

Face recognition with frame size reduction and DCT compression using PCA algorithm

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ABSTRACT

Face recognition has become a very important study of research because it has a variety of applications in research field such as human computer interaction, pattern recognition (PR). A successful face recognition procedure, be it mathematical or numerical, depends on the particular choice of the features used by the classifier. Feature selection in pattern recognition consists of the derivation of salient features present in the raw input data in order to reduce the amount of data used for classification. For the successful face recognition, the database images must have sufficient information so that when presented with the probe image, the recognition must be possible. Majority of times, there is always excess information present in the database images, leads higher storage, hence optimum size of the images needs to be stored in the database for good performance, are compressed with reduction in frame size and then compressed with that of the DCT.

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1. INTRODUCTION

Currently there are a wide variety of algorithms used in the field of face recognition. Some of them include principle component analysis (PCA), independent component analysis (ICA) [1], linear discriminant analysis (LDA), eigen space based approach, and Kernel methods. Of late, there has been great interest growing in the area of 3-D face recognition [2, 3], main novelty of the approach is the ability to compare surfaces independent of natural deformations resulting from facial expressions. First, the range image and the texture of the face are acquired. Next, the range image is preprocessed by removing certain parts such as hair [4], which can complicate the recognition process. Finally, a canonical form of the facial surface is computed [5]. Such a representation is insensitive to head orientations and facial expressions, thus significantly simplifying the recognition procedure. The recognition itself is performed on the canonical surfaces [6]. PCA [7] is the most popular technique for feature selection and dimensionality reduction. The methodology of PCA involves deriving the orthogonal projection basis using the standard de-correlation technique.

This leads to dimensionality decrease and possibly to feature selection. Under the PCA recognition technique, eigenfaces used and this eigen faces defines a component space or 'face space, which quickly decreases the dimensionality of the first space, and face location and identification is carried out in the reduced space. Generally, PCA uses the 2nd order data only and it un-correlates the data since PCA derives only the most expressive features for face reconstruction rather than face classification, one could generally use some subsequent discriminant analysis [8, 9] to enhance PCA performance. In this work, the images are

compressed with reduction in frame size [10] and then reduced with that of the DCT [11] to realize the benefits of both frame size reduction compression and DCT compression.

For the effective face recognition, the database images must have adequate data the size of the images can be shrinking to the necessary size [12] and stored in the database. By shrinking the size of the images, there will be loss of data at the same time, it very well may be put away in huge numbers and transmission of the pictures over the system is quick. The loss of data prompts disappointment [13] of the calculations in the recognition of the subjects in the images. Particularly, the data relating to iris [14] will be lost harshly. Advances have been made around there of research.

One of the major drawbacks in the face recognition [15], utilizing compacted images is the image must be in the decompressed mode. The face recognition frameworks would benefit if full decompression could some way or another be wiped out. Means the face recognition is done while the images are in compact mode and it would also speed up and by and large execution of a face recognition framework. JPEG and their related transformations discrete cosine transform and discrete wavelet transform are most popular compression techniques. These techniques dealt with that normal imagecompressionstandards such as JPEG and JPEG2000 havea greaternumber of applications in real life, because the image will be decompressed and presented to a human sooner or later. It is required to store huge number of images in a given space in the compressed form of gray images using different compressions methodsbutit affects the face recognition when the image is compressed with normal transformation method.

In this work, it is verified to check if the face recognition algorithms, based on the global feature recognition can recognize the faces. For this purpose, PCA is chosen for the global feature recognition. Also, several reconstruction algorithms were evaluated for their performance along with the PCA. On the size compressed images [16, 17], images are again applied with DCT for further compression and their face recognition is tested and important conclusions are drawn. Figure 1 shows different face recognition methods such as feature extraction and classification in feature extraction DCT and DWT techniques are used where as classification carries with neural network.

