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International Journal of Current Research
Vol. 6, Issue, 12, pp.10516-10526, December, 2014

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

FACE RECOGINATION USING PCA ALGORITHM WITH MATLAB

Viky Bagde and *Moresh Mukhedkar

Department of Electronics and Telecommunication, Pune University Dr. D. Y. Patil College of Engineering, Ambi, Pune Maharashtra, India

ARTICLE INFO

Article History:
Received 24th September, 2014
Received in revised form
26th October, 2014
Accepted 09th November, 2014
Published online 27th December, 2014

Key words:
Matlab,
PCA and LDA Algorithms,
Insert formatting.

ABSTRACT

This project is mainly focussed on the recognition of face for security purpose. But it could also be used to obtain quick access to medical, criminal, or any type of records. Solving this problem is important because it could allow personnel to take preventive action, provide better service - in the case of a doctor's appointment, or allow a person access to a secure area. This project work is proposed to design using MATLAB. In this project we are using PCA algorithms for saving database of image i.e. different expressions of face and detection of the face for security reasons. A face recognition system generally consists of four modules as face localization, normalization, feature extraction, and matching. There was a dormant period in automatic face recognition until the work by Sir Ovich and Kirby on a low dimensional face representation. This was derived using the Karhunen–Loeve Transform or Principal Component Analysis (PCA). It is the pioneering work of Turk and Pentl and on Eigen-face that reinvigorated face recognition research. Other major milestones in face recognition include: the Fisher face method, which applied Linear Discriminate Analysis (LDA). LDA method is used after a PCA step to achieve higher accuracy. Local filters such as Gabor jets are used to provide more effective facial features. The design of the Adaboost learning based cascade classifier architecture is used for real time face detection.

INTRODUCTION

In the current scenario at social, industrial, national and international levels security is a matter of highest concern. Person identification and subsequent decisions are at the helm of affairs in most of the security systems. Thus face recognition i.e. the core issue in personnel identification is of very high importance in a broad range of applications. Though a lot of research efforts are being dedicated to robust face recognition, universal algorithms and systems are far distant dreams. Most of the advanced face recognition systems though claim to achieve around 90% face recognition rather classification efficiencies, their efficiencies drastically reduce if the situations like illumination, face orientation, image size variation, adult features, ornaments, hairstyles, bared end moustaches etc come into picture. Most of the available work computes the statistical features of face images and try to invent new and efficient classifiers, thus most of the works finally end up with a few new or modified features and again a new or modified mathematical classifier. The facial image features can be categorized in here categories:

- Organic features these correspond to features of lips, nose, eyes etc like contour shapes and characteristic dimensions.
- Morphological features they include face contour, chin structure, cheek bone locations and their distance from the chin point, forehead structure etc.
- Adult features like beard, moustaches, ornaments, hairstyle and other add-ons like cap etc.

In this work we intend to concentrate on the first two features. These features may also be called as local features in a few published papers. The published work also doesn't pay any attention to how human beings are executing the task of face recognition. In the proposed work, we present a heuristic combination of selection and computation of local features like human beings and then classification using statistical techniques namely Principal Component Analysis (PCA). The local features are separated in terms of lips, nose and eyes. These features will have major contribution in the final matching scores.

The second major contribution will be from the morphological features. The add-on features do not contribute to the matching score at this level. We have constructed one facial orientation of twenty persons. Maximum matching score with any one orientation will be considered for computation of final matching scores. A query image will be matched with the all twenty database image entries, the final matching scores will

****Corresponding author: Moresh Mukhedkar***
Electronics and Telecommunication Department, Pune University Dr. D. Y. Patil College of Engineering,, Ambi,Pune Maharashtra, India

be organized in descending order. The image with the least error from the query image will be considered as the potential match. Face identification involves one-to-many matching that compares a query face against multiple faces in the enrollment database to associate the identity of the query face to one of those in the database. In some identification applications, one just needs to find the most similar face. In a watch list check or face identification in surveillance video, the requirement is more than finding most similar faces a confidence level threshold is specified and all those faces whose similarity score is above the threshold are reported. The performance of a face recognition system largely depends on a variety of factors such as illumination as facial pose, expressions, facial wear and motion.

