 Result Analysis using YALE face dataset

The quantifiable % RR values are calculated by growing training ratio values from 50% to 90% and decaying testing ratio values from 50% to 10% using YALE face dataset. The %RR values for training and testing ratios of 50:50, 70:30 and 90:10 using a KNN with K=1 process through seven different distance equations is shown in Table 2. The % RR values rise as the percentage ratio of training valuesarises. The % RR is recorded as100 for training and testing ratio of 90% and 10% with all seven dissimilar distance equations. The low value of %RR is recorded withlow training and testing ratio of 50%and 50%. The computation of % RR using Minkowski distance equation yields a maximum average %RR value compared to other six distance equations. The low value of average%RR is recorded with Euclidean and SSD distance equations.

Table 2: Comparison of %RR values using diverse mixtures of training and testing ratios using YALE Face dataset

Distance methods	**% Recognition Rate**		
	Training=50%, Testing=50%	**Training=70%, Testing=30%**	**Training=90%, Testing=10%**
Euclidean	89.33	95.55	100
Manhattan	90.66	95.55	100
Correlation	89.33	97.77	100
Minkowski (order = 0.5)	90.66	95.55	100
Sum of squared distance (SSD)	89.33	95.55	100
Cosine	89.33	97.77	100
Spearman	88	97.77	100

5.2 Result Analysis using ORL face dataset

The quantifiable % RR values are calculated by growing training ratio values from 50% to 90% and decaying testing ratio values from 50% to 10% using ORL face dataset. The %RR values for training and testing ratios of 50:50, 70:30 and 90:10 using a KNN with K=1 process through seven different distance equations are shown in Table 3. The % RR values rise as the percentage ratio of training values arises. The % RR is recorded as100 for training and testing ratio of 90% and 10% with all seven dissimilar distance equations. The low value of %RR is recorded for low training and testing ratio of 50%and 50%. The computation of % RR using Spearman distance equation yields a maximum average RR value compared to other six distance equations. The low value of average %RR is recorded usinga correlation distance equation.

Table 3: Comparison of %RR values using diverse mixtures of training and testing ratios using ORL Face dataset

Distance methods	**%Recognition Rate**		
	Training=50%, testing=50%	**Training=70%, testing=30%**	**Training=90%, testing=10%**
Euclidean	97.5	100	100
Manhattan	97.5	100	100
Correlation	98.5	98.33	100
Minkowski (order = 0.5)	97.5	100	100
Sum of squared distance (SSD)	97.5	100	100
Cosine	98	99.16	100
Spearman	99.5	99.16	100

5.3 Result Analysis using JAFFE face dataset

The quantifiable % RR values are calculated by growing training ratios from 50% to 90% and decaying testing ratios from 50% to 10% using JAFFE face dataset. The %RR values for training and testing ratios of 50:50, 70:30 and 90:10 using a KNN with K=1 process through seven different distance equations are shown in Table 4. The % RR values rise as the percentage ratio of training values rises up to 100%. The % RR is recorded as100 for all combinations of training and testing ratios with all seven dissimilar distance equations. The variations in face images are very less, hence the results are very good with a 100% recognition rate.

Table 4: Comparison of %RR values using diverse mixtures of training and testing ratios using JAFFE Face dataset

Distance methods	%Recognition Rate		
	Training=50%, testing=50%	**Training=70%, testing=30%**	**Training=90%, testing=10%**
Euclidean	100	100	100
Manhattan	100	100	100
Correlation	100	100	100
Minkowski (order = 0.5)	100	100	100
Sum of squared distance (SSD)	100	100	100
Cosine	100	100	100
Spearman	100	100	100

5.4 Proposed method results are comparedwith existing method results on the ORL face dataset

The measurable percentage RR values of the proposed systemare compared tocurrentmethods presented by several authors viz., Catalin-Mircea Dumitrescu and Acad. loan Dumitrache [26], Rana JelokhaniNiaraki and AsadollahShahbahrami [27], Minghua Wan et al., [28], Sagar et al., [29], Swarup Kumar Dandpat and SukadevMeher [30], Pallavi D. Wadakar and MeghaWankhade [31], and Murugan et aI.,[32] are given in Table 5.The recognition rates of our method are very promising, a representation that the usage of the GIST approach along with DWT could be sufficient through lower dimensional features. The proposed face image recognition techniqueobtained the best performancewith effective, least number of salient features, which establishes the efficacy and feasibility of our technique.

Table 5. Comparison of proposed techniquewith existing techniques on ORL

Sl No	Authors	Year	Techniques	% RR
1	Catalin-Mircea Dumitrescu and Acad. loan Dumitrache [26]	2019	Combined Neural Networks and Global Gabor Features	98.75
2	Rana JelokhaniNiaraki and AsadollahShahbahrami [27]	2019	Co-occurrence Matrix of Local Median Binary Pattern	96.25
3	Minghua Wan et al., [28]	2019	Tri-direction 2D-Fisher Discriminant Analysis	96.50
4	Sagar et al., [29]	2015	Convolution + DWT	93.30
5	Swarup Kumar Dandpat and SukadevMeher [30]	2013	PCA and 2DPCA	90.50
6	Pallavi D. Wadakar and MeghaWankhade [31]	2012	DWT	90.00
7	Murugan et aI.,[32]	2010	Gabor filter + DWT + PCA	92.00
8	Proposed Method	2020	DWT, GIST, KNN	99.50

6 CONCLUSION

Efficient human recognition with face image biometric validation is the widespread methodology adopted in electronic gadgets, which are used in our day-to-day activities.This research paper proposed efficient, low dimensional face recognition system based on salient features, built by GIST in conjunction with DWT. The stored and query face images are preprocessed for uniform size and DWT is usedto convert images into the frequency domain by means of low and high pass filters. The low frequency band of DWT with reduced noise and low dimensional is considered prior to feature extraction. The GIST approach with Gabor filters is used to extract final effective features. The KNN classifier with seven distance equations is used to validate the performance of the system. The experimental results of the proposed technique revealed that themethodology is competently proficient of executinghuman recognition to achieve an enhanced recognition rate compared to existing methods. In future, the principal component analysis technique is combined with DWT before the GIST feature extraction approach to enhance further results.

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