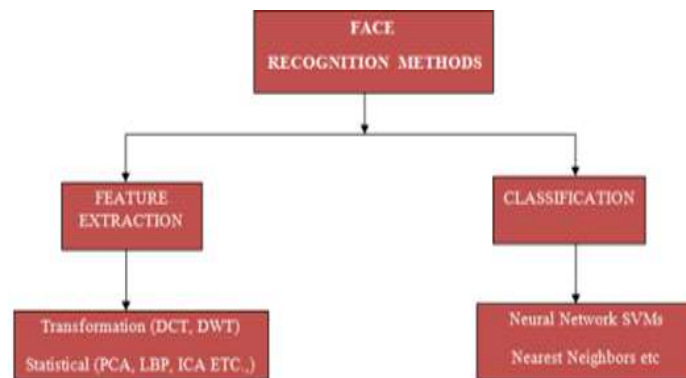


Figure 1. Face recognition methods

In this research work, the images are compressed with reduction in frame size than with that of the DCT for further compression. As an extension to the proposed algorithm using the frame size reduction, the DCT is applied to smaller frame size images to realize the benefits of both frame size reduction compression and DCT compression. The rest of the paper is organized as follows. The Section 2 is a research method, that describes the proposed method of frame size reduction and DCT based compression technique. In Section 3 the corresponding results and discussions explained. Conclusion given in Section 5 respectively.

2. RESEARCH METHOD

A face recognition method, which is based on frame size reduction and DCT based compression using PCA algorithm is being carried out in this work. The methods we used and the work flow is describing in this section.

2.1. Face recognition with PCA algorithm

Principal component analysis is a mathematical procedure that changes number of correlated variables into a number of uncorrelated variables called principal components. It finds a compact dataset [18, 19]. At

first, the principal component is taken along the direction of the maximum variance. 2nd component is in the subspace perpendicular to the 1st component within this subspace, this component points the direction of maximum variance. 3rd component taken in maximum variance in subspace direction perpendicular to 1st two and so on. PCA is a general statistical system that changes multivariate information with correlated variables into one with uncorrelated variables.

A 2D image made up of pixels arranged in the form of a matrix. Every pixel has three basic colors red, green and blue. The color intensity of each pixel is represented by an integer between 0 and 255. Hence, the image can be represented by three matrices equal to the size of the image. If the image size 180x200 pixels, then 3 individual matrices of size 180x200 required to represent this image. A gray image will one matrix of pixels. A 2D image can be transformed to 1D vector by concatenating all rows one after the other into a long thin vector, a column vector c_i . This operation can also be performed column wise to get a long thin vector.

A 2D picture made up of pixels organized as a grid. Every pixel has three qualities spoke to for three essential hues red, green and blue. The shading force of every pixel is spoken to by a whole number and is typically in the range somewhere in the range of 0 and 255. Consequently, the picture can be spoken to by a three networks of size equivalent to the size of the picture. If the picture size 180x200 pixels, at that point it tends to be spoken to by 3 individual lattices of size 180x200. A dark picture will have one network speaking to the pixels. A 2D picture can be changed to 1D vector by connecting all lines in a steady progression into a long dainty vector, a section vector c_i . This activity can likewise be performed segment savvy to get a long dainty vector.

All the images can be averaged to get a mean image. The idea of mean image is just scientific in the sense thus not conveys any physical any physical significance. The focused image with respect to mean image can be found by subtracting mean image from each image. W is the matrix composed by placing the column vectors c_i of all images side by side. If 180x200 is the size of image, the column vector c_i is of size 36,000. If there are 20 images in the training set, the size of W is 36,000x20. The covariance matrix can be defined by the (1).

$$Q = WW^T \quad (1)$$

Hence the size of covariance matrix becomes $N \times N$. For example, for the image size of 180 x 200 pixels, the size of the covariance matrix Q becomes 36000x36000 which is huge for solving the covariance matrix for eigen values and eigen vectors. The eigen vectors corresponding to the biggest eigen values are the eigen faces.

