A Singular Value Decomposition-based method for face recognition using a Daubechies Wavelet-HMM representation of faces

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Abstract

Face recognition is a natural, user friendly and non-contact way for human identification/authentication. Face recognizers are used in the recent years for identity authentication, access control, surveillance, human-computer interface and smart environments. This paper proposes a new method of face representation which is used for face recognition by quantized Singular Value Decomposition (SVD) coefficients with Wavelet Daubechies 2 (db2) to transform the faces to a more discriminated space and then Hidden Markov Model (HMM) is applied. The proposed method produced a significant improvement which includes a substantial improvement in recognition rate and reduces the delay. The system has been evaluated on the Olivetti Research Laboratory (ORL) face database. The system has been evaluated on different JPEG resized ORL database as 64×64, 128x128 and 256 x256. The proposed EWSVD-HMM method is compared with the traditional HMM-SVD. The results show that the proposed method is the fastest one, having approximately 95% recognition rate.

Keywords: Face recognition, Wavelet transforms, Support vector machines, Image recognition, Hidden Markov Model

I. INTRODUCTION

Face Recognition is the capacity to build up a man's character in light of facial attributes. One of the approaches to do this is by contrasting chosen facial highlights from the test picture and a facial database. Ordinarily, the face picture of a sample is coordinated to the display information by utilizing a balanced arrangement. The process of coordinating one-to-many or one to one are considered as validation and identification. Face is most usually utilized biometric to perceive individuals. Face acknowledgment has gotten significant consideration from scientists due to human exercises found in different uses of security like air terminal, criminal recognition, confront following, criminological and so on. Contrasted with other biometric characteristics like palm print, Iris, unique finger impression and so on. Hence, the face biometric is non- intrusive. They can be taken even without client's learning and further can be utilized for security based applications like criminal discovery, confront following, airplane terminal security, and legal reconnaissance frameworks.

As shown in the figure 1, the face recognition module has four units namely, face detection, face standardization, face feature extraction and matching. The face acknowledgment process can be worked in confront confirmation, confront recognizable proof and face watch. In confront check an inquiry face picture is analysed against a format confront picture whose character is being asserted. In confront distinguishing proof an inquiry confront picture is thought about against all formats in the database to decide the asserted character. In confront following and reconnaissance, confront pictures are followed and contrasted and the put away databases.

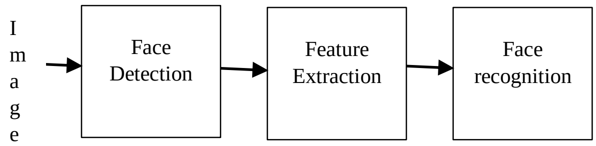

Figure 1: Face Recognition module

Face recognition includes catching face picture from a video or from an observation camera. They are contrasted and the put away database. Face biometrics includes preparing known pictures, order them with known classes and afterward they are put away in the database. At the point when a test picture is given to the framework it is arranged and thought about with put away database. Face biometrics is a testing field of investigate with different confinements forced for a machine confront acknowledgment like varieties in head posture, change in brightening, facial articulation, maturing, impediment because of extras and so forth.,. Different approaches were recommended by specialists in overcoming the impediments expressed.

Machine recognition of a protest, for example the face from a still photo or a video has been a testing undertaking for a very long while now. Although human, with relative effectiveness can perceive a face in jumbled landscapes, machine recognition is a substantially more difficult and threatening undertaking. Human– machine recognition framework approach is a dynamic and alive research field spread over a few regions, for example, computer vision investigation, picture analysis and preparing, design recognition and neural systems. Among such frameworks, confront recognition approaches have accomplished a more extensive scope of noteworthiness in the current past, as it has numerous considerable applications like, singular ID or validation, human-PC correspondence, security get to control and law-authorization, where it can be utilized for distinguishing criminals. In order to recognize a face the algorithms need to be implemented making use of particular software to meet the challenges.

Face acknowledgment is the main approach where the biometric information can be caught at a separation. Consequently the individual need not remain before the framework to catch the posture and sit tight for verification. This approach is unmistakable and unpretentious. It is reasonable and far reaching with regards to usage part. Hence, it is important to develop the classification strategy for face recognition.