Processing Workflow

Face recognition is a visual pattern recognition problem, where the face, represented as a three dimensional object that is subject to varying illumination, pose, expression, and other factors, needs to be identified based on acquired images. While two dimensional face images are commonly used in most applications, certain applications requiring higher levels of security demand the use of three dimensional images or optical images beyond the visual spectrum. A face recognition system generally consists of four modules as depicted in Figure 3.2 face localization, normalization, feature extraction, and matching. These modules are explained below. Face detection segments the face area from the background. In the case of video, the detected faces may need to be tracked across multiple frames using a face tracking component. While face detection provides a coarse estimate of the location and scale of the face, face land marking localizes facial landmarks. This may be accomplished by a land marking module or face alignment module.

Face normalization is performed to normalize the face geometrically and photo metrically. This is necessary because state of the art recognition methods are expected to recognize face images with varying pose and illumination. The geometrical normalization process transforms the face into a standard frame by face cropping. Warping or morphing may be used for more elaborate geometric normalization. The photometric normalization process normalizes the face based on properties such as illumination and gray scale. Face feature extraction is performed on the normalized face to extract salient information that is useful for distinguishing faces of different persons and is robust with respect to the geometric and photometric variations. The extracted face features are used for face matching. In face matching the extracted features from the input face are matched against one or many of the enrolled faces in the database. The output is the identity of the input face when the top match is found with sufficient confidence or unknown when the tip match score is below a threshold. The accuracy of face recognition systems highly depends on the features that are extracted to represent the face which, in turn, depend on correct face localization and normalization.

Litreture Review

Face recognition is a task that humans perform routinely and effortlessly in our daily lives. Wide availability of powerful and low cost desktop and embedded computing systems has created an enormous interest in automatic processing of digital images in a variety of applications, including biometric authentication, surveillance, human computer interaction, and multimedia management. Research and development in automatic face recognition follows naturally. Face recognition has several advantages over other biometric modalities such as fingerprint and iris: besides being natural and nonintrusive, the most important ad-vantage of face is that it can be captured at a distance and in a covert manner. Among the six biometric attributes considered by Hietmeyer , facial features scored the highest compatibility in a Machine Readable Travel Documents (MRTD) (Hietmeyer, 2000), system based on a number of evaluation factors, such as enrollment, renewal, machine requirements, and public perception, shown in Figure 3.1 Face recognition.

The first automated face recognition system was developed by Takeo Kanade in his Ph.D. thesis work in 1973. There was a dormant period in automatic face recognition until the work by Kirby and Sirovich on a low dimensional face representation, derived using the Karhunen Loeve Transform or Principal Component Analysis (PCA). . Other major milestones in face recognition includes Fisherface method (Belhumeur *et al*), which applied Linear Discriminant Analysis (LDA) after a PCA step to achieve higher accuracy the use of local filters such as Gabor jets to provide more effective facial features and the design of the AdaBoost learning based cascade classifier architecture for real time face detection.

Strategies

There are two strategies for tackling the challenges outlined (i) extract invariant and discriminative face features (ii) construct a robust face classifier. A set of features, constituting a feature space, is deemed to be good if the face manifolds are simple (i.e., less nonlinear and non-convex). This requires two stages of processing: (1) normalizing face images geometrically and photo metrically and (2) extracting features in the normalized images, such as using Gabor wavelets and LBP (local binary pattern), that are stable with respect to possible geometric and photometric variations. A powerful classification engine is still necessary to deal with difficult non linear classification and regression problems in the constructed feature space. This is because the normalization and feature extraction cannot solve the problems non linearity. The two stages of processing may be designed jointly using learning methods. Properties of the features and relations (e.g., areas, distances, angles) between the features were used as descriptors for face recognition. Advantages of this approach include economy and efficiency when achieving data reduction and insensitivity to variations in illumination and viewpoint. However, facial feature detection and measurement techniques developed to date are not sufficiently reliable for the geometric feature-based recognition.