The eigen vectors can be computed for each of the non-zero eigen value and sorted out in descending order based on the eigen values. The eigen vector relating to the biggest eigen vector is the one with most prominent change among all images and the eigen vector comparing to the smallest eigen esteem is the one with least variance. We keep largest eigen vectors and these are corresponding to dataset or known images. Now for probe images or unknown images, same steps repeated to get eigen vectors and eigen values. The both database and probe images are projected on to the new dimensional space of eigen vectors and euclidean distance between them calculated using $\sqrt{(x-s)^2 + (y-t)^2}$. The image with least euclidean distance is the closest image to the probe image.

The number of eigen values is equal to size of the Co-variance matrix. However, it is possible to consider only the eigen vectors of largest eigen values, after arranging them in descending order that contribute to a certain percentage of total variance, e.g. say 95% variance.

2.2. Reconstruction of database images back to size of probe images

In this work, the image is compressed and stored using the BOX algorithm and reconstructed back to original size using BOX, TRIANGLE, NEAREST, CUBIC, BILINEAR, BICUBIC, LANCZOS2, LANCZOS3 algorithms [20].

2.2.1. Box interpolation

In this work images from a small database are considered for the face recognition purpose. There are 10 images which are taken from 10 different people. There two sets of the images, namely database set and probe set. The probe set has 10 images and the database set has 20 images and each person has two expression of the face, totaling to 20 images. The database has been modified to 9 different sizes in this work to reduce the size of the database. Original size of the image is 180 x 200 pixels. When the image is compressed to 10% of its original size the image size becomes 18x20 pixels. For each image, apart from the original image, the images are compressed to 90%, 80%, 70%,....., 10% using the BOX interpolation

technique. Hence the purpose of this research work is to find out if the images that are stored in smaller sizes are indeed recognizable.

In BOX interpolation techniques, the average of a set of adjacent pixels is computed. For example, every pixel is surrounded by eight pixels around it. The average of all the nine pixels are computed and stored as one pixel for the set of all nine pixels. That means the nine pixels in a group of 3x3 will be reduced to one pixel. In the next computations, the adjacent 3x3 cells are considered and then its average value is computed. With this approach, the size of the image is reduced to 9:1. The size of the cell need not be constant. It can be taken 2x2, 2x3, 3x4, 3x1 etc depending upon the level of compression required.

2.2.2. Triangle interpolation

Let there be three points 1, 2 and 3, as shown in Figure 2, which are the pixel values that are used to find the pixel value located at point 6. To find the pixel value at point 6, the pixel values at point 4 and 5 are to be found by linear interpolation. The point 1 and 3 are used to interpolate point 4 and points 2 and 3 are used to interpolate 5. Once the pixel values at 4 and 5 are known, then the pixel value at point 6 can be interpolated.

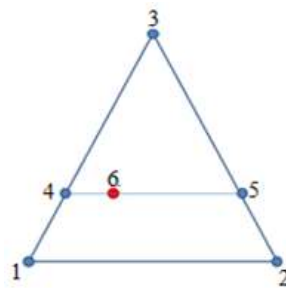


Figure 2. Triangle interpolation

2.2.3. Nearest neighbour interpolation

In this type of interpolation, when pixels are enlarged as in the case of zooming, the nearest neighbor pixel values are copied. In Figure 3(a), the pixels of 4 x 4 sizes are to be enlarged to 8 x 8. When it is enlarged, the space between two neighboring pixels will have zero value, which is shown as white cell in Figure 3(b) (it is black in color since no value is assigned). The zero value cells are filled with the nearest neighbor values and finally the 8 x 8 grid will become like the one shown in Figure 3(c).

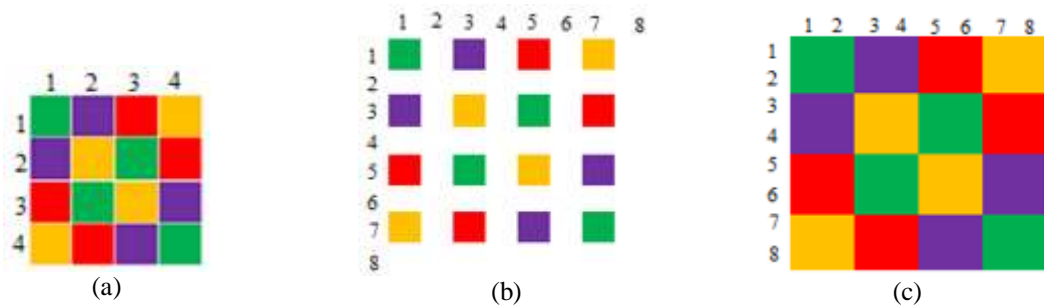


Figure 3. (a) 4X4 image (b) Interpolated image (c) Nearest neighbour interpolation