The main intentions of this research is to develop or extend the traditional algorithms to make the face recognition accurately on large dataset. It discussed about various concepts of face recognition and its classification methodologies. The criteria considered here is to evaluate the performance of the proposed work that must follow the existing face recognition system. Implement the classification process by combining the proposed algorithm and test with recognition rate with the help of MATLAB simulations. Identify the particular person by selecting different pose (angle) of a same person. Select complex dataset for evaluating the proposed algorithm. To plan and create multimodal biometric authentication system with more precision and cost adequacy. The algorithm is to be perfectly designed to suite all the requirements and detect the face.

The scope of this research is to design an effective and secure technique for face recognition and also evaluate the performance of the designed algorithm by comparing the performance of previous face recognition system. The study also provides the high security mechanism in recognition system.

The remaining part of the paper is organized as follows: In section 2, the detailed survey is framed with the help of recent face recognition research ideas. Section 3, provides the methodology concept that states its algorithmic procedure and description. Section 4 provides the experimental results with respect to the objectives. Finally, the article is summarized under section 5 with some future suggestions.

II. Literature Review

Numerous methods and algorithms have been suggested by researchers. The accuracy of face recognition technique is affected by factors like variation in illumination, facial expression, scaling and perspective movement. It is important to note that Speeded-up Robust Features (SURF) extracted from a facial image are invariant to shifting, scaling and rotation. In addition to that they are also partially invariant to illumination and affine transformation.

Anand et al., (2016) suggested a facial recognition technique using SURF features and Support Vector Machine (SVM) classifier [1]. Above techniques has been tested on Yalefaces and UMIST face databases. Face recognition is one of the challenging problems in the area of pattern detection and recognition. It is practically applicable in different automated systems for security purpose, access control, public security, desktop login and many more. Due to vagueness and intricacy in face pattern, there need more exercise in order to enhance the quality of face recognition. For this purpose, Akbar et al., (2015) proposed a robust and reliable computational model for face recognition. In this model, two Transformation methods such as discrete wavelet transform (DWT) and discrete sine transform (DST) along with local based feature representation namely: local binary pattern (LBP) and local phase quantization are used to extract numerical features from face images. Irrelevant, noisy, and redundant features are eradicated using Minimum redundancy maximum relevance (mRMR). Various classification learners such as K-nearest neighbor (KNN), Support vector machine (SVM) and Probabilistic Neural Network (PNN) are utilized. SUMS facial dataset and 10-folds cross validation test are used to evaluate the performance of classification algorithms [2].

Sanjay, G. (2016) studied the face recognition model and its utilization of PCA and LDA in face recognition. Face recognition has become a field of interest in pattern recognition and artificial intelligence [3]. One of the vital steps involved in face recognition is that of 'Feature Extraction'. Feature extraction is imperative because handling data whose dimensions are inherently high, is rather a tedious process and therefore we adopt strategies for the purpose of dimensionality reduction. This process of studying data by reducing dimensions is called subspace analysis. Two such subspace methods are Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). PCA extracts the most significant components or those components which are more informative and less redundant, from the original data. While LDA is used to find a linear combination of features that characterizes or separates two or more classes in the data.

Wang et al., (2016) utilized an s-level decomposition on the basis of dual-tree complex wavelet transform (DTCWT), in order to obtain 12s "variance and entropy (VE)" features from each subband. Afterwards, we used support vector machine (SVM) and its two variants: the generalized eigenvalue proximal SVM (GEPSVM) and the twin SVM (TSVM), as the classifiers. In all, it proposed three novel approaches: DTCWT + VE + SVM, DTCWT + VE + GEPSVM, and DTCWT + VE + TSVM [4].

Local descriptors are widely used technique of feature extraction to obtain information about both local and global properties of an object. Here, we discuss an application of the Chain Code-Based Local Descriptor to face recognition by focusing on various datasets and considering different variants of this description method. Karczmarek et al., (2017) augmented the generic form of the descriptor by adding a possibility of grouping pixels into blocks, i.e., effectively describing larger neighbourhoods [5].

