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A Pragmatic Evaluation of Face Smile Detection

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ABSTRACT
Face detection is gaining the interest of marketers. A webcam can be integrated into a television and detect any face that walks by. The system then calculates the race, gender, and age range of the face. Once the information is collected, a series of advertisements can be played that is specific toward the detected race/gender/age. Face detection is used in biometrics, often as a part of (or together with) a facial recognition system. It is also used in video surveillance, human computer interface and image database management. This manuscript underlines the face smile detection approaches with the related dimensions in assorted domains and dimensions.

Keywords: Face Detection, Face Smile Detection, Face Analytics, Digital Image Processing

INTRODUCTION
Face detection is a computer technology being used in a variety of applications that identifies human faces in digital images. Face detection also refers to the psychological process by which humans locate and attend to faces in a visual scene. Face detection can be regarded as a specific case of object-class detection. In object-class detection, the task is to find the locations and sizes of all objects in an image that belong to a given class. Examples include upper torsos, pedestrians, and cars.

Face-detection algorithms focus on the detection of frontal human faces. It is analogous to image detection in which the image of a person is matched bit by bit. Image matches with the image stores in database. Any facial feature changes in the database will invalidate the matching process.

A reliable face-detection approach based on the genetic algorithm and the eigen-face technique:

Firstly, the possible human eye regions are detected by testing all the valley regions in the gray-level image. Then the genetic algorithm is used to generate all the possible face regions which include the eyebrows, the iris, the nostril and the mouth corners.

Each possible face candidate is normalized to reduce both the lightning effect , which is caused by uneven illumination; and the shirring effect, which is due to head movement. The fitness value of each candidate is measured based on its projection on the eigen-faces. After a number of iterations, all the face candidates with a high fitness value are selected for further verification. At this stage, the face symmetry is measured and the existence of the different facial features is verified for each face candidate.

Images containing faces are essential to intelligent vision-based human computer interaction, and research efforts in face processing include face recognition, face tracking, pose estimation, and expression recognition. The rapidly expanding research in face processing is based on the premise that information about a user's identity, state, and intent can be extracted from images and that computers can then react accordingly, e.g., by knowing person's identity, person may be authenticated to utilize a particular service or not. A first step of any face processing system is registering the locations in images where faces are present. However, face registration for whole database is a challenging task because of variability in scale, location, orientation (up-right, rotated), and pose (frontal, profile). Facial expression, occlusion, and lighting conditions also change the overall appearance of face. The Image registration algorithm will register all these images present in the database. The face recognition algorithm which is insensitive to large variation in lighting direction and facial expression is to be implemented. Taking a pattern classification approach, each pixel in an image can be considered as a coordinate in a high-dimensional space. The advantage of this is that the images of a particular face, under varying illumination but fixed pose, lie in a 3D linear subspace of the high dimensional image space—if the face is a Lambertian surface. However, since faces are not truly Lambertian surfaces and do indeed produce self-shadowing images will deviate from this linear subspace. Rather than explicitly modeling this deviation, project the image into a subspace in such a manner which discounts those regions of the face with large deviation.

Face recognition has been an active research area over the last 30 years. It has been studied by scientists from different areas of psychophysical sciences and those from different areas of computer sciences. Psychologists and neuroscientists mainly deal with the human perception part of the topic, whereas engineers studying on machine recognition of human faces deal with the computational aspects of face recognition. Face recognition has applications mainly in the fields of biometrics, access control, law enforcement, and security and surveillance systems.

Biometrics is methods to automatically verify or identify individuals using their physiological or behavioral characteristics. Biometric technologies include:

- Face Recognition
- Finger Print (dactylogram) Identification
- Hand Geometry Identification
- Iris Identification
- Voice Recognition
- Signature Recognition
- Retina Identification
- DNA Sequence Matching

Configuration of face recognition system

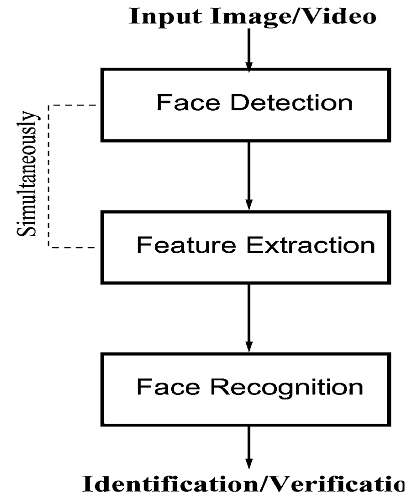

Figure 1. Configuration of a generic face recognition system.