2.2.4. Cubic interpolation

Let (x_k, x_{k+1}) be the two points between which the interpolation needs to be made. Let x be the interpolation point between (x_k, x_{k+1}) . The interpolation function is given by the (2).

$$p(x) = h_{00}(t)p_k + h_{10}(t)(x_{k+1} - x_k)m_k + h_{01}(t)p_{k+1} + h_{11}(t)(x_{k+1} - x_k)m_{k+1} \tag{2}$$

Where

$$t = \frac{(x-x_k)}{(x_{k+1}-x_k)} \tag{3}$$

$$h_{00}(t) = 2t^3 - 3t^2 + 1 \tag{4}$$

$$h_{10}(t) = t^3 - 2t^2 + t \tag{5}$$

$$h_{01}(t) = -2t^3 + 3t^2 \tag{6}$$

$$h_{11}(t) = t^3 - t^2 \tag{7}$$

p_k : Starting point at x_k , p_{k+1} : Ending point at x_{k+1} , m_k : Tangent at starting point at x_k , m_{k+1} : Tangent at ending point at x_{k+1} and h is the Hermite basis functions.

2.2.5. Bilinear interpolation

Bilinear interpolation is an extension of linear interpolation in two directions, namely, x and y directions, for interpolating pixel values on a rectilinear 2D grid. Figure 4 shows the pixels located four at red dots, indicated by the red dots with designations P_{11} , P_{12} , P_{21} and P_{22} . These four points need to be interpolated to a point indicated by green dot designated by P . The coordinates of the points P_{11} , P_{12} , P_{21} and P_{22} are (x_1, y_1) , (x_1, y_2) , (x_2, y_1) and (x_2, y_2) , respectively. The coordinate of the point P is (x, y) . To determine the value of the unknown function f at the point (x, y) , the interpolation must be done in the x and y directions. The linear interpolation in the x -direction is given by:

$$f(x, y_1) \approx \frac{(x_2-x)}{(x_2-x_1)} f(P_{11}) + \frac{(x-x_1)}{(x_2-x_1)} f(P_{21}) \tag{8}$$

$$f(x, y_2) \approx \frac{(x_2-x)}{(x_2-x_1)} f(P_{12}) + \frac{(x-x_1)}{(x_2-x_1)} f(P_{22}) \tag{9}$$

Extending linear interpolation in the y -direction also,

$$f(x, y) \approx \frac{(y_2-y)}{(y_2-y_1)} f(x, y_1) + \frac{(y-y_1)}{(y_2-y_1)} f(x, y_2) \tag{10}$$

$$f(x, y) \approx \frac{(y_2-y)}{(y_2-y_1)} \left[\frac{(x_2-x)}{(x_2-x_1)} f(P_{11}) + \frac{(x-x_1)}{(x_2-x_1)} f(P_{21}) \right] + \frac{(y-y_1)}{(y_2-y_1)} \left[\frac{(x_2-x)}{(x_2-x_1)} f(P_{12}) + \frac{(x-x_1)}{(x_2-x_1)} f(P_{22}) \right] \tag{11}$$