Current approaches have not obtained good results. Zhang et al., (2016) aimed to propose a new emotion recognition system based on facial expression images. It enrolled 20 subjects and let each subject pose seven different emotions: happy, sadness, surprise, anger, disgust, fear, and neutral. Afterward, it employed the biorthogonal wavelet entropy to extract multiscale features, and used fuzzy multiclass support vector machine to be the classifier. The stratified cross validation was employed as a strict validation model [6].

Duan et al., (2008) investigated the way, in which variations in illumination can influence the performances of some face recognition methods. Three different classes have been defined to grade the methods: the first is the shape from shading approaches, which extract the shape information of the face, from one or more of its views. The second one is the representation based method, which tries to get a characterization of the face invariant to illumination changes. The third one is the generative method, which produces a wide set of synthetic images containing as much variations as possible [7].

Learned face images are automatically extracted from 3-D head models that provide the expected positions of the components. These expected positions were employed to match the detected components to the geometrical configuration of the face. Guizatdinova and Surakka (2005) [8] presented a facial landmarks detection method. In this method, edge orientations were made use of to construct edge maps of the image. The estimation of the orientation of local edges was done with the help of a kernel with maximum response. The local oriented edges were extracted and put together into regions representing candidates for facial landmarks.

Sagar et al., (2015) proposed a novel technique of generating compressed unique features of face images which helps in improving matching speed of recognition [10]. The training face database samples are applied to 2D-DWT to obtain LL band features. The LL band features are subjected to normalization to scale the magnitude values in the range 0 to 1. The output of normalization is further convolved with the original face sample to obtain unique features. The convolved output is subjected to Gaussian filter to obtain smoothened image features.

Lu et al., (2017) proposed a simultaneous feature and dictionary learning (SFDL) method for image set-based face recognition, where each training and testing example contains a set of face images, which were captured from different variations of pose, illumination, expression, resolution, and motion [11]. Chen et al., (2017) examined the Preserving Projection (SPP) on feature extraction, the discriminant information was introduced into SPP to arrive at a novel supervised feather extraction method that named Uncorrelated Discriminant SPP (UDSPP) algorithm.

III. Research Methodology

The normal HMM algorithm is a class of numerical model which is utilized to describe the noticeable things of a signal. The HMMs include two steady process, namely hidden/ inconspicuous Markov chain with a limited number of states administered by a state change likelihood lattice and an underlying state likelihood dispersion. The arrangement of perceptions, characterized by the perception thickness capacities is related with each state. The HMM technique depends on coordinating the picture formats to a chain of conditions with a doubly-implanted stochastic model. This section traces the fundamental standards of HMMs and clarifies how they can be utilized for confront acknowledgment. The segments are sorted out as takes after: initial a general outline of HMMs is introduced, at that point some HMM applications in computer vision are quickly looked into lastly the proposed HMM-based design.

HMM are utilized for stochastic demonstrating of non-stationary vector time series. All things considered, they have a quick and evident application in speech processing, especially recognition, where the signal of intrigue is normally spoken to as a time varying arrangement of spectral gauges. In this way, a significant part of the advancement of HMMs in late years has been done inside the discourse region.

A. HMM Variants

Numerous applications and issues that utilization a concealed Markov demonstrate require more variations on the standard frame. The left-right or feel-forward model varies in its change framework: it isn't ergodic (few out of every odd state can be come to by each state in a limited number of steps). Its names originate from the way that each state in a requested arrangement of states it changes to is at an equivalent or higher request number than the past state. In this way the change lattice takes after a frame such like the accompanying, where each * is a positive likelihood: This is helpful for displaying a few sorts of signs that advance after some time. Another variation on the standard HMM is the utilization of invalid or epsilon changes. These assign certain changes, paying little respect to their likelihood, as not hastening discharge, despite the fact that the goal state can create a full range of outflows with various earlier states.

