Dissertation on
DESIGN AND DEVELOPMENT OF AN IMPROVED FACE RECOGNITION SYSTEM

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of the requirements for the degree of

Master in Multimedia Development

Submitted by
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CERTIFICATE OF RECOMMENDATION

This is to certify that the thesis entitled "DESIGN AND DEVELOPMENT OF AN IMPROVED FACE RECOGNITION SYSTEM" is a bonafide work carried out by Pooja Banerjee under our supervision and guidance for partial fulfillment of the requirements for the degree of Master in Multimedia Development in School of Education Technology, during the academic session 2021-2022.

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<u>CERTIFICATE OF APPROVAL</u> **

This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactory to warranty its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted.

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I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of her Master in Multimedia Development studies.

All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by this rule and conduct, I have fully cited and referenced all materials and results that are not original to this work.

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EXECUTIVE SUMMARY

A face recognition system is a computer program that uses a digital picture to identify or verify a person. One method is t o compare chosen face traits from the picture with those in t he facial database.

Many research works have been done on face recognition system but there are also some challenges like the face direction, different face poses, illumination variations, presence and absence of spectacles, beard, moustache etc.

A new technique to human face recognition is suggested in this work. The proposed technique outperforms the traditional PCA method in terms of outcomes. It works with both colour and grayscale photos. As a pre-processing step for face recognition, a wavelet feature extraction approach is presented. It is feasible to accurately detect faces even if there are certain changes in the face by combining Principal component analysis with discrete wavelet transform (1-level). Hence, some of the challenges like face poses, presence and absence of spectacles, beard and illumination (in some cases), distorted images etc. are able to overcome and a good success rate is achieved.

Chapter 1

INTRODUCTION

The process of ascertaining if a user is who they claim they are is known as authentication. It is essentially a method of verifying digital identification, ensuring that users have the appropriate authorization to access or complete the activity at hand. The following primary types of authentication procedures can be classified:

- **Password Authentication:** User is required to type a valid password during login time.
- **Token-Authentication**: Devices, hardware and software that generates codes for logging in. The user also needs to type a PIN code.
- **Smart cards**: Can store personal information of customers through an embedded chip and can be used for user identification.
- **Biometrics**: Biometrics is the most effective method for reliably and quickly identifying and verifying people based on their unique biological traits.

1.1. Background Concepts

The terms 'bios' and ‘metron’ which mean "life" and "measure," respectively, relate to two distinct disciplines of study and application. The gathering, synthesis, analysis, and management of quantitative data on biological communities

like forests is the oldest and older definition employed in biological research. Biological statistics is how most people think of it. The definition of this word has lately been expanded to cover the study of strategies for recognizing humans individually based on one or more intrinsic physical or behavioral features.
There are two categories of biometric characteristics:

1) Physiological: These are linked to the body's form, such as DNA, fingerprints, face recognition, and retinal patterns.
2) Behavioral: These pertain to a person's actions, such as signatures, keystroke dynamics, and speech patterns. Although voice is a physiological attribute because everyone has a varied pitch, voice recognition is mostly focused on the study of how a person talks, hence it is often categorized as behavioral.
Our main focus is on physiological parameters, the most common of which is facial recognition.

DNA: DNA is a nucleic acid that holds the general instructions that all living creatures utilize to develop and function. The major function of the DNA molecule is to store information for a long time. Because it carries the instructions for constructing other components of the cell, such as protein, DNA is sometimes compared to a collection of blueprints. Genes are DNA segments that convey this information. DNA is a lengthy polymer of simple units called nucleotides containing a sugar and phosphate group in its backbone. Each sugar has one of four types of molecules called bases attached to it. Information is encoded by the sequence of these four nucleotides along the backbone.

Fingerprint Recognition: A fingerprint is an imprint of the friction ridges on all or part of the finger. A friction-ridge is a raised area of the palm and finger skin. Fingerprints can be created by ink or other pollutants transmitted from the skin to a smooth surface, or they can be made by natural secretion from a gland under the skin. Friction ridge analysis is based on the notion that friction ridges are permanent and distinct. Even identical twins have unique fingerprints. The act of comparing a questioned and known skin imprint to see if they are from the same finger or palm is known as fingerprint recognition.

Facial Recognition: A facial recognition system is a computer program that automatically recognizes or verifies a person based on a digital image. Comparing chosen facial features from the image and the facial database is one approach to do this. It's commonly found in security systems and can be likened to other biometrics like fingerprint or eye-iris recognition. Eigen face, Fisher face, the Hidden-Markov model, and neural motivated dynamic link matching are all popular recognition algorithms. Every human face is distinct and contributes to one's own identity. For self-recognition, the face is one of the most important elements of the body. The primary functions of the face include vision, hearing, olfaction, feeding, and breathing.

Furthermore, the face is the most visible part of the body. Researchers have found that our brows are actually some of the most important features of our face.

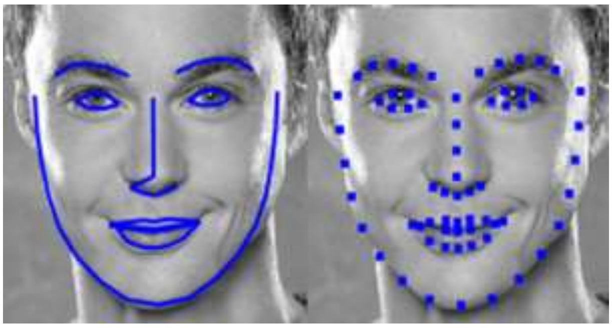


Fig 1: Human face with all the features

1.2. Problem Statement

To recognize a person (with distinct face poses or varying illumination, etc.) from digital images.

1.3. Objectives

- From the existing approaches studied, creating a better facial recognition technique.
- Designing a system which is improved with better algorithm.
- To recognize faces even if some changes occur in the face such as growing beard, moustache or presence and absence of spectacles.
- To recognize different face poses and find the best match.

1.4. Challenges

- Illumination variations.
- Presence or absence of accessories or beard or moustache on face.
- Change of pose
- Change of Facial expression
- Fontal vs distinct poses

1.5. Applications

- Video surveillance
- Identification of criminals
- Authentication
- Security system

Chapter 2

LITERATURE SURVEY

In this survey, the foremost advanced face recognition techniques planned in controlled or uncontrolled environments square measure reviewed mistreatment totally different databases. There will be 3 styles of approaches [1] like native, holistic and hybrid approaches. The primary approach is assessed consistent with sure face expression, without considering the entire face. The second method uses the entire face as a computer file, which is then placed in a small topological space or a correlation plane. The third method improves facial recognition accuracy by combining native and international alternatives. Native techniques to face recognition only consider a subset of facial expressions. They're extremely sensitive to facial expressions, occlusions, and the origin of [1]. The main goal of these approaches is to come up with unique options. These approaches will be classified into two types in general: (a) approaches that are based on a person's natural appearance The facial image is broken into tiny sections (patches) and isn't going to extract native options [2,3]. (b) Key-points-based techniques square measure won't to notice the points of interest within the face image, when that the options localized on these points square measure extracted.

Based on outward appearance, a geometrical technique, often called a feature or analytic technique, is a type of geometrical technique. The face image is described in this situation by a collection of different vectors with small dimensions or small areas (patches). To come up with a lot of details, native appearance-based strategies focus on vital aspects of the face such as the nose, lips, and eyes. In addition, it considers the quality of the face as a natural form when detecting and using a limited set of characteristics. Moreover, element orientations, histograms [4,5], geometric features, and correlation planes [3,6,7] are used to define the native options.

- LBP (local binary pattern) and variants: LBP could be a good all-around texturing approach for extracting options from any object. It is employed in a variety of applications, including face recognition [3], facial expression identification, texture segmentation, and texture classification.