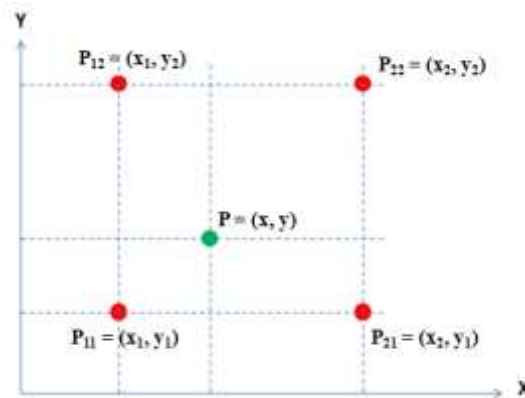


Figure 4. Two-dimensional grid for the BOX interpolation

2.2.6. Bicubic interpolation

Bicubic interpolation may be considered as an extension to the cubic interpolation but on a two-dimensional grid. The interpolation surface can be determined as:

$$p(x, y) = \sum_{i=0}^3 \sum_{j=0}^3 a_{ij} x^i y^j \tag{12}$$

There are 16 coefficients a_{ij} needed to be determined based on $p(x, y)$.

$$p(0,0) = a_{00} \tag{13}$$

$$p(1,0) = a_{00} + a_{10} + a_{20} + a_{30} \tag{14}$$

$$p(0,1) = a_{00} + a_{01} + a_{02} + a_{03} \tag{15}$$

$$p(1,1) = \sum_{i=0}^3 \sum_{j=0}^3 a_{ij} \tag{16}$$

The equations for derivatives and cross derivatives include

$$p_x(0,0) = a_{10} \tag{17}$$

$$p_x(1,0) = a_{10} + 2a_{20} + 3a_{30} \tag{18}$$

$$p_x(0,1) = a_{10} + a_{11} + a_{12} + a_{13} \tag{19}$$

$$p_x(1,1) = \sum_{i=0}^3 \sum_{j=0}^3 a_{ij} i \tag{20}$$

$$p_y(0,0) = a_{01} \tag{21}$$

$$p_y(1,0) = a_{01} + a_{11} + a_{21} + a_{31} \tag{22}$$

$$p_y(0,1) = a_{01} + 2a_{02} + 3a_{03} \tag{23}$$

$$p_y(1,1) = \sum_{i=0}^3 \sum_{j=0}^3 a_{ij} j \tag{24}$$

$$p_{xy}(0,0) = a_{11} \tag{25}$$

$$p_{xy}(1,0) = a_{11} + 2a_{21} + 3a_{31} \tag{26}$$

$$p_{xy}(0,1) = a_{11} + 2a_{12} + 3a_{13} \tag{27}$$

$$p_{xy}(1,1) = \sum_{i=0}^3 \sum_{j=0}^3 a_{ij} ij \tag{28}$$

2.2.7. Lanczos2 interpolation

Let s_{ij} be the two-dimensional signal at two points i and j . The interpolation function is given by

$$S(x, y) = \sum_{i=|x|-1}^{|x|+2} \sum_{j=|y|-1}^{|y|+2} s_{ij} L(x - i) L(y - j) \tag{29}$$

Where

$$L(x) = \begin{cases} \text{sinc}(x) \text{sinc}\left(\frac{x}{2}\right) & \text{if } -2 < x < 2 \\ 0 & \text{otherwise} \end{cases} \tag{30}$$

2.2.8. Lanczos3 interpolation

Let s_{ij} be the two-dimensional signal at two points i and j . The Lanczos3 interpolation function is given by,

$$S(x, y) = \sum_{i=|x|-2}^{|x|+3} \sum_{j=|y|-2}^{|y|+3} s_{ij} L(x - i) L(y - j) \tag{31}$$

Where

$$L(x) = \begin{cases} \text{sinc}(x) \text{sinc}\left(\frac{x}{3}\right) & \text{if } -3 < x < 3 \\ 0 & \text{otherwise} \end{cases} \tag{32}$$

2.3. Frame size reduction and DCT compression with PCA face recognition algorithm

Figure 5 shows the flow chart of face recognition [21] of the size reduced and DCT compressed images using PCA [22] in which Global feature-based [23] face recognition is used. Steps involved in this algorithm are explained below.