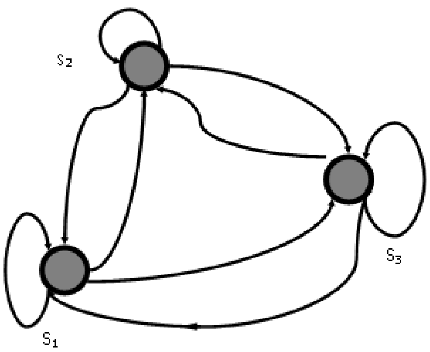

Figure 2: A Markov chain with 3 states

A stochastic procedure is a filed arrangement of irregular factors. When all is said in done, there can be a subjective reliance among the irregular factors. This procedure is portrayed by the joint likelihood mass capacity. Presently, consider a procedure that can be portrayed whenever as being in one of an arrangement of N particular states as represented in figure 1 (N=3). At any list of time, framework experiences a difference in state (potentially back to a similar state) as indicated by an arrangement of probabilities. A full probabilistic portrayal of the above framework requires particular of current state and every single past state. For the unique instance of first request Markov process this probabilistic portrayal is truncated to recently the present and past state.

$$P(q_t = S_j \mid q_{t-1} = S_i, q_{t-2} = S_k, \ldots) = P(q_t = S_j \mid q_{t-1} = S_i) \quad (1)$$

$$= a_{ij} \qquad 1 < i, j < N$$

Where qt is real state at time t and aij is the progress likelihood between state I and j. State progress coefficients have the property.

$$\sum_{j=1}^{N} a_{ij} = 1 \qquad (2)$$

A One dimensional (1D) discrete start to finish (Bakis) HMM was utilized to portion each face into states as appeared in Figure 3. The calculation for feature extraction appeared was utilized to produce the perception vector. Two dimensional Discrete Wavelet Transform (2D DWT) was used to disintegrate the picture into its estimate coefficients, level subtle elements, vertical points of interest and the inclining subtle elements. 'db1', one of the Daubechies group of wavelets was utilized for deterioration. The estimation coefficient was coded utilizing 256 dim levels along these lines creating a coded type of the first picture. The "coded" picture was separated into sub-pictures and the cover between progressive sub-pictures was permitted to be up to 5 pixels not as much as the aggregate stature of the sub-picture

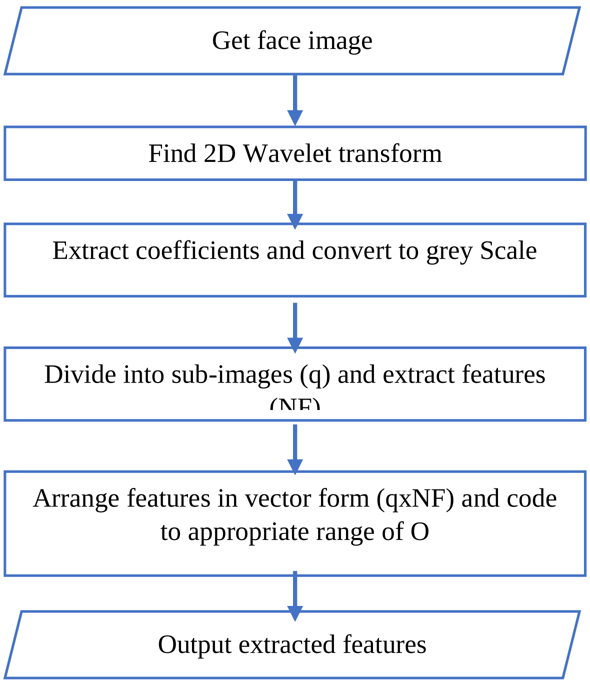

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Figure 3 Flow chart representation for face image feature extraction

Rabiner and Juang (1986) stated that the hidden Markov model is a variation of a limited state machine. Not at all like limited state machines, are they not deterministic [9]. A typical limited state machine discharges a deterministic image in a given state. Further, at that point deterministically changes to another state. Concealed Markov models do neither deterministically or maybe both change nor transmit under a probabilistic model. As per the figure 2 representation, the image is collected and processed by extracting the greyscale image and divide all the sub images. Finally, the output is achieved with the extracted features.

To produce the perception vector from each sub-picture, the two dimensional sub-pictures were changed over into a vector by removing the coefficients segment. The quantity of features chosen was fluctuated to see its impact on the acknowledgment capacity of the framework. From figure 4 it is noticed that the original greyscale image is separated into different matrix formats by top down approach.