In face recognition system the input is an image or a scene. So the first step is to extract the face from the image i.e. to detect the face space from the image space. After that the important features are extracted. In identification problems, the input to the system is an unknown face, and the system reports back the determined identity from a database of known individuals, whereas in verification problems, the system needs to confirm or reject the claimed identity of the input face.

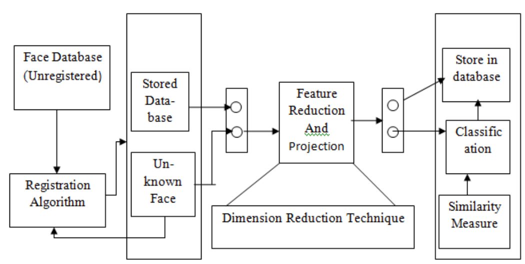

Figure1.2: Block diagram of face recognition.

The face is our primary focus of attention in social intercourse, playing a major role in conveying identity and emotion. Although the ability to infer intelligence or character from facial appearance is suspect, the human ability to recognize faces is remarkable. A human can recognize thousands of faces learned throughout our lifetime and identify familiar faces at a glance even after years of separation. This skill is quite robust, despite large changes in the visual stimulus due to viewing conditions, expression, aging, and distractions such as glasses, beards or changes in hair style. Face recognition has become an important issue in many applications such as security systems, credit card verification and criminal identification. For example, the ability to model a particular face and distinguish it from a large number of stored face models would make it possible to vastly improve criminal identification. Although it is clear that people are good at face recognition, it is not at all obvious how faces are encoded or decoded by the human brain. Unfortunately developing a computational model of face recognition is quite difficult, because faces are complex, multi-dimensional visual stimuli. Therefore, face recognition is a very high level computer vision task, in which many early vision techniques can be involved.

The first step of human face identification is to extract the relevant features from facial images. Research in this field primarily intends to generate sufficiently reasonable familiarities of human faces so that another human can correctly identify the face. The question naturally arises as to how well facial features can be quantized. If such a quantization is possible then a computer should be capable of recognizing a face given a set of features. Investigations by numerous researchers over the past several years have indicated that certain facial characteristics are used by human beings to identify faces.

The block diagram of system is shown in Figure, which explain about the step by step procedure for Training and Testing of face images. The initial step is the Registration of images present in database. Once all images are registered they are applied to dimension reduction block where the most important dimension are kept and then for classification it goes to classification block where different similarity measures are used to classify the test image.

Associated Problems

Due to the dynamic nature of face images, a face recognition system encounters various problems during the recognition process. The problems may include variation in lighting conditions, pose, etc. One more problem that is usually encountered is high dimensionality problem. The dimensions of an image are very large so it makes the calculation and thus the face recognition system very complex. So, techniques are required that not only reduces the dimensions of the image but are also time efficient. The other problems of a robust face recognition system are given below:

Scale invariance

The same face can be presented to the system at different scales as shown in Figure. This may happen due to the focal distance between the face and the camera. As this distance gets closer, the face image gets bigger. So at the time of recognition the algorithm should be invariant to the scale.

Figure 2. Faces at different scales.

Shift invariance

The same face can be presented to the system at different perspectives and orientations

Figure 3. Frontal and profile view of same person.

as shown in Figure. For instance, face images of the same person could be taken from frontal and profile views. Besides, head orientation may change due to translations and rotations. The system must incorporate this shift invariance property for proper results.

Illumination invariance

Face images of the same person can be taken under different illumination conditions such as, the position and the strength of the light source can be modified like the ones shown in Figure.

Figure 4. Variation in illumination.

Emotional expression and detail invariance
Face images of the same person can differ in expressions when smiling or laughing. Also, like the ones shown in Figure, some details such as dark glasses, beards or moustaches can be present. A smiling face, a crying face, a face with closed eyes, even a small nuance in the facial expression can affect facial recognition system significantly.

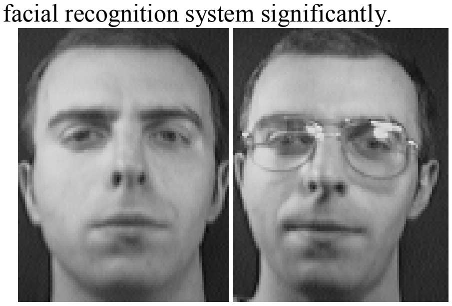

Figure 5. Same person with and without glasses.