  A quick face recognition technique based on LBP, PLBP and rotation invariant native binary pattern (RI-LBP) is provided by Khoi et al. [8]. To extract gradable representations of information, Xi et al. [9] presented a new unattended deep learning-based technique known as native binary pattern network (LBP Net). Because of the convolutional neural network, the LBP web maintains a similar structure (CNN). According to experimental results obtained using open benchmarks (LFW and FERET), LBP web corresponds to a variety of unattended techniques.

Laure et al. [10] devised a procedure for resolving face recognition issues involving large fluctuations in factors such as expression, illumination, and wholly distinct positions. The LBP and K-NN procedures are the foundations of this methodology.

Since it is resilient to rotation of the target image, LBP has become one of the most vital approaches for face recognition.

A "multiscale native binary pattern (MLBP)" variant of the LBP approach is proposed by Bonnen et al. [11] for feature extraction. The native ternary pattern (LTP) technique is another LBP variant. Compared to the original LBP method, it is less noise-sensitive. This method employs three processes to determine the differences between neighbouring elements and, as a result, the core element. For face illustration, Hussain et al. create an area quantity pattern (LQP) approach. LQP is a generalisation of native pattern options that is inherently resistant to lighting conditions. The LQP options use ternary split writing to create a mix of binary codes by sampling local pixels using the disc layout.

- Histogram of Oriented Gradients (HOG) histogram [12]: One of the most fundamental terms for describing form and edge is the HOG. The HOG approach will be used to explain the distribution of edge direction or intensity gradient in the face form victimization. This method involves dividing the complete face picture into cells (small regions or areas). It creates a bar chart of element edge direction or direction gradients for each cell and finally, combining the histograms of all cells for extracting the features of the facial image. The HOG descriptor computes the feature vector as follows [4,5]: To begin, the original image is divided into cells and computed the amplitude of each cell's first-order gradients in both the horizontal and vertical directions.

A trustworthy face recognition system was developed by Karaaba et al. [12] using a unification of various histograms of oriented gradients (HOG). This procedure is referred to as "multi-HOG." The key-points-based strategies are used to look for certain geometric possibilities based on few geometric information on the face surface (e.g., the space between the eyes, the breadth of the head). Two crucial processes, key-point detection and have extraction, are detailed in these strategies [2,13,14]. The primary step examines the performance of the detectors of the facial image's key-point alternatives. The second step focuses on illustrating the knowledge by using the face image's key-point alternatives. Scale invariant feature rework (SIFT), binary sturdy freelance elementary options (BRIEF), and speeded-up sturdy options (SURF) strategies are often used to characterise the feature of the face picture, even though these techniques will fix the missing components and occlusions.

- SIFT (Scale Invariant Feature Transform): SIFT is an algorithmic program that examines a picture's natural choices. The algorithmic software is broadly used to connect two images using their native descriptors which holds the information that allows them to be matched. The SIFT descriptor's main goal is to turn the image into an artwork made up of points of interest. The information about the face image is stored in these locations. SIFT demonstrates unchangeability in terms of scale and rotation. SIFT is commonly used these days and is rapid, which is vital in time applications. But one of its shortcomings is the time it takes to match the essential points. The algorithmic programme has four steps: a) Finding the most and least points inside the space-scale, (b) finding characteristic points, (c) assigning orientations, and (d) describing the distinctive purpose are all included. L. Lenc et al. [15] proposed a framework to monitor the key-points supported by the SIFT descriptor in which the SIFT technique in conjunction with a Kepenekci strategy is applied for face identification.

- Speeded-up robust features (SURF) [22]: the SIFT served as a model for the SURF technology. But instead of using wavelets as an approximation of the Wellington determinant, it employs wavelets as an approximation of the Wellington determinant to achieve higher performance. In comparison to the SIFT descriptor, SURF could be a detector and descriptor that claims to achieve similar, if not better, results in terms of repeatability, differentiation, and lustiness. The most significant advantage of SURF is its execution time, which is significantly less than that of the SIFT descriptor. The SIFT descriptor is also tuned to explain faces that are affected by lighting, scaling, translation, and rotation [22]. SURF tries to make the most of Associate in Nursing approximation of the Wellington matrix by utilising integral images to substantially reduce the process method duration.

Holistic or mathematical space techniques are thought to method the entire face, i.e., they do not require the extraction of face areas or choices points (eyes, mouth, noses, and so on). The most frequent of these ways is to represent the face image as a pixel matrix, which is then split into feature vectors to make treatment easier. Following that, these feature vectors are enforced in a low-dimensional space. Holistic or mathematical space procedures, on the other hand, are sensitive to variations (facial expressions, illumination, and positions), and these advantages help to make these approaches popular. Furthermore, these methodologies can be classified as linear or non-linear procedures, depending on the strategy used to represent the mathematical space. Eigenfaces (principal element analysis; PCA) technique, Fisher faces (linear discriminative analysis; LDA) technique, and freelance element analysis are the most popular linear techniques for face recognition systems (ICA).

- Eigenface and principal component analysis (PCA) [16,17]: Eigenfaces is one of the most widely used holistic methods for extracting choices points from a face image. The principal element analysis (PCA) technique is used in this method. The main components produced by the PCA technique are known as Eigenfaces or face templates. The PCA technique reduces a large number of likely related factors to a small number of erroneous variables known as "principal components." The goal of PCA is to lower the large spatiality of the information area to the smaller intrinsic spatiality of feature area (independent variables) which is required to economically describe the information. PCA calculates the variance matrix's Eigenvectors and applies the initial knowledge to a lower-dimensional feature region outlined by eigenvectors with large eigenvalues. PCA has been used in face identification and visualisation, where the derived eigenvectors are referred to as eigenfaces. PCA and LDA square measure two fundamentally different feature extraction methods that are used to extract facial expression. To classify facial expressions, riffle fusion and neural networks are used. For analysis, the ORL information is used.

- Discrete Wavelet Transform (DWT): Another method of facial recognition that is linear is DWT. A new patch strategy and a two-dimensional distinct riffle remodel (2D-DWT) technique is employed by the authors for face recognition. Two top-level high-frequency sub-bands of 2D-DWT are treated unfairly by using an integral projection technique, and a non-uniform patch technique is used for the commanding's low-frequency sub-band. It supported the usual image of all coaching samples. This patch approach is better for maintaining the integrity of native data and is more suitable for mirroring the structure feature of the facial image. The choice is made using the neighbour classifier after creating the fix strategy using the testing and coaching samples. Several datasets, including Faces in the Wild (LFW), Extended Yale B, Face Recognition Technology (FERET), and AR, are used to measure this technique.

- Improvements to the PCA, LDA, and ICA procedures: A variety of analysis techniques have been created to improve linear mathematical space techniques. To extract the face region and wear down noise variation, Z. Cui et al. [18] devised a brand-new spatial face region descriptor (SFRD) approach. The following is a description of this technique: Every face picture is divided into numerous spatial areas, and token-frequency (TF) options are extracted from each region by sum-pooling the reconstruction coefficients over the patches at intervals within each region. Finally, to extract the SFRD for face images, use a variation of the PCA technique known as "whitened principal element analysis (WPCA)" to reduce the feature dimension and remove noise from the leading eigenvectors. Furthermore, the authors in [19] devised a probabilistic linear discriminant analysis (PLDA) form of the LDA to seek out directions in areas with the best discriminability, and are thus best suited for both face recognition and frontal face recognition under varied conditions.

In the paper [20], a brand-new strong technique particularly WTPCA-L1 is planned for face recognition. 3 level riffle is employed because of the pre-processing step that minimizes the computation time of the PCA-L1 extraction method. Experiments are performed on 2 databases ORL and GTFD facial datasets and it offers a better recognition rate.

In this paper [21], human face recognition using PCA is done using Faces94 database. This project finally uses the PCA technique to acknowledge faces. So, it's known that the system with success acknowledges the faces as in step with the input provided thereto within the testing part. The potency achieved is 75.83%.

Chapter 3

PROPOSED METHODOLOGY

3.1. Motivation:

Already there are several works on face recognition, but also there are certain challenges and hence there is a huge scope of improvement. So, in this proposed approach my aim is to fill certain research gaps or challenges faced in recognizing the faces correctly.