Figure 4 Grey-scale version original image and its separation

Storing pictures in raw format waste spaces. Hence, one of the many available compression technique always follows the matrix format of image. The sample matrix is shown below.

$$\mathbf{A} = \begin{bmatrix} 2 & 255 & 2 & 255 \\ 10 & 200 & 200 & 100 \\ 50 & 100 & 50 & 2 \\ 2 & 50 & 150 & 200 \end{bmatrix}$$

B. 7-STATE HMM WITH SINGULAR VALUE DECOMPOSITION

The Singular Value Decomposition (SVD) has been a critical device in flag preparing and measurable information examination. Particular estimations of given information framework contain data about the commotion level, the vitality, the rank of the lattice, and so on. As solitary vectors of a framework are the traverse bases of the lattice, and orthonormal, they can show a few highlights of the examples inserted in the flag. SVD gives another approach to separating arithmetical highlights from a picture. A solitary esteem decay of an m×n lattice X is any capacity of the frame

$$X = U \sum V^T \tag{3}$$

Where, U(m×m) and V(m×m) are orthogonal matrix, and W is and m×n diagonal matrix of singular values with components.

A large portion of the face acknowledgment frameworks generally utilize pre-processing to enhance their execution. In the proposed framework as the initial step, we utilize a particular channel which specifically influences the speed and acknowledgment rate of the calculation. Request measurement channels are nonlinear spatial channels. Their operations are as per the following; a sliding window moves from left to right and best to down with ventures of measure one pixel, at every circumstance the focused pixel is supplanted by one of pixels of the window in light of the sort of channel. For instance least, greatest and middle of pixels of the window may supplant the focused pixel. A two dimensional request measurement channel, which replaces the focused component of a 3×3 window with the base component in the window, was utilized as a part of the proposed framework. It can just be spoken to by the following condition.

$$\hat{f}(x,y) = min_{(s,t)\in S_{xy}\{g(s,t)\}} \tag{4}$$

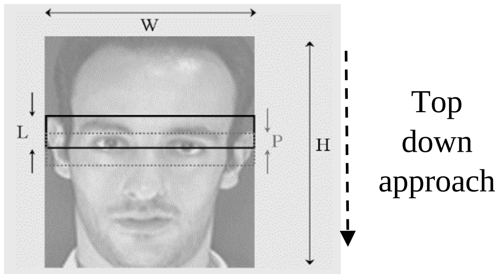


Figure 5: Face image separation

The SVD coefficients have intrinsically nonstop esteems. These coefficients manufacture the perception vectors. On the off chance that they are considered in the same constant sort, we will experience a limitless number of conceivable perception vectors that can't be demonstrated by discrete HMM. The combination of different face images are separated by input face image as shown in the figure 5. Daubechies wavelet of order 2(db2) made it more sufficient to detect changes of the signals. Therefore, the wavelet coefficients were computed using the db2. The frequency bands corresponding to different levels of decomposition for Daubechies wavelet of order 2 (db2) with a sampling frequency of 256 Hz .The discrete wavelet coefficients were computed using the MATLAB software. The feature selection is an important component of designing the pattern classification .since even the best classifier will perform badly if the features used as inputs are not selected well.

IV. Experimental Results

For evaluating our new method, we have used the ORL database. The ORL face database (developed at the Olivetti Research Laboratory, Cambridge, U.K.) is composed of 400 images with ten different images for each of the 40 distinct subjects. The variations of the images are across pose, size, time, and facial expression. All the images were taken against a dark homogeneous background with the subjects in an upright, frontal position, with tolerance for some tilting and rotation of up to about 20°. There is some variation in scale of up to about 10%. The spatial and grey-level resolutions of the images are 92 112 and 256, respectively. Five images from each individual are selected randomly for training and the five rest images are used for testing.

For implementing and testing the proposed algorithm, the image samples are resized into 64×64, 128x128 and 256 x256. These samples are tested in terms of training time, recognition rate, training time and recognition time. All the process carried out with the help of MATLAB simulations to test the proposed algorithm.