Noise invariance
A robust face recognition system should be insensitive to noise generated by frame grabbers or cameras. Also, it should function under partially occluded images.

Motivation
Today security and surveillance systems are of major importance in high risk areas like military, companies etc. In surveillance system face recognition is an important step for better and accurate surveillance. The complexity involves in it are high dimension subspace, variation of expressions, lighting, size etc motivates to develop a new and better algorithm which really enhance the security of such systems. The necessity for personal identification in the fields of private and secure systems made face recognition one of the main fields among other biometric technologies. The importance of face recognition arises from the fact that a face recognition system does not require the cooperation of the individual while the other systems need such cooperation. Face recognition algorithms try to solve the problem of both verification and identification. When verification is on demand, the face recognition system is given a face image and it is given a claimed identity. The system is expected to either reject or accept the claim. On the other hand, in the identification problem, the system is trained by some images of known individuals and given a test image. It decides which individual the test image belongs to.

The main problem of face recognition is its high dimension space which is to be reduced by any dimension reduction techniques. The pattern recognition approach then tries to match the face features which are extracted from all the images present in the database. So there are two major problems one is feature extraction and then pattern recognition. Before this image registration of all the faces is required to enhance the recognition rate of whole system. So these all motivates to search for new or better method to solve all these problems and then integrate them to make fully functional system with high accuracy, more time efficient and better recognition rate.

The problem of face recognition can be stated as follows: Given still images or video of a scene, identifying one or more persons in the scene by using a stored database of faces. The problem is mainly a classification problem. Training the face recognition system with images from the known individuals and classifying the newly coming test images into one of the classes is the main aspect of the face recognition systems. The topic seems to be easy for a human, where limited memory can be a main problem; whereas the problems in machine recognition are manifold. Given still or video images of a scene, recognize or identify a person in the scene using a stored database of large number of faces.

- The database used should be registered so that all the session database of the same person should be uniform.
- Classification methods should be able to differentiate between the true and the false image with a high percentage.

Many face recognition techniques have been developed over the past few decades. One of the successful and well studied techniques to face recognition is the appearance-based method . In using appearance based methods, a face image of size $N \times M$ pixels is represented as a vector in an $N \times M$ dimensional space. In practice these $N \times M$ spaces are very large .This leads one to consider methods of dimensionality reduction that allows one to represent the data in a lower dimensional space. In practical situations, when n is very large, one is often forced to use linear techniques . BLPP is based on the Laplacian face method. Both the algorithms aim at dimensionality reduction since the first step in both the algorithms is PCA which helps in dimensionality reduction. BLPP aims to build a binary adjacency graph which can best reflect the geometry of the face manifold and the class relationship between the sample points. The basis functions in the case of BLPP are orthogonal. The empirical results have proven that BLPP has got more discriminating and preserving power when compared to the LPP.

Image Registration

Registration is a fundamental task in image processing used to match two or more pictures taken, for example, at different times, from different sensors or from different viewpoints. Over the years, a broad range of techniques have been developed for the various types of data and problems. These techniques have been independently studied for several different applications resulting in a large body of research. In case of face recognition this is an important step because when the image is captured at different instant of time this might be possible that the image is translated, rotated or scaled with respect to the images present in the database. Thus for better recognition rate the image must be registered before implementing any recognition algorithm. Most image registration problems are formulated in an asymmetric fashion. Given a pair of images, one is implicitly or explicitly regarded as a template, and warped onto the other to match as well as possible. The same is implemented for the face which comes for the recognition and also all images in database are registered prior to classification step.

Registration algorithms attempt to align a pattern image over a reference image so that pixels present in both images are in the same location. This process is useful in the alignment of an acquired image over a template, a time series of images of the same scene, or the separate bands of a composite image. Two practical applications of this process are the alignment of radiology images in medical imaging and alignment of satellite images for environmental study. For typical image registration problems, the sources of differences between two images fall into four categories:

1. **Differences of alignment** between images are caused by a spatial mapping from one image to the other. Typical mappings involve translation, rotation, warping, and scaling. For infinite continuous domain images, these differences are a result of a spatial mapping from one image to the other. Changing the orientation or parameters of the imaging sensor can cause differences of alignment.
2. **Differences from occlusion** occur when part of a finite image moves out of the image frame or new data enters the image frame of a finite image due to an alignment difference, when sensor errors produce identifiably invalid data in an image, or when an obstruction comes between the imaging sensor and the object being imaged. For example, in satellite images, clouds frequently occlude the earth.
3. **Differences from noise** occur from sampling error and background noise in the sensor, and from undeniably invalid data introduced by sensor error.
4. **Differences due to change** are actual differences between the objects or scenes being imaged. In satellite images, lighting, erosion, construction, and deforestation are examples of differences due to change. It may be impossible to distinguish between change and noise.