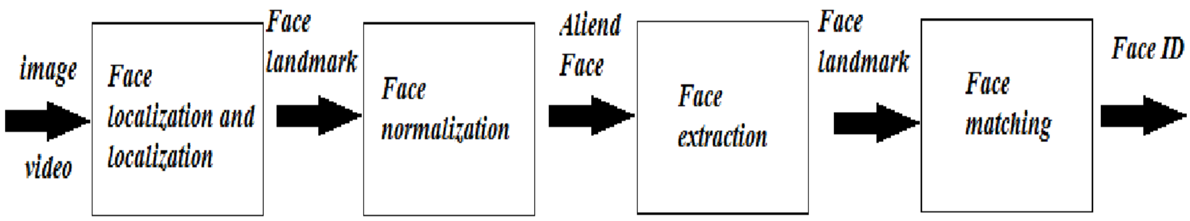

Figure 1. Depiction of face recognition processing flow

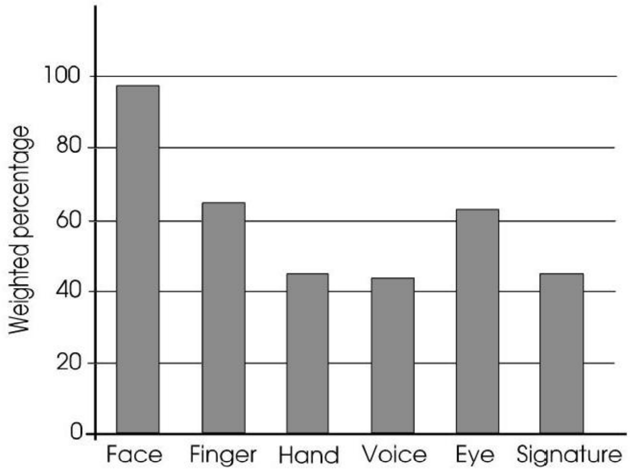

Figure 3.1. A scenario of using biometric MRTD systems for passport control (left), and a comparison of various biometric traits based on MRTD compatibility (from Hietmeyer, 2000)

Further, geometric properties alone are inadequate for face recognition because rich information contained in the facial texture or appearance is not utilized. These are the main reasons why early feature based techniques were not effective. During the learning, both prior knowledge about face(s) and variations encountered in the training data are taken into consideration. The appearance based approach, such as PCA and LDA based methods, has significantly advanced face recognition technology. Using PCA, an optimal face subspace is constructed to represent only the face object using LDA, a Discriminant subspace is constructed to distinguish faces of different persons. It is now well known that LDA based methods generally yields better results than PCA-based methods. These linear, holistic appearance based methods encode prior knowledge contained in the training data and avoid instability of manual selection and tuning needed in the early geometric feature based methods.

Nonlinear subspace methods use nonlinear transforms to convert a face image into a feature vector in a discriminative feature space. Kernel PCA and kernel LDA use kernel tricks to map the original data into a high-dimension space to make the data separable. Manifold learning, which assumes that face images occupy a low dimensional manifold in the original space, attempts to model such manifolds. These include ISOMAP. Although these methods achieve good performance on the training data, they tend to over fit and hence do not generalize well to unseen data.

The most successful approach to date for handling the non-convex face distribution works with local appearance based features extracted using appropriate image filters. This is advantageous in that distributions of face images in local feature space are less affected by the changes in facial appearance. Early work in this direction included local features analysis (LFA) and Gabor wavelet based features. Current methods are based on local binary pattern (LBP) and many variants (for example ordinal feature, Scale-Invariant Feature Transform (SIFT), and Histogram of Oriented Gradients (HOG). While these features are general purpose and can be extracted from arbitrary images, face specific local filters may be learned from images.

A large number of local features can be generated by varying parameters associated with the position, scale, and orientation of the filters. For example, more than 400 000 local appearance features can be generated when an image of size 100 × 100 is filtered with Gabor filters with five different scales and eight different orientations for all pixel positions. While some of these features are useful for face recognition, others may be less useful or may even degrade the recognition performance. Boosting based methods have been implemented to select good local features. A Discriminant analysis step can be applied to further transform the space of the selected local features to discriminative subspace of a lower dimensionality to achieve better face classification.

FUNCTIONALITY

The Face Recognitions is analyzed by using the RECOGINATION and PCA algorithms. The algorithms are as follows:

RECOGNITION

```
function [outputimage]=Recognition(T,m1, Eigenfaces,
ProjectedImages, imageno);
MeanInputImage=[];
[fname pname]=uigetfile('*.jpg','Select the input image for
recognition');
InputImage=imread(fname);
InputImage=rgb2gray(InputImage);
InputImage=imresize(InputImage,[200
180],'bilinear');%resizing of input image. This is a part of
preprocessing techniques of images
[m n]=size(InputImage);
imshow(InputImage);
Imagevector=reshape(InputImage',m*n,1);%to get elements
along rows as we take InputImage'
MeanInputImage=double(Imagevector)-m1;
ProjectInputImage=Eigenfaces'*MeanInputImage;% here we
get the weights of the input image with respect to our
eigenfaces
% next we need to euclidean distance of our input image and
compare it
% with our face space and check whether it matches the
answer...we need
% to take the threshold value by trial and error methods
Euclideandistance=[];
for i=1:T
   temp=ProjectedImages(:,i)-ProjectInputImage;
   Euclideandistance=[Euclideandistance temp];
end
% the above statements will get you a matrix of Euclidean
distance and you
% need to normalize it and then find the minimum Euclidean
distance
tem=[];
for i=1:size(Euclideandistance,2)
   k=Euclideandistance(:,i);
   tem(i)=sqrt(sum(k.^2));
end
% We now set some threshold values to know whether the
image is face or not
% and if it is a face then if it is known face or not
% The threshold values taken are done by trial and error
methods
[MinEuclid, index]=min(tem);
if(MinEuclid<0.8e008)
if(MinEuclid<0.35e008)
   outputimage=(strcat(int2str(index),'.jpg'));
   figure,imshow(outputimage);
   switch index % we are entering the name of the persons in
the code itself
      % There is no provision of entering the name in real time
      case 1
         disp('Jonathan Swift');
         disp('Age=22');
      case 2
         disp('Eliyahu Goldratt');
         disp('Age=25');
      case 3
         disp('Anpage');
         disp('Age=35');
      case 4
         disp('Rizwana');
         disp('Age=30');
      case 5
         disp('Rihana');
         disp('Age=48');
      case 6
         disp('Seema');
         disp('Age=19');
      case 7
         disp('Kasana');
         disp('Age=27');
      case 8
         disp('Hanifa');
         disp('Age=33');
      case 9
         disp('Alefiya');
         disp('Age=22');
      case 10
         disp('Mamta');
         disp('Age=50');
      case 11
         disp('Mayawati');
         disp('Age=39');
      case 12
         disp('Elizabeth');
         disp('Age=87');
      case 13
         disp('Cecelia Ahern');
         disp('Age=78');
      case 14
         disp('Shaista Khatun');
         disp('Age=56');
      case 15
         disp('Rahisa Khatun');
         disp('Age=45');
      case 16
         disp('Ruksana');
         disp('Age=64');
      case 17
         disp('Parizad Zorabian');
         disp('Age=38');
      case 18
         disp('Heena kundanani');
         disp('Age=20');
      case 19
          disp('Setu Savani');
          disp('Age=21');
       case 20
          disp('Mohd Zubair Saifi');
          disp('Age=20');
       otherwise
         disp('Image in database but name unknown')
   end
```

```
else
   disp('No matches found');
   disp('You are not allowed to enter this system');
   outputimage=0;
end
else
   disp('Image is not even a face');
   outputimage=0;
end
save test2.mat % this is used to save the variables of the file and thus can be used to set Eigen-values
end
```

PCA ALGORITHM

```
% This is a face recognition system using Eigen-face approach
% PCA algorithm for face recognition
clc
disp('                Main Menu                 ');
disp('        Calculate Eigen-faces.............[1]');
disp('        Input Image for Recognition......[2]');
disp('        Update the database..............[3]');
y=input('Press appropriate keys for required operation........', 's');
switch(y)
   case '1'
      imageno=input('Enter the no of data images with which you want to continue');
      [T, m1, Eigen-faces, Projected Images, imageno]=Eigenface_calculation (imageno);
      save Eigenface.mat;

   case '2'
      load Eigenface.mat;
      outputimage=Recognition(T, m1, Eigenfaces, ProjectedImages, imageno);
      disp('Press any key to continue...............');
      pause;

   case '3'
       load Eigenface.mat;
       global imageno;
       imageno=imageno+1;
       [filename pathname]=uigetfile('*.jpg', 'Select image for input');
       movefile(filename,strcat(int2str(imageno),'.jpg'));
       [T, m1, Eigenfaces, ProjectedImages, imageno]=Eigenface_calculation(imageno);
       save Eigenface.mat;

otherwise
      disp('We hope you enjoyed your journey with our Face Recognition System- THE IDENTITY');
 load test2.mat
 end
```

RESULTS

Face Recognition Analysis is results can be shown by giving various input to the system. This system gives results for various input images like image which is stored in the database, image which is not stored in the database, images with various facial expressions of the image which is stored in the database etc. This system does not show any result for images which is not stored in the database. The Face Recognition Analysis for various can be proved by several snapshots:

Eigen-Face calculation

The first option in the Face Recognition Analysis system is to calculate the Eigen-faces. Hence the result of Eigen-face calculation can be shown by following screenshot:

Option 1 in the FCA is to calculate the Eigen-face of the given image to be stored in the database. This calculated database is stored in the database. The Eigen-face of the given image is shown in the above screenshot.

Face Recognition

FCA for Images Which are Already Stored in Database

The second option in the Face Recognition Analysis is face recognition that means the image to be recognized is The image to be tested is given as the input to the FCA which is shown in the above screenshot. The result of the input image given to the FCA is shown by the above screenshot.

FCA for Various Facial Expressions

The results for various facial expressions of the image which is stored in the database can be displayed by following screenshot:

In above screenshot, the Figure 1 is the input image of the individual and Figure 2 is the output of the input image. Here the exact input image is not stored in the database but the image of same individual is stored. FCA also gives desirable result this condition as shown in the figure.

FCA for Image Which is not Stored in Database

Following screenshot shows the result for image which is not stored in database:

Here the input image is not stored in the database which result is stored in the screenshot4.5b.

Update Database

Results for Update database that means to store new image to the database of Face Recognition Analysis as shown below:

The new image to be stored in the database is the input to the FCA and the updated database is shown in the Fig 11.

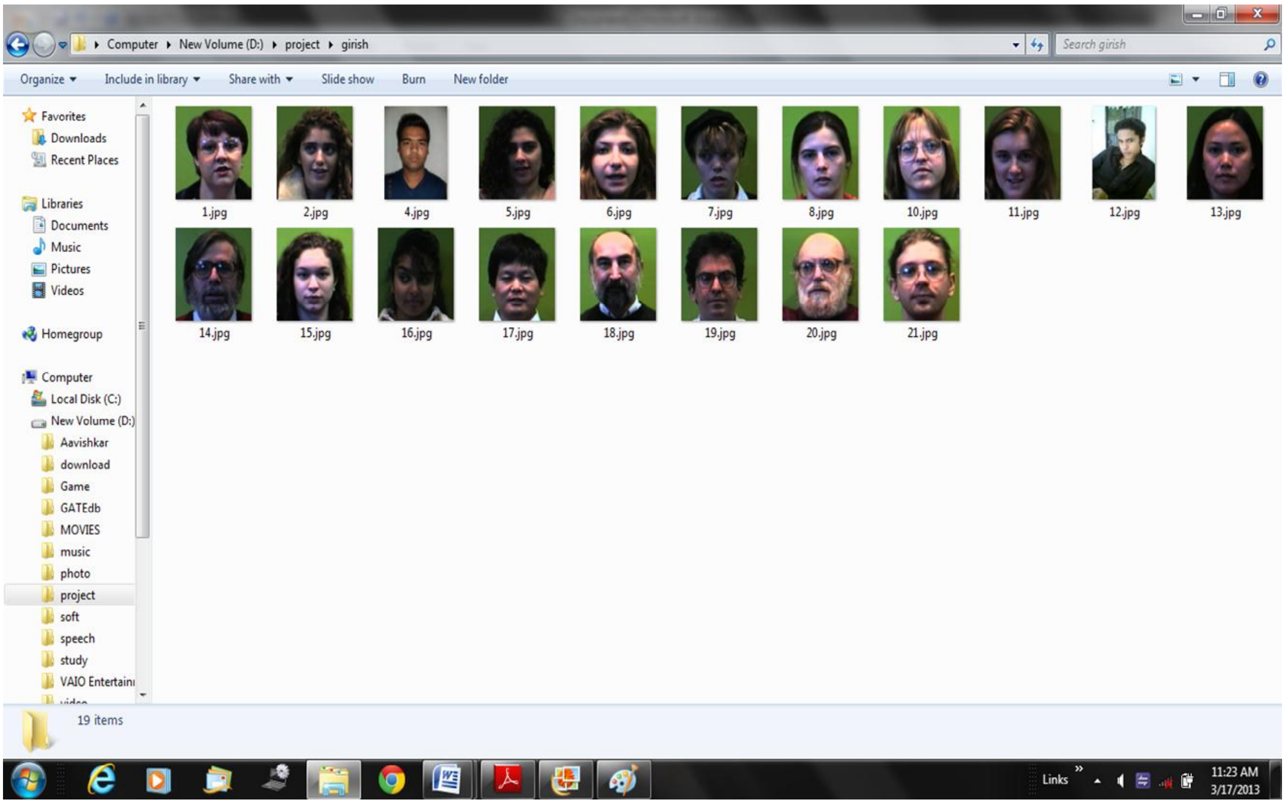

Figure 2. Database for face recognition analysis