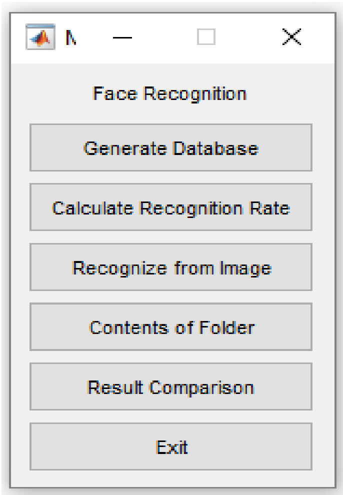
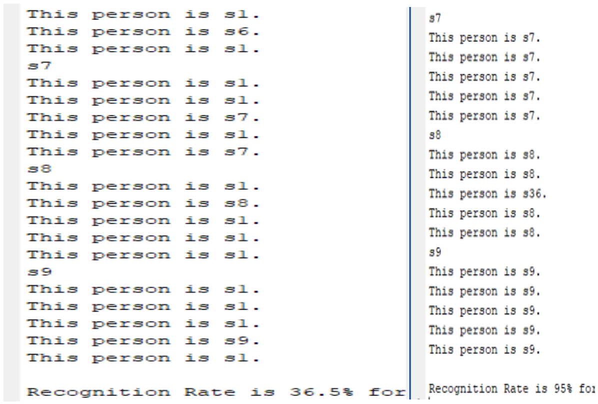


Figure 6: Main menu for face recognition process

Initially, the all the face image is processed from the database. The image recognition rate is displayed as per the classification accuracy. Figure 6 shows the overall flow of this research in MATLAB simulation window. Next, select the particular image from any one folder. For example, the folder s12 is opened manually and selected one image file.pgm file, which may be any attributes. However, the proposed method identifies the image and displays its name s12 with the recognition rate.



(a) Existing HMM-SVD (b) EWSVD-HMM

Figure 7: Command window

A quick and proficient framework was introduced. Pictures of each face were changed over to a succession of trails. Each square was highlighted by a couple of number of its SVD parameters. Each class has been related to cover up Markov show as its classifier. The assessments and examinations were performed on the ORL dataset. This was accomplished by resizing the pictures to littler size and utilizing few highlights portraying squares.

Table 1 Comparison chart with different parameters

Image Re-size	Methods	Training Time (seconds)	Recognition of an image (seconds)	Recognition period for 200 images (seconds)	Recognition rate (%)
64 x 64	HMM-SVD	48.43	3.422	28.38	97
	EWSVD-HMM	51.13	1.23	24.86	90.5
128 x 128	HMM-SVD	61.76	0.418	45.14	97
	EWSVD-HMM	54.59	4.297	31.17	96.5
256 x 256	HMM-SVD	75.43	5.3	76.03	36.5
	EWSVD-HMM	63.69	3.93	38.13	95

Miar-Naimi et al., (2008) followed HMM techniques for face recognition and its algorithm provides 84.2% as recognition rate. Table 1 provides the recognition rate of both existing and proposed module. The proposed system has the best recognition rate 95%, when the number of training images is resized to 256 x 256.

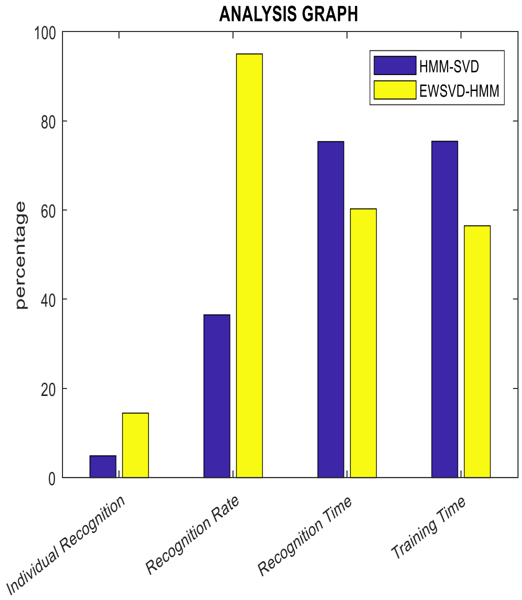


Figure 8: Comparison of HMM-SVD and Proposed EWSVD-HMM

The number of symbols required for proposed method is 860, which is minimum when comparing with the existing module symbol represented as 1260. Hence, the proposed method has several merits like minimum recognition time and symbols. The recognition rate is determined as 95 for the sample image re-sized value 256 x 256. The best outcome of the proposed method is achieved in all categories like recognition time for analysing single image is 3.93. Since, the existing module has the value of 5.3 seconds for processing a single image.