Because images are registered in order to detect the changes in a scene, successful registration detects and undoes or accounts for differences due to alignment, occlusion, and noise while preserving difference due to change.

Registration algorithms must assume that change is small with respect to the content of the image; that is, the images being registered is assumed to be “visibly similar" after accounting for differences due to alignment, occlusion, and noise. In addition, a sufficient amount of the object or scene must be visible in both images. It is assumed that at least 50% of the content of the reference image is also present in the pattern to be registered against it. In practice, facial, medical and satellite sensors can usually be oriented with enough precision for images to share 90% or more of their content.

For image registration of facial images the technique used is Fourier Mellin transform which gives the features which are invariant to scaling, rotation and translation. For recovering translation parameters, phase correlation technique is used which is explained in the next section.

Fourier Mellin Transform

The Fourier-Mellin transform is a useful mathematical tool for image recognition because its resulting spectrum is invariant in rotation, translation and scale. The Fourier Transform itself (FT) is translation invariant and its conversion to log-polar coordinates converts the scale and rotation differences to vertical and horizontal offsets that can be measured. A second FFT, called the Mellin transform (MT) gives a transform-space image that is invariant to translation, rotation and scale. The working flow chart of the image registration algorithm based on the Fourier–Mellin transform is illustrated.

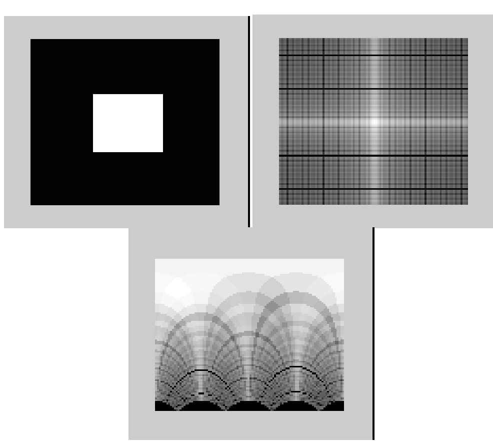

Figure 6. Original image, FFT in Cartesian and Log-polar coordinates.

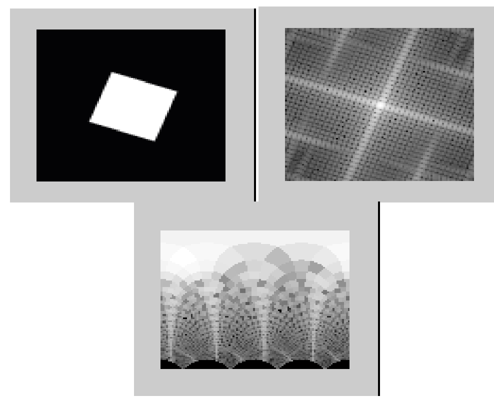

Figure 7. Rotated image, FFT in Cartesian and Log-polar coordinates.

Basic Dimension Reduction Techniques

In statistics, dimension reduction is the process of reducing the number of random variables under consideration, and can be divided into feature selection and feature extraction. Images having faces as main image content is generally very high in dimension and while recognizing them the dimensions comes out to be very large. To reduce the computation time for recognition and making it real time the dimension of the features must be reduced. As shown in Figure, at a particular dimension the performance of system is maximum both in terms of computation time and accuracy. So for all these reasons good dimension reduction techniques are required which keeps those dimensions only which are helpful for classification and discard all others. Some Basic dimension reduction techniques are:

- Principal Component Analysis
- Linear Discriminant Analysis
- Locality Preserving Projection

Principal Component Analysis

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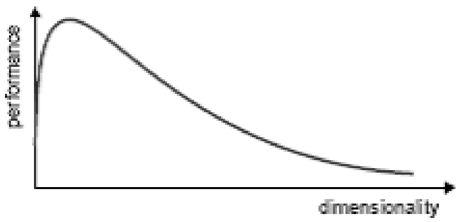


Figure 8. Performance (Accuracy+Time consumption) vs Dimension graph.