- Step 1: Select the database images in uncompressed form of size $M \times N$ for face recognition.
- Step 2: Reduce the size of the images using BOX interpolation method to a p percentage (50%, 25%, 10% or 5% of original size) to a size of $m \times n$, where $m = pM/100$ and $n = pN/100$ so that $m < M$ and $n < N$.
- Step 3: Using DCT, frame size reduced images converted into set of transform coefficients.
- Step 4: Quantizer converts this transform coefficients into compressed code.
- Step 5: Encoder represents set of symbols from the quantized code.
- Step 6: Store the encoded and compressed images in the database.
- Step 7: When a probe image is presented to the face recognition systems, the probe image is collected in the size $M \times N$.
- Step 8: Decode the coded coefficients of the compressed images that is stored in the database
- Step 9: Inverse Quantizer gives decompressed coded coefficients.
- Step 10: Inverse DCT to get the pixel values
- Step 11: Reconstruct the images back into the size $M \times N$ from the any of the eight interpolation methods namely BOX, TRIANGLE, NEAREST, CUBIC, BILINEAR, BICUBIC, LANCZOS2, LANCZOS3 algorithms.
- Step 12: Compare the probe image with the set of all reconstructed images using PCA face recognition algorithm.
- Step 13: Read all the reconstructed images from the database.
- Step 14: Extract RGB components of the reconstructed images from the database.
- Step 15: Convert RGB of reconstructed images from the database into grayscale images.
- Step 16: Convert pixel values of each image into a vector and create a matrix of vectors of all grayscale images.
- Step 17: Compute mean values of grayscale images of the database.
- Step 18: Calculate the deviation of each grayscale image from the center image.
- Step 19: Compute Eigen values and Eigenvectors from the covariance matrix.
- Step 20: Create a set of Eigen faces from the Eigenvectors and image vectors
- Step 21: Create projected images from the Eigen faces
- Step 22: Similarly create projected image of the probe image face
- Step 23: Compare projected images of the database with probe image using Euclidean distance.
- Step 24: If the minimum Euclidean distance is less than a threshold, then treat it as a match.
- Step 25: If any of the reconstructed images matches with the probe image, then display the reconstructed image and the file name.
- Step 26: Else, display "No match found for the probe image".

2.4. Face recognition on COLOR FERET database with PCA

In order to test database for the successful face recognition, COLOR FERET database that is shown Figure 6, is chosen and tested. There are 100 images in the database with a frame size of 300×200 pixels for each of the image. The images are again compressed to sizes 50%, 25%, 10% and 5% of the original frame size and stored in the train database. PCA [24, 25] is applied to these images for face recognition [26] of the probe image with all the eight reconstruction interpolation algorithms as explained above.