V. Conclusion

In this paper, the traditional HMM-SVD face recognition techniques have been analysed. The problem identified from the literature is stated that the unique face recognition method is a predominant innovation in the biometric advertise. The face recognition is implemented using the hybrid approach named as daubechies 2 (db2) SVD based Hidden Markov Model with multi-scaling of facial components concept for feature extraction. The Performance for traditional methods namely HMM-SVD and the proposed Enhanced Wavelet based HMM has been evaluated in terms of percentage of recognition at different variations. It is analysed for partial face images considering ORL databases. The face recognition rate increments with respect to the number of concealed layer nodes, since measurement of weight lattice increments with covered up layer hubs, which helps in reducing the preparing of weights. Proposed face recognition module is best suitable for low resolution face image detection. The experimental results proves that the proposed EWSVD-HMM module contains better results compared to the existing HMM-SVD method.

VI. Future Enhancement

Further, some neural networks are used to conquer the issue of face recognition with substantial information base also, Relevance Vector Machine (RVM) classifiers can be utilized to enhance the face recognition rate with high variety in posture.

References

[1]. Anand, B., & Shah, M. P. K. (2016). Face Recognition using SURF Features and SVM Classifier. International Journal of Electronics Engineering Research, 8, 1-8.

[2]. Akbar, S., Ahmad, A., Hayat, M., & Ali, F. (2015). Face Recognition Using Hybrid Feature Space in Conjunction with Support Vector Machine. J. Appl. Environ. Biol. Sci, 5(7), 28-36.

[3]. Sanjay, G. (2016). A Comparative Study on Face Recognition using Subspace Analysis. In International Conference on Computer Science and Technology Allies in Research-March (p. 82).

[4]. Wang, S., Lu, S., Dong, Z., Yang, J., Yang, M., & Zhang, Y. (2016). Dual-tree complex wavelet transform and twin support vector machine for pathological brain detection. Applied Sciences, 6(6), 169.

[5]. Karczmarek, P., Kiersztyn, A., Pedrycz, W., & Dolecki, M. (2017). An application of chain code-based local descriptor and its extension to face recognition. Pattern Recognition, 65, 26-34.

[6]. Zhang, Y. D., Yang, Z. J., Lu, H. M., Zhou, X. X., Phillips, P., Liu, Q. M., & Wang, S. H. (2016). Facial emotion recognition based on biorthogonal wavelet entropy, fuzzy support vector machine, and stratified cross validation. IEEE Access, 4, 8375-8385.

[7]. Duan, H., Yan, R., & Lin, K. (2008, November). Research on face recognition based on PCA. In Future Information Technology and Management Engineering, 2008. FITME'08. International Seminar on (pp. 29-32). IEEE.

[8]. Guizatdinova, I., & Surakka, V. (2005). Detection of facial landmarks from neutral, happy, and disgust facial images.

[9]. Rabiner, L., & Juang, B. (1986). An introduction to hidden Markov models. ieee assp magazine, 3(1), 4-16.

[10]. Sagar, G. V., Barker, S. Y., Raja, K. B., Babu, K. S., & Venugopal, K. R. (2015, December). Convolution based Face Recognition using DWT and feature vector compression. In Image Information Processing (ICIIP), 2015 Third International Conference on (pp. 444-449). IEEE.

[11]. Lu, J., Wang, G., & Zhou, J. (2017). Simultaneous feature and dictionary learning for image set based face recognition. IEEE Transactions on Image Processing.

[12]. Chen, Z., Huang, W., & Lv, Z. (2017). Towards a face recognition method based on uncorrelated discriminant sparse preserving projection. Multimedia Tools and Applications, 76(17), 17669-17683.

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