Images of faces can be linearly encoded using a modest number of basis images. This demonstration is based on the Karhunen-Loe`ve transform, which also goes by other names, e.g., principal component analysis (PCA), and the Hotelling transform. Given a collection of N by M pixel training images represented as a vector of size $N \times M$, basis vectors spanning an optimal subspace are determined such that the mean square error between the projection of the training images onto this subspace and the original images is minimized. The set of optimal basis vectors Eigen pictures since these are simply the eigenvectors of the covariance matrix computed from the vectorized face images in the training set. Principal component analysis on a training set of face images is performed to generate the Eigen pictures (here called EIGEN FACES) which span a subspace (called the face space) of the image space. Images of faces are projected onto the subspace and clustered. Similarly, non face training images are projected onto the same subspace and clustered. Since images of faces do not change radically when projected onto the face space, while the projection of non-face images appear quite different. To detect the presence of a face in a scene, the distance between an image region and the face space is computed for all locations in the image. The distance from face space is used as a measure of "faceness," and the result of calculating the distance from face space is a "face map." A face can then be detected from the local minima of the face map. Many works on face detection, recognition, and feature extractions have adopted the idea of eigenvector decomposition and clustering.

Results

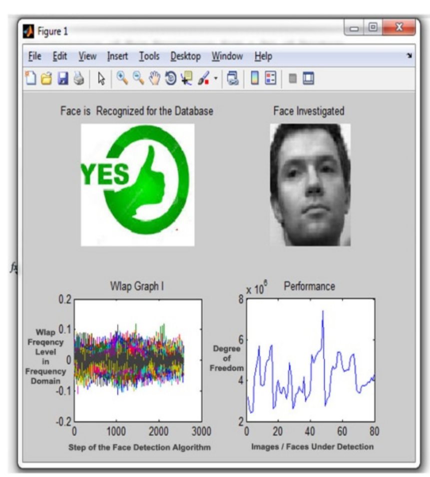
This section shows all the results that are obtained in the proposed work. First the result of locality preserving Projections are shown and after that the results got through Binary Locality Preserving Projections.

Results of binary locality preserving projections

Figure 9. Implementation Scenario of the Face Recognition with different options.

In Figure, there are different options by which any face can be detected from the training data set. Using this panel, any image file can be matched to show whether it matches with the specific set of images.

Scenario I: To demonstrate the matching attempt of face recognition algorithmic approach.



Successful attempt demonstration of the face detection algorithm.

In Figure, it is evident that the image that is test with the back end database used as a training set is matched. It is showing the successful attempt as well as the graphical representation of the performance and the proposed algorithm.

Implementation of Face Recognition from a Set of Database
choice = 1
wtime = 7.1563
Face is recognised
Face Detection Implementation Execution Time : 7.156347 seconds.

Scenario II : To demonstrate non-matching attempt of face recognition algorithmic approach.

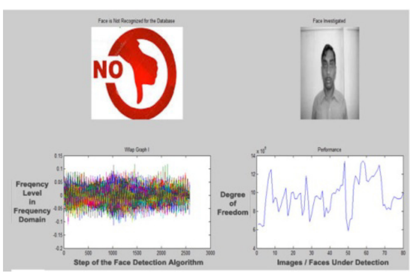


Figure 10. Unsuccessful attempt demonstration of the face detection algorithm.

In Figure, it is demonstrated that the image under test with the backend training database is not matched. It is showing the non-matching attempt as well as the graphical representation of the performance and proposed algorithm.

Implementation of Face Recognition from a Set of Database

choice = 1
wtime = 5.9383
Face is not recognised
Face Detection Implementation Execution Time : 5.938288 seconds.

Generation of test images from the dataset

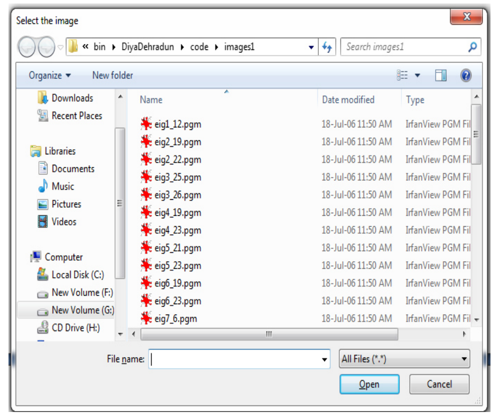


Figure 11. To depict the generation of test image from the training data set.