3.2. Proposed Approach:

A face recognition scheme is implemented using the wavelet features. Wavelets are oscillations having amplitudes beginning from zero, increases or decreases, then back to zero. Wavelet coefficients are used to extract features from hyperspectral data. These extracted features are called wavelet features. The proposed scheme is very robust and capable of recognizing faces even if some changes occur in the face.

3.2.1: BLOCK DIAGRAM:

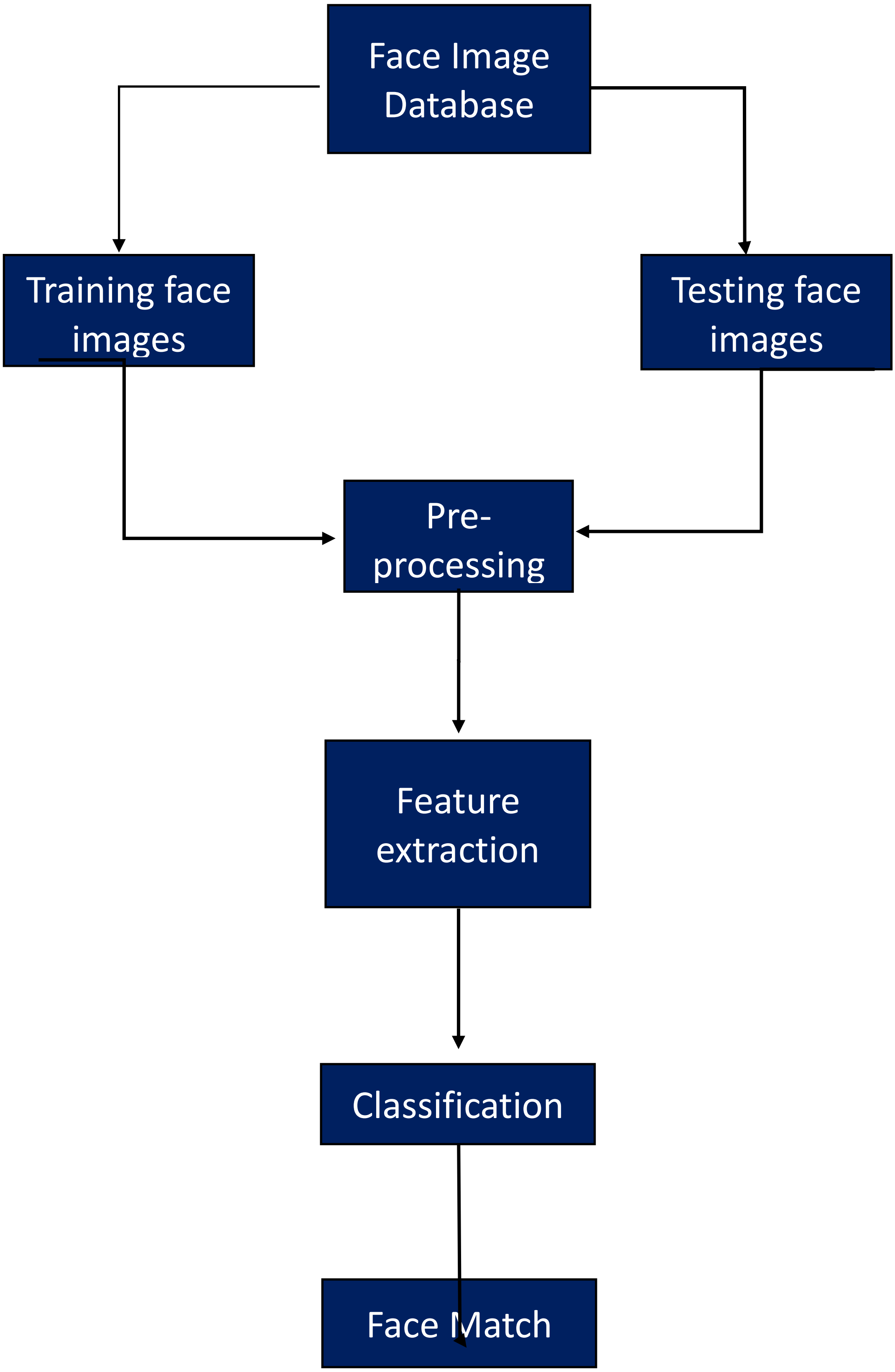


Fig 2.1: Generalised Block Diagram

Finding the wavelet features:

Here it is shown how to find the wavelet features that will be utilized for recognizing faces. At first the input image (93x112) is binarized to get the binary image. DWT of 1-level is performed to get the approximated coefficients(cA), Horizontal detailed coefficients(cH), Vertical detailed coefficients(cV), and detailed diagonal coefficients(cD). Here db10 wavelet is used. We get the row-wise and the column-wise standard deviation to get these features. Combining the row-wise (stdrow) and column-wise standard deviation (stdcol), we get the corresponding wavelet feature vector. The wavelet feature vector (fvsd) will be of the size 204. Because this dimension is too big, we need to reduce it to conserve memory space. Therefore, the principal component analysis (PCA) has been used to reduce this dimension. The image shown in the fig 2 is the basic algorithm for finding these features:

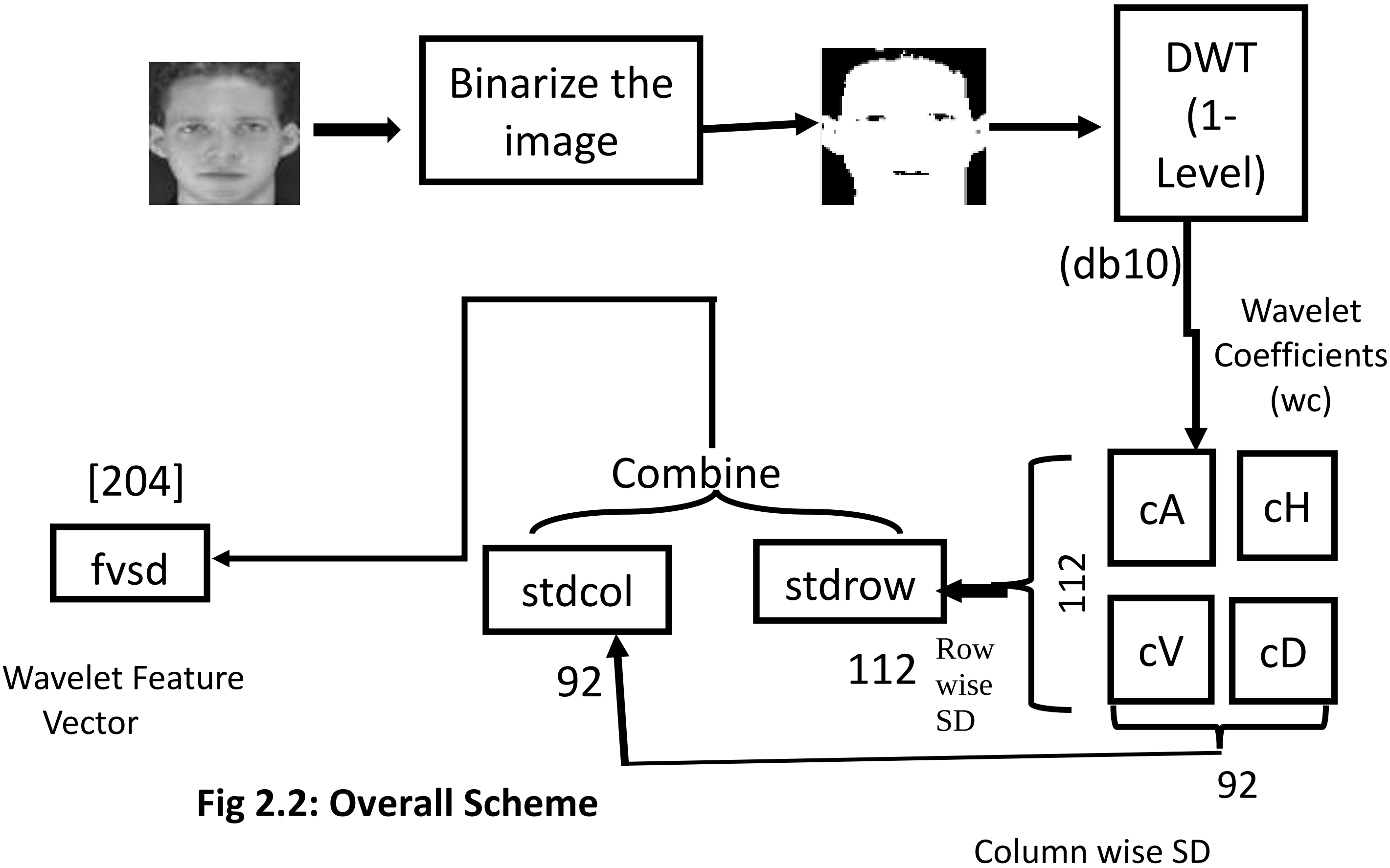


Fig 2.2: Overall Scheme

3.2.2. Face recognition algorithm using Eigen Values:

PCA is a dimension reduction approach that uses unsupervised machine learning. PCA reduces the number of variables in high-dimensional data while preserving trends and patterns. The steps involved in the algorithm are as follows:

- Step 1: to transform the acquired image to a grayscale image.
- Step 2:to compute the acquired images' Eigen values and mean.
- Step 3: determine the difference between each image and the mean.
- Step 4: Create a covariance matrix, calculate its Eigen value and Eigen vectors, then sort the eigen values in ascending or der before selecting the highest values.
- Step 5: Using Eigen faces, calculate Eigen values and identify projected train images.
- Step 6: Take the query or test image and repeat the first step for it
- Step 7: Reshape the image by combining it with the previously projected images.
- Step 8: Using the difference of picture and Eigen faces, determine the reshaped image's difference from the mean, and then determine the projected test image.
- Step 9: Calculate the Manhattan distance between the anticipated train and test photos. The Manhattan distance was chosen because it is more accurate than other classifiers.
- Step 10: Face recognition will be performed based on the shortest absolute distance, with the best match being displayed.

The general algorithm is shown below:

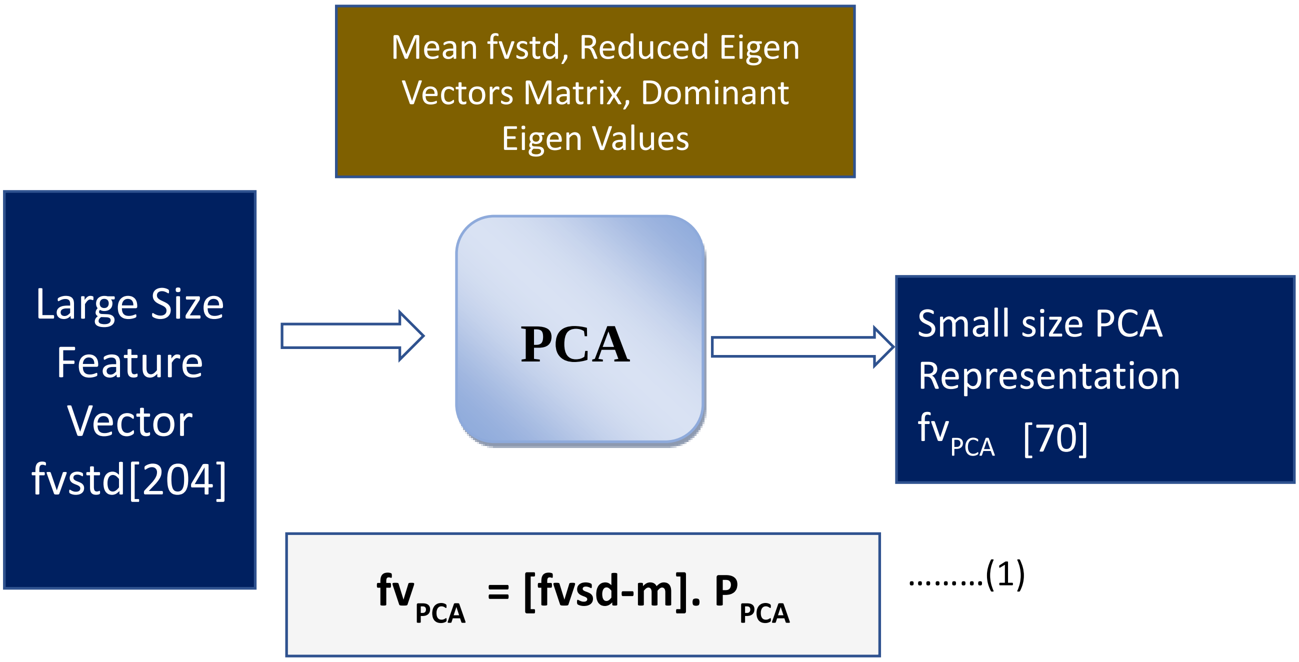


Fig 3: PCA Algorithm

Our large size feature vector is projected in the PCA space, giving a small size PCA representation. This PCA representation is the eigen values.

The general PCA formula is: $\mathbf{fv_{PCA} = [fvsd\text{-}m] * P_{PCA}}$ ....(2)

Where fvstd is the input feature of size M+N, m is the mean of all feature vectors, P_{pca} is the transformation matrix and fv_{PCA} is the reduced feature vector. Here d most dominant eigen values are taken and it can also be reduced.

Hence **fvsd is the feature vector** which is created by combining **the row-wise and column-wise standard deviation**. After that these feature vectors will be stored in matrix X.

3.3. Training and Testing Procedures

Now the Training part will be discussed briefly. The first step is to read all the images and to get their corresponding wavelet features (fvsd) of the size M+N where M and N are height and width of the image in pixels. It gives a matrix of (M+N) x n (where n=number of training images in dataset). This matrix is passed through the PCA space to get a matrix of d x n where d is considered as the dominant eigen values. Though the size of fvsd is not very large but still it will work faster after the use of PCA and will give a fast face search which will reduce the computation time.

A. Code for training is written in Appendix

The process of getting the wavelet features and projecting them into PCA space is shown in the figure below:

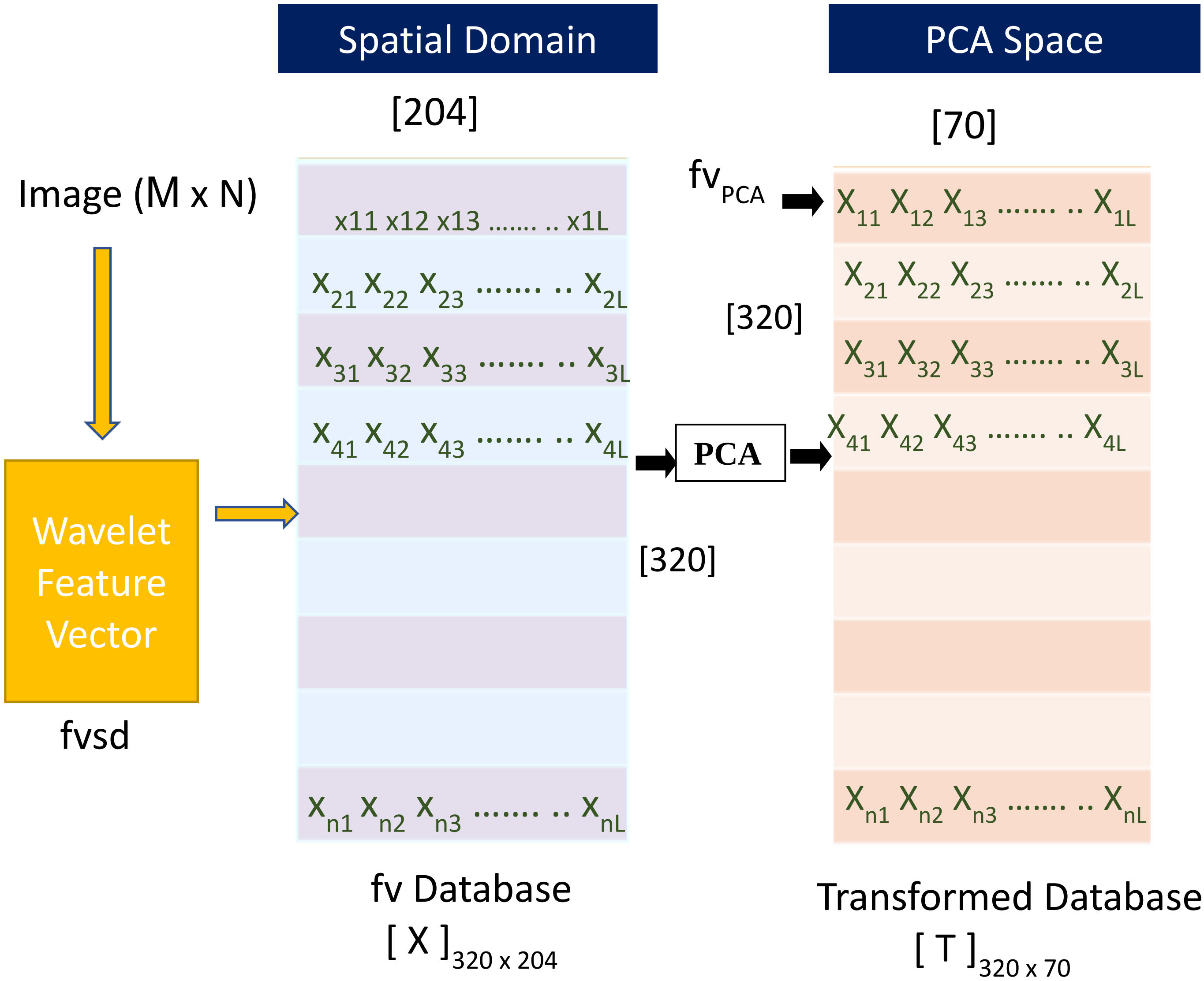


Fig 4: Training Procedure

In the training procedure, there are total n images in our folder and we have to read all the images. Then we have to find the wavelet feature vector by the method shown above and we get the fvsd vector whose size is (M+N). A matrix X is created whose size is n x (M+N) (size of each feature vector is

M+N). So, all the n images are converted to their corresponding wavelet feature vector whose size is M+N. Since this size of X is large, so it will require more memory and for searching it will require more time and thus to have the faster search and to have less memory, the PCA is utilized to reduce its size. This matrix is projected to PCA and the reduced size matrix is obtained. Therefore, X is transformed to matrix T whose size is n x d.

Now, the testing part will be discussed that means finding the nearest match. It is a simple process. Our aim is to search the nearest match for the query image. So first we have to find the wavelet feature vector whose size is 1x(M+N). Then the M+N sized feature vector is projected to PCA and it will be reduced to 1xd. This 1xd is represented by fvq that is the query feature vector.

B. Code for discrete testing is written in Appendix

Classification:

Now we have to match this fvq with the previously stored n feature vectors which we have just obtained by applying the PCA on all wavelet feature vectors of those n images. Then it will find the match sequentially and we will get the similarity on the basis of finding L1 distance (Manhattan distance). Obviously, the best match will be one where we will get the least distance between feq and fvpca. Euclidean distance can also be used as the classifier but the accuracy is not as expected. Other classifiers can also be used but the challenges faced were not solved fully compared to L1 distance.

The testing process is briefly shown in the figure 5.

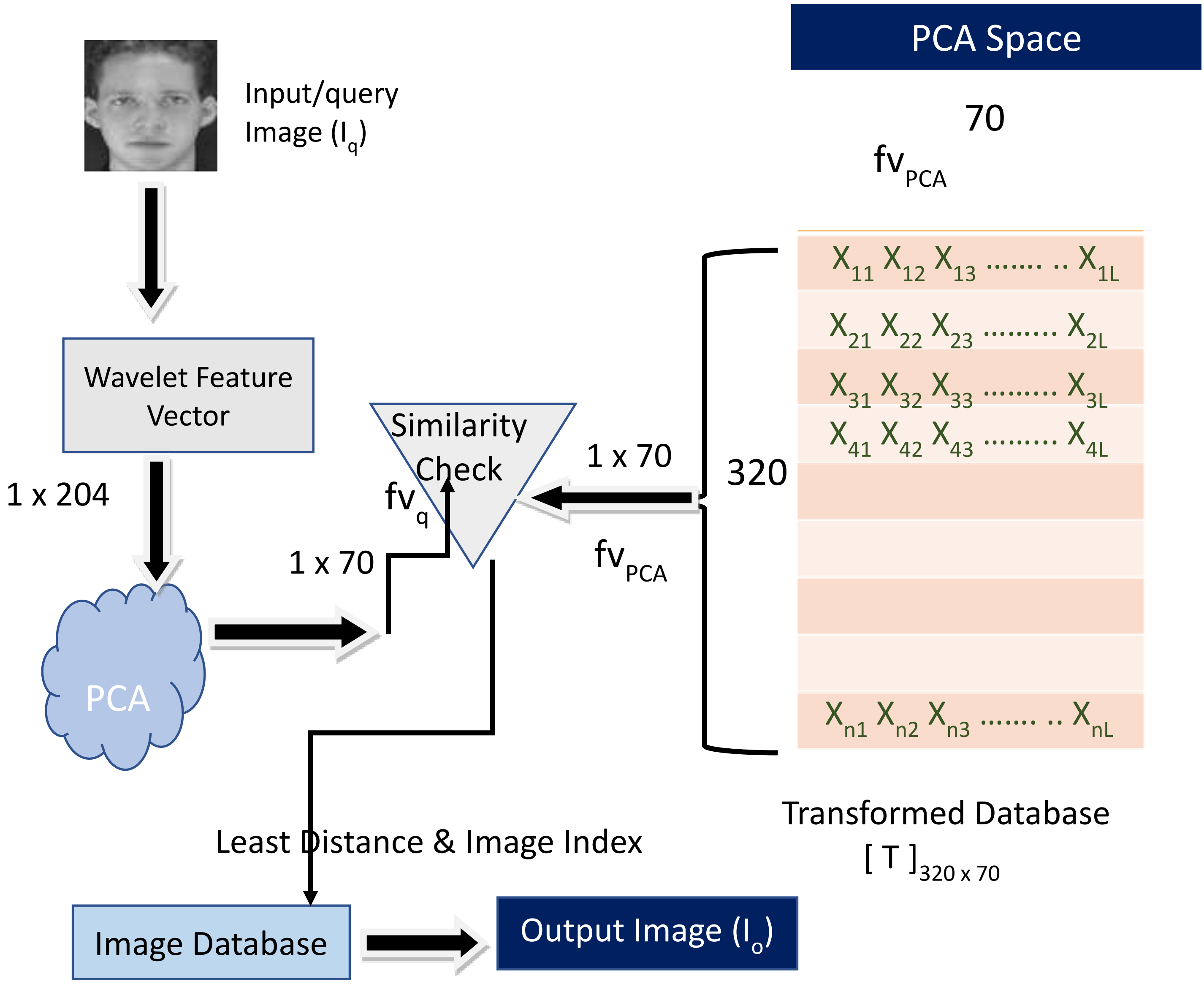


Fig 5: Testing Procedure

Chapter 4

Experimental Results

Database preparation for training and testing:

A query image is given as input for its corresponding right face detection. The ORL database was used, which has 400 photos of 40 people, each with ten different stances. The photos for some people were taken at different times, with variable lighting, facial emotions (open vs. closed eyes, smiling vs. frowning), and face details (spectacles vs. no spectacles). All of the photographs were taken against a dark, uniform background, with some side movement allowed). Each image's original size is 92x112 pixels.

All 400 photographs are employed in the proposed approach, with 320 images being used for training and the remaining 80 images being used for testing. So, 40 classes are taken into consideration. The first 4-5 matches are shown at the time of recognition.

All the faces of 40 persons are shown below:

Fig 6: Sample faces from each class

The binarized image of a face is also shown below:

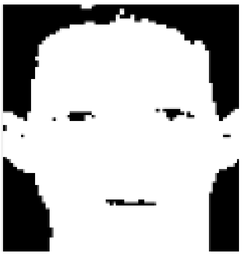


Fig 7: Binarized face image

All the images in the dataset have been allotted with an index in an sequential manner. They are numbered from 1 to 400 and hence the test images will start from 321 to 400. For testing only 2 distinct face poses (which are not part of training) of one person are considered. Hence for 40 persons, total 80 distinct poses are there in the same database. A sample of faces with their index is shown below:

Fig 8: Training face images with their names in database

Similarly, some sample faces for testing with their names is shown below:

Fig 9: Testing face images along with respective names

A single image has been selected as test or query image. Then the discrete wavelet transform (1-Level) is applied using the db10 wavelet, then it is projected to PCA space for the similarity check with the corresponding images present in the transformed database of size 320x70. There will be four wavelet coefficients namely approximate coefficient matrix (cA), horizontal coefficient matrix (cH), detailed vertical coefficient matrix (cV) and diagonal detailed coefficient matrix (cD). Altogether they form the wavelet coefficient matrix (wc).

The result obtained from one query image is shown in the figure below:

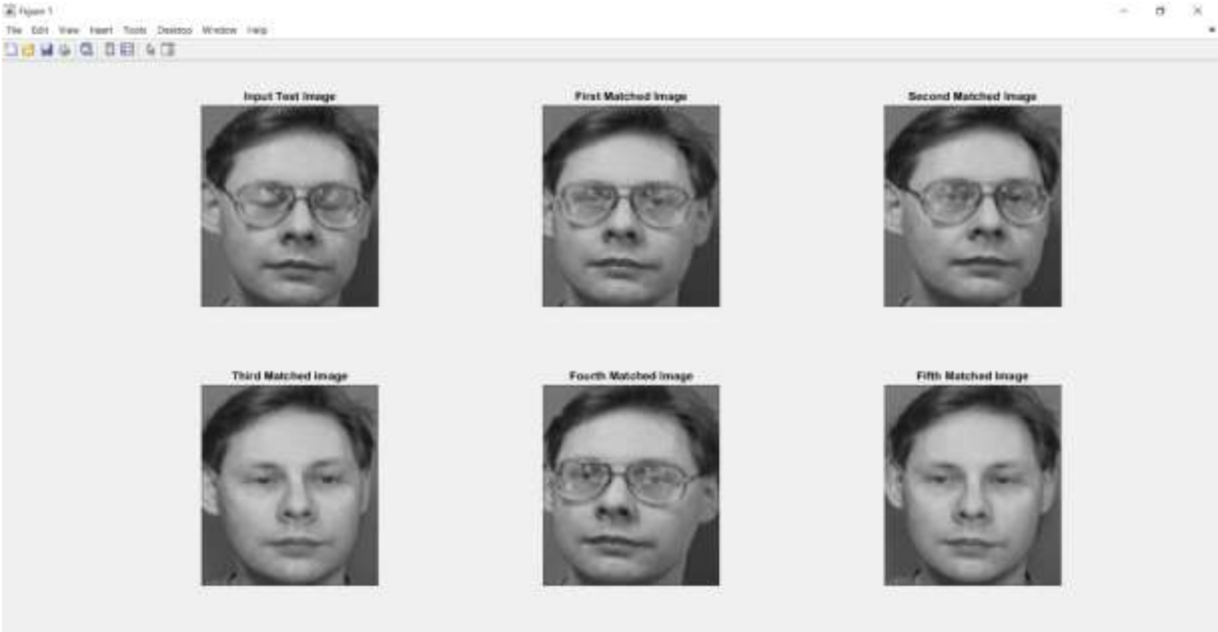


Fig 10: First five nearest matches of the query image

It is observed that this approach is able to recognize a person with variable face poses as well as it can identify a person even if there are some changes in face (presence or absence of spectacles). The figure above is obtained by implementing the proposed method in MATLAB.

After that a bulk testing method is also done to get the recognition accuracy by using L1 distance. Using the equation stated below, we can get L1 distance –

$$L_1 \text{ distance} = \sum |fv_{qi} - fv_{PCAi}| \quad \text{...........(3)}$$

Accuracy Calculation

From this method, we were able to identify most of the faces correctly except very few faces. Since we wanted to get first five nearest matches, so in few cases, the third or fourth or fifth match is not matching with the query image. Mostly we have got the first nearest match correctly but there are few exceptions.

Accuracy can be calculated according to this equation:

Accuracy=(number of correct classified samples)/(number of total test data)*100

Hence from this proposed method based on the ORL dataset, we have got the accuracy of 87.5%.

Also, apart from the classifier used above (Manhattan distance), the subspace KNN classifier is also giving a high accuracy of 91.3%.

The scatter plot obtained is shown in the figure below:

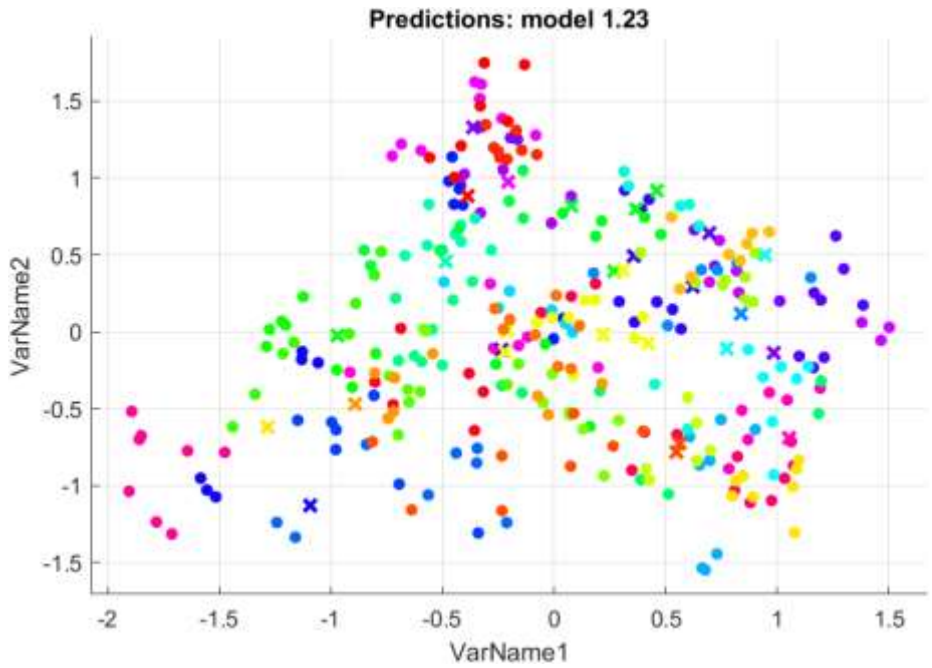


Fig 11: Scatter Plot

The confusion matrix is shown in the figure below:

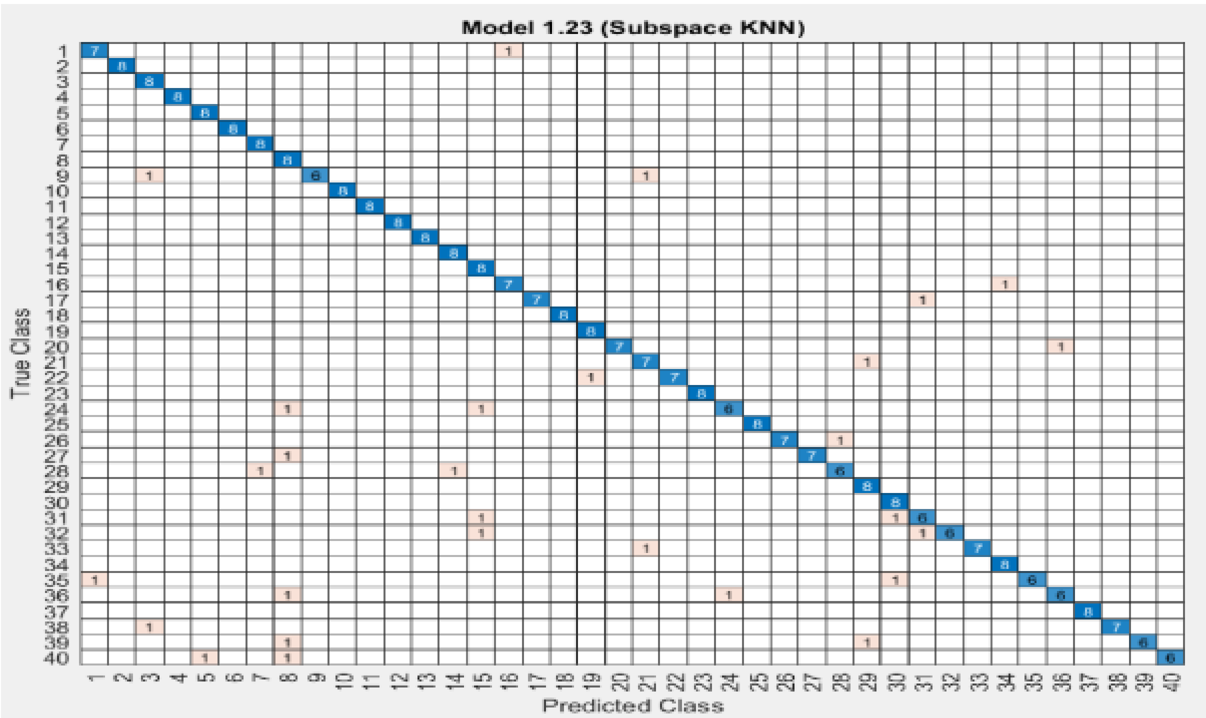


Fig 12: Confusion matrix

Chapter 5

Comparative Analysis

Face recognition can be done using multiple algorithms. Among all those PCA is one of the best methods because it can handle huge data by reducing its dimension. Our aim is to build an improved face recognition system by using less memory so that the execution time will be faster as compared to other techniques. But this method also has certain limitations and so face recognition by using only PCA is not meeting our objectives at all. For frontal view of faces, the PCA method is working fine but if the face poses change (as shown in ORL database) then it is not giving proper results and hence the test face cannot be identified correctly. So, the proposed method that is face recognition using wavelet features along with PCA came into picture which is capable of recognizing all the faces (frontal as well as distinct poses) correctly. Also, it can give correct results even if there is varying illumination or there are certain changes in face or even if the image is distorted.

Since it is known that the frontal view of a face can be well recognized by any method, so our main focus is on distinct face poses as well the faces with some certain changes like the presence or absence of beard, spectacles etc.

The results obtained from only using PCA and by using DWT(1-level) + PCA are shown in the figures given below.

Only using PCA (for distinct face poses):

Fig 13: Face recognition using PCA

Using DWT+PCA (distinct face poses):

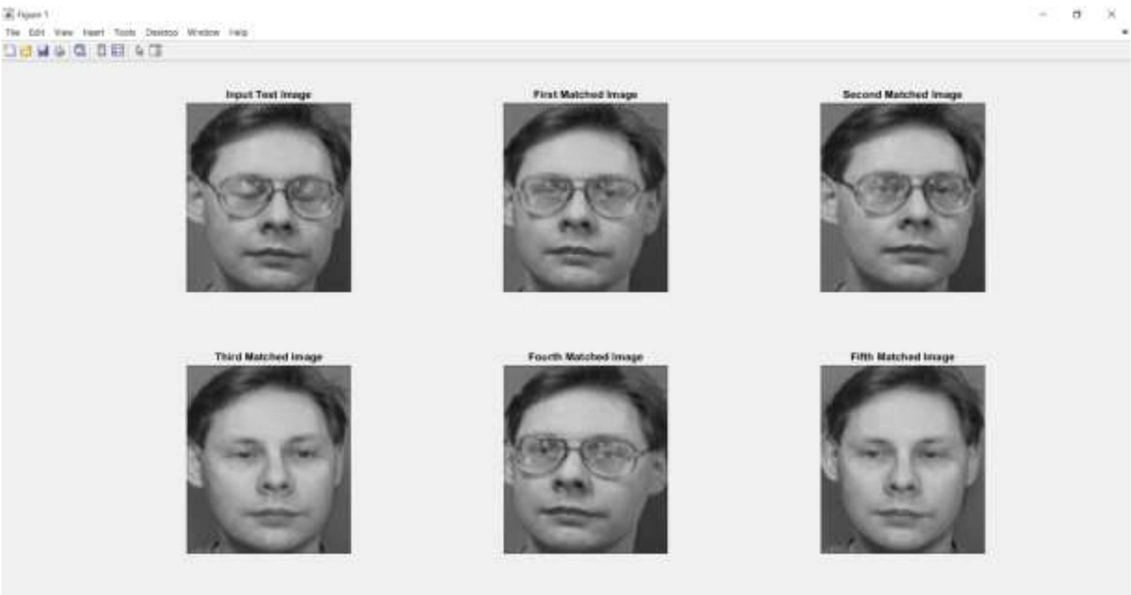


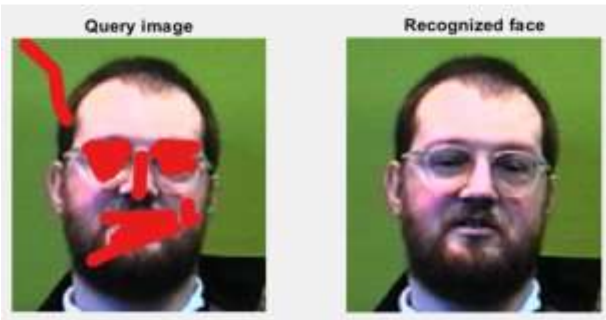
Fig 14: Face recognition using wavelet features and PCA

It is evident from the above two figures that which method is favourable of correct face recognition of persons with distinct poses. Thus, simply by extracting wavelet features along with PCA, far better results will come than the conventional method. From the second figure, it is also seen that the face of the person can be identified with or without spectacles.

Now it will be showed how this proposed method can identify faces even if the image is distorted. Some samples of distorted images are shown below. The images used are taken from 'Faces94' database.

Fig 15: Some distorted face images

The result obtained from this method is shown in the below figures.



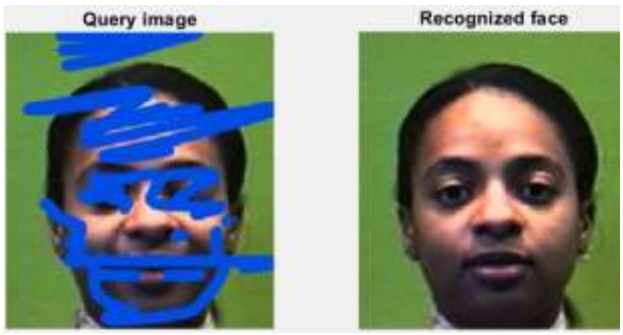


Fig 16a: First matched image **Fig 16b: Second matched image**

It is clear from the above pictures that this method is very robust and can recognize the correct face even if the test image is distorted. The faces shown above are taken from 'Faces94' database.

A comparison of several of the approaches for face recognition is provided in Table 1 based on the number of photographs in the training set and the resulting success rate.

Table 1

Method	**Number of training set images**	**Success**
Principal Component Analysis	400	79.64%
PCA + RCA	400	92.36%
Independent Component Analysis	170 40	Tanh function 69.41% Gauss function 81.33%
Hidden Markov Model	200	83.9%
Active Shape Model	100	78.14-92.06%
Wavelet Transform	100	80-92%
Proposed Method	320	85-93%

All the methods which are present in table 1 are predominantly used for face recognition. Principal component analysis is already discussed before. Hidden Markov Model and Active shape model are also used to recognize faces correctly but it faces some problem when various face poses are taken into database. For frontal face recognition there is no problem but for distinct poses as well as different facial expressions, these methods face some challenges. Whereas in the proposed approach, the expected results are achieved with a good success rate.

Table 2 outlines the many approaches, as well as the various classifiers, that are used to reduce the dimensionality and complexity of the detection and recognition processes. Under various lighting conditions and face expressions, linear and non-linear algorithms provide reliable recognition. Although these (linear and non-linear) strategies reduce dimensionality and enhance identification rates, they are not translation and rotation invariant when compared to local procedures.

Table 2

Techniques used	**Classifier**	**Limitation**	**Advantage**	**Result**
LARK + PCA	L2 Distance	Detection Accuracy	Reduces computational complexity	85.10%
ICA + LDA	Bayesian Classifier	Sensitivity	Recognition accuracy	88%
PCA + LDA	Bayesian Classifier	Sensitivity	Specificity	59%
2D-DWT	KNN	Pose	Frontal facial images	90.6%
PCA + Gabor filter	Cosine metric	Precision	Pose	87.7%
DCT	NCC	High memory	Controlled and Uncontrolled databases	93.3%
Eigen Faces + DOG Filter	Chi-square distance	Processing time	Reduce the representation	84.26%

PCA	SVM	Recognition rate	Reduces dimensionality	84.21%
SURF + KPCA	FLANN Matching	Processing time	Reduces dimensionality	80.34%
SIFT + KPCA	FLANN Matching	Low Recognition rate	Complexity	69.20%
CNN	--	Poses	High Recognition rate	95%

Contribution:

My contribution towards this work is that I have designed a system which can identify human faces even if there are certain challenges, using wavelet features i.e., a combination of PCA and discrete wavelet transform (1-level) can recognize different poses of a face or distorted faces or if there are certain changes in face, which was not correctly recognized in the conventional PCA method.

Chapter 6

CONCLUSION AND FUTURE SCOPE

On a huge database of 320 photos, the Eigen faces approach is combined with the discrete wavelet transform 1-level. The challenges like background, eye-glasses, lighting conditions, distinct face poses are dealt with. Simulation results are showing correct output except some cases. The recognition accuracy is nearly 88% for ORL database and 95% for Faces94 database. This proposed method is very robust and fast, however not perfect. The approach is intended to build high performance scalable and low-cost facial recognition system Even if the image is distorted, it is still possible to recognize the faces accurately using these features. Thus, it is very effective to use.

Since no method is perfect, this method is also not an exception. Though this method gives expected results but still has some future scopes. This method can be used to analyze real-time photographs. Variation in illumination can be improved. This method can also be used to identify criminals based on sketches.

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APPENDIX: Code for the Implementation

A: Code for training

A1.1. Initialization and finding discrete wavelet transform

```
n=320;
L=70;
M=112; N=92;
X=zeros(n,(M+N));

for count=1:n
   I = imread (sprintf('%d.jpg', count));
   I = imresize(I,[M,N]);
   level=graythresh(I);
   Ibin=imbinarize (I, level);

   dwtmode('per','nodisp');
   [cA,cH,cV,cD]=dwt2(double(Ibin),'db10');
   wc=[cA,cH;cV,cD];
   stdcol=std(wc);
   wcc=(wc');
   stdrow=std(wcc);
   fvsd=[stdcol stdrow];
   X(count,:)=fvsd;

End
```

A1.2. Projecting all the feature vectors to PCA space

```
m=mean(X);
for i=1:n
   X(i,:)=X(i,:)-m;
end

Q=(X'*X)/(n-1);
[Evecm, Evalm] = eig(Q);
Eval=diag (Evalm);
[Evalsorted, Index] = sort (Eval, 'descend');
Evecsorted=Evecm(:,Index);
Ppca=Evecsorted (:,1:L);
T=X*Ppca;
```

Save the variables n, m, M, N, Ppca, T of workspace in the working directory and name the file.

B. Code for discrete testing

```
load ('directory address of saved workspace’, ’M’, ’N’, ’m’,
’n’, ’Ppca’, ’T’);

[filename, pathname] = uigetfile ('*.*','Select Input Face
Image');
filewithpath=strcat (pathname, filename);
img=imread(filewithpath);
imgo=img;
img=imresize (img, [M, N]);
level=graythresh(img);
Ibin=imbinarize (img, level);
```

```
dwtmode('per','nodisp');
[cA, cH, cV, cD] = dwt2(double (Ibin),'db10');
 wc= [cA, cH; cV, cD];
 stdcol=std(wc);
 wcc=(wc');
 stdrow=std(wcc);
 fvsd= [stdcol stdrow];
 fvpca=(fvsd-m) *Ppca;
 distarray=zeros(n,1);

for i=1:n
   distarray(i)=sum(abs(T(i,:)-fvpca));
    %distarray(i)=sqrt(sum(abs(T(i,:)-fvpca).^2));
 end
```

Displaying first five matches

```
 [result, indx]=sort(distarray);
 resultimg1=imread (sprintf ('%d.jpg', indx (1)));
 resultimg2=imread (sprintf ('%d.jpg', indx (2)));
 resultimg3=imread (sprintf ('%d.jpg', indx (3)));
 resultimg4=imread (sprintf ('%d.jpg', indx (4)));
 resultimg5=imread (sprintf ('%d.jpg', indx (5)));
  subplot (231); imshow(imgo); title ('Input Test Image')
 subplot (232); imshow(resultimg1); title ('First Matched
Image')
 subplot (233); imshow(resultimg2); title ('Second Matched
Image')
 subplot (234); imshow(resultimg3); title ('Third Matched
Image')
```

```
 subplot (235); imshow(resultimg4); title('Fourth Matched
Image')
subplot (236); imshow(resultimg5); title ('Fifth Matched
Image')
```

C. Bulk testing code to get accuracy results

```
load ('directory address of saved workspace’, ’M’, ’N’, ’m’,
’n’, ’Ppca’, ’T’);

nop = 40;
ntr=320;
nte=80;
p=nte/nop;
q=ntr/nop;
K=320;
L=0;
flag=zeros (1, nte);

while(K<=((ntr+nte)-p))
   for i=(K+1): (K+p)
      img=imread (sprintf ('%d.jpg', i));
      indx=orlfacerecog (img, M, N, m, n, Ppca, T);
      if (i>=K+1) &&(i<=K+p) &&(indx>=L+1) &&(indx<=L+q)
         flag(i)=1;
      else
         flag(i)=0;
      end
   end
   K=K+p; L=L+q;
end
```

```
result=(nnz(flag)/nte) *100;
disp ('Accuracy= ')
result
```

D. <u>Face Identification function based on wavelet features and PCA</u>

orlfacerecog.m

```
function indx=orlfacerecog (img, M, N, m, n, Ppca, T)

img=imresize (img, [M, N]);
level=graythresh(img);+
Ibin=imbinarize (img, level);
dwtmode('per','nodisp');
[cA, cH, cV, cD] = dwt2(double (Ibin),'db10');
 wc= [cA, cH; cV, cD];

 stdcol=std(wc);
 wcc=(wc');
 stdrow=std(wcc);
 fvsd = [stdcol stdrow];
 fvpca=(fvsd-m)*Ppca;
 distarray=zeros(n,1);

 for i=1:n
   distarray(i)=sum(abs(T(i,:)-fvpca));
   %distarray(i)=sqrt(sum(abs(T(i,:)-fvpca).^2));
 end
  [~, indx] =min(distarray);
```