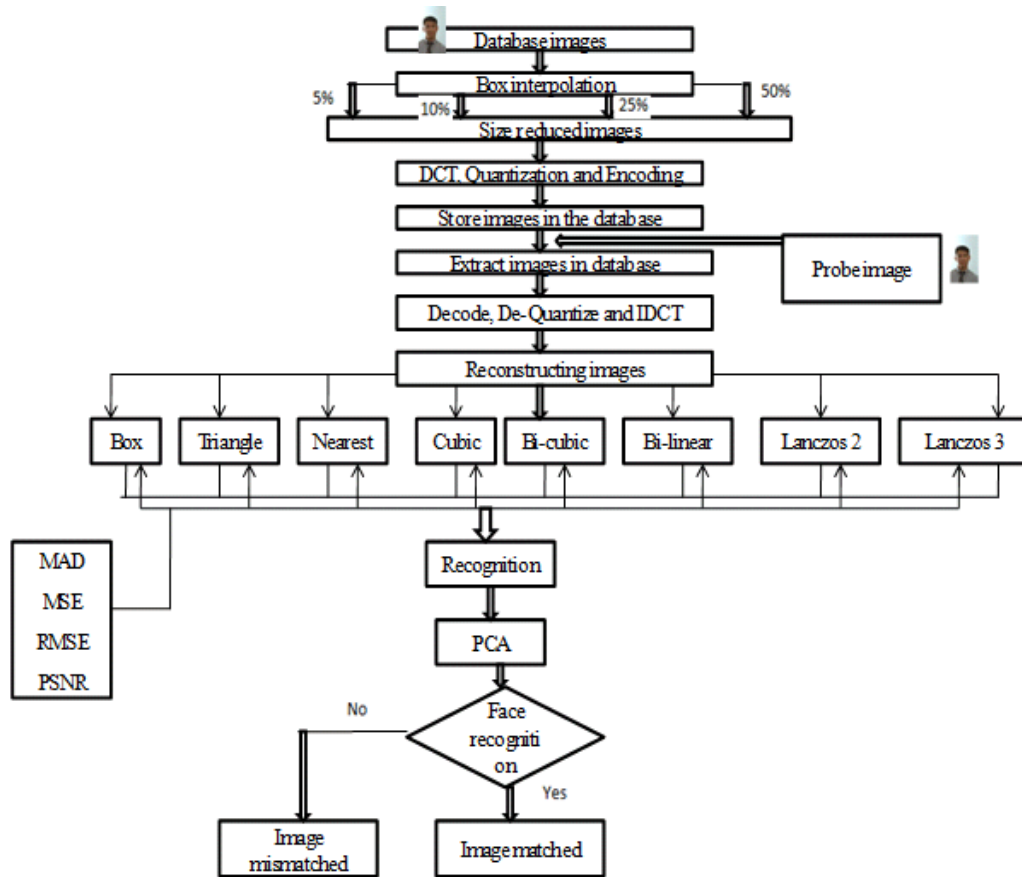


Figure 5. Flowchart of proposed face recognition algorithm

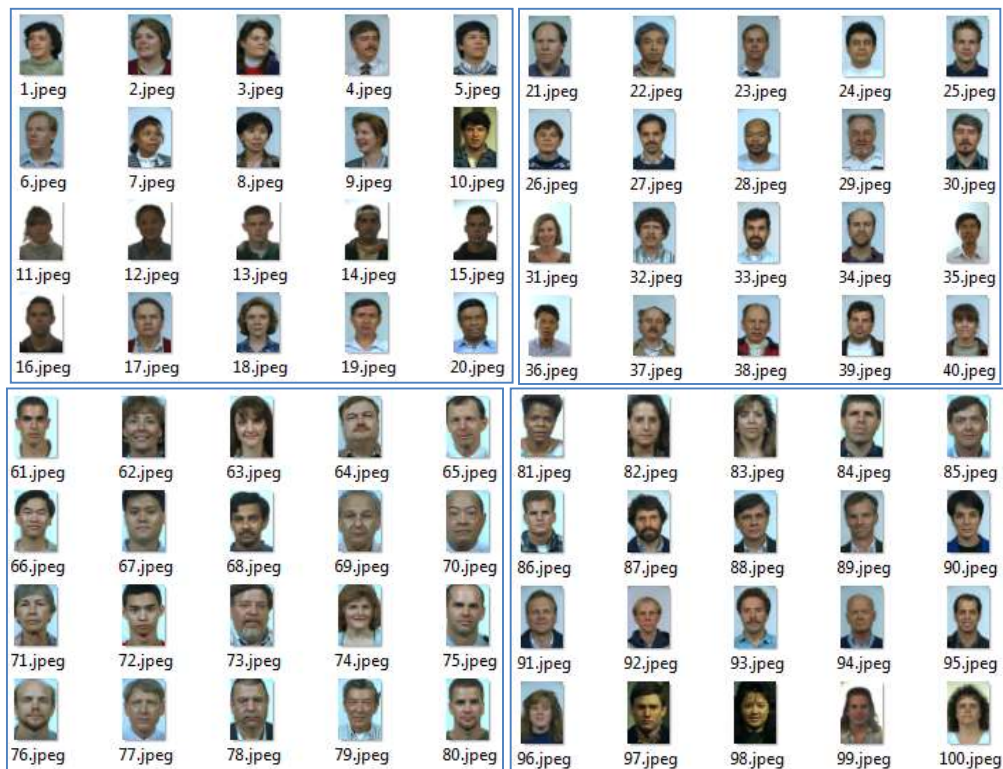


Figure 6. Face image of COLOR FERET database

3. RESULTS AND DISCUSSION

This work deals with the face recognition [27] of the SIZE as well as JPEG compressed images using PCA. In this work, the images are JPEG compressed [28] after the images are SIZE compressed. That means, the SIZE compressed images are usually stored in the JPEG format after compressions with appropriate quantization. Those images can be retrieved with inverse DCT and verified for the face recognition using PCA. The images are size compressed first to 50%, 25%, 10% and 5% and they are compressed again using DCT with appropriate quantization and stored. These images are decompressed using IDCT and then reconstructed back to different algorithms to compare with PCA.

3.1. Face recognition with PCA-DCT

COLOR FERET database images are used with PCA and LBP for the purpose of face recognition on the SIZE and JPEG compressed images. Table 1 shows the percentage recognition of the images for PCA-DCT algorithm [29] for COLOR-FERET database. For example, images of 50% size are verified for face recognition against the original probe images. It can be seen that when TRIANGLE, CUBIC, BILINEAR, BICUBIC, LANCZOS2 and LANCZOS3 methods are used for reconstruction, only 41 out of 100 images are successfully recognized with PCA-DCT and hence the percentage of recognition is 41%.

Table 1. Percentage recognition of the images for PCA-DCT algorithm for several reconstruction methods on COLOR FERET

PCA-DCT	Image Reconstruction Method							
	Box	Triangle	Nearest	Cubic	Bilinear	Bicubic	Lanczos2	Lanczos3
Original	52	53	52	53	53	53	53	53
50% Size	40	41	40	41	41	41	41	41
25% Size	23	27	23	26	27	26	26	26
10% Size	18	20	18	20	20	21	21	23
5% Size	19	25	19	18	18	18	19	21

Similarly, for 25% size, the best yield comes from TRIANGLE and BILINEAR methods for PCA-DCT which is 27%. For the case of 10% size, the best yield for PCA-DCT is from LANCZOS3 with 23. This is a huge reduction in the recognition rate when DCT is also considered into compression for 25% and 10% size reduction cases. For 5% size, maximum recognition given by TRINAGLE method for PCA-DCT which is 25%.

This is again a huge reduction in the recognition rate when DCT is also considered into compression. One can observe that the PCA-DCT recognizes the images with original size itself with a maximum recognition rate of 53%. There is reduction seen in the percentage recognition when the compression ratio is reduced from 50% to 25%. But at 25%, 10% and 5% size reduction cases almost yield the similar results. Table 2 shows Normalized percentage recognition of the images using several reconstruction methods of PCA-DCT algorithms on COLOR FERET with respect to 53% of maximum recognition rate.

Table 2. Normalized percentage recognition of the images for PCA-DCT algorithm for several reconstruction methods on COLOR FERET

PCA-DCT	Image Reconstruction Method							
	Box	Triangle	Nearest	Cubic	Bilinear	Bicubic	Lanczos2	Lanczos3
Original	98.11	100.00	98.11	100.00	100.00	100.00	100.00	100.00
50% Size	75.47	77.36	75.47	77.36	77.36	77.36	77.36	77.36
25% Size	43.40	50.94	43.40	49.06	50.94	49.06	49.06	49.06
10% Size	33.96	37.74	33.96	37.74	37.74	39.62	39.62	43.40
5% Size	35.85	47.17	35.85	33.96	47.17	33.96	35.85	39.62

4. CONCLUSION

In this work, new image compression techniques are developed for the purpose of face recognition. In order to achieve this, current compression techniques are understood along with the face recognition systems. This method of image compression is based on reducing the frame size of the images to store them in the database to mitigate the limitations of the compressions based on transformation techniques like DCT or DWT. However, to avail the benefits of compression, based on frame size reduction and DCT, the DCT compression is also carried out on the frame size reduced images which will provide the double benefit of compression based on frame size reduction and DCT. Two face recognition systems PCA is used to analyze successful face recognition rates with DCT compression.

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