Laplacian faces obtained from binary locality preserving projections

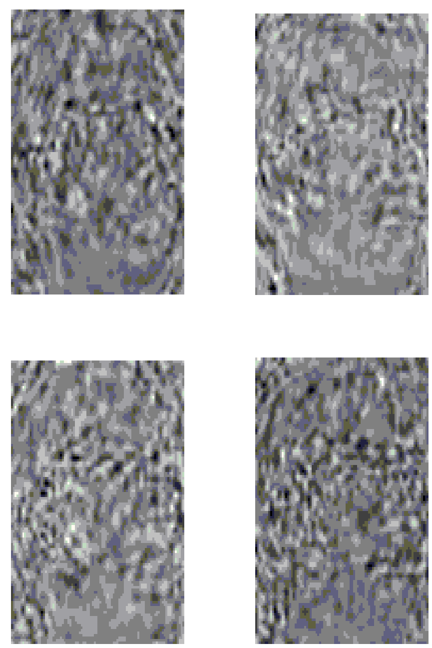


Figure 12. Binary Laplacian faces.

Recognition Rate versus number of vectors

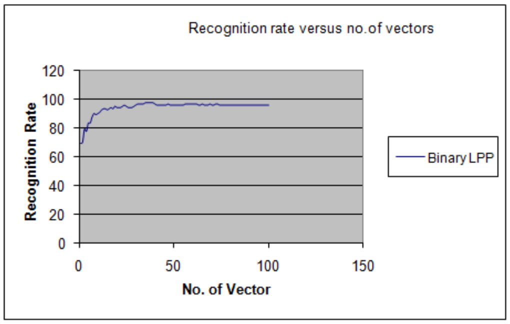


Figure 13. Recognition rate versus number of vectors for Binary LPP.

Figure shows the best basis faces for the database obtained from Binary LPP from which all the faces can be reconstructed. Figure shows the recognition rate with respect to number of vectors chosen for recognition. For this also after a particular number there is no improvement in the recognition rate. So again the proper number of vectors is to be chosen for better performance. However, for the same number of vectors chosen BLPP has higher recognition rate.

The Laplacian faces determined using Binary Locality Preserving Projections are used for efficient face identification. The face recognition becomes a pattern classification task, once the Orthogonal Laplacian faces are created. The face recognition process has three steps. First, the Laplacian faces from the training set of face images are calculated. Then the new face image to be identified is projected into the face subspace spanned by the calculated Laplacian faces. Finally, this projected face image is identified by K-nearest-neighbor search. This completes the face recognition task.

The orthogonal locality preserving subspace is determined for each person with different poses from which the Laplacian faces are obtained. Then the test image is obtained from the user, which has to be identified. The test image is also projected to determine the Binary Laplacian face subspace, and then they are classified based on Euclidean metric using the training set. If a person's test image is found to be one of the training person's face image, then the test image is recognized, else the test image is not recognized. In table 1 represents the results. Here(a),(b),(c),(d) are faces in database;(e),(f),(g),(h) are Laplacian faces;(i),(j),(k),(l) are modified Laplacian faces obtained from BLPP.the results show that the Laplacian faces or basis vectors obtained from binary algorithm has more locality preserving power.

The manifold ways of face analysis are introduced in this thesis in order to detect the underlying nonlinear manifold structure in the manner of linear subspace learning. In reference to Laplacian faces this concept which uses labeled samples, a different and effective similarity measure works very well on the database for the purpose of recognition of identity of a person. The accuracy rate also increases due the effect of class concept i.e. labeled samples which are absent in Laplacian faces concept. Also the computational complexity is reduced due to no more searches for k nearest neighbor for each sample.

Conclusion

This research work focus on the face detection algorithmic approach that is solely dependent on the wavelet transform. In this research work, the frequency domain of the training images are investigated. Using the proposed algorithmic approach, the user defined test images can be matched with a set of specific training data sets of images. Using this approach, the research work is able to conclude that the face detection algorithm is working efficiency for any image and can be tested for the efficiency as well as overall performance. This approach can work best in terms of recognition rate if combined with Hamming Distance as similarity measure and Genetic Algorithm to optimize the minimization problem. In most of the applications this objective function is minimized using mathematical functions and models like solving General Eigen value problem. But in future Continuous Genetic Algorithm approach to optimize this will be more efficient. Once the transformation vector is obtained after training then the nearest neighbor classification approach will classify test face in reduced dimension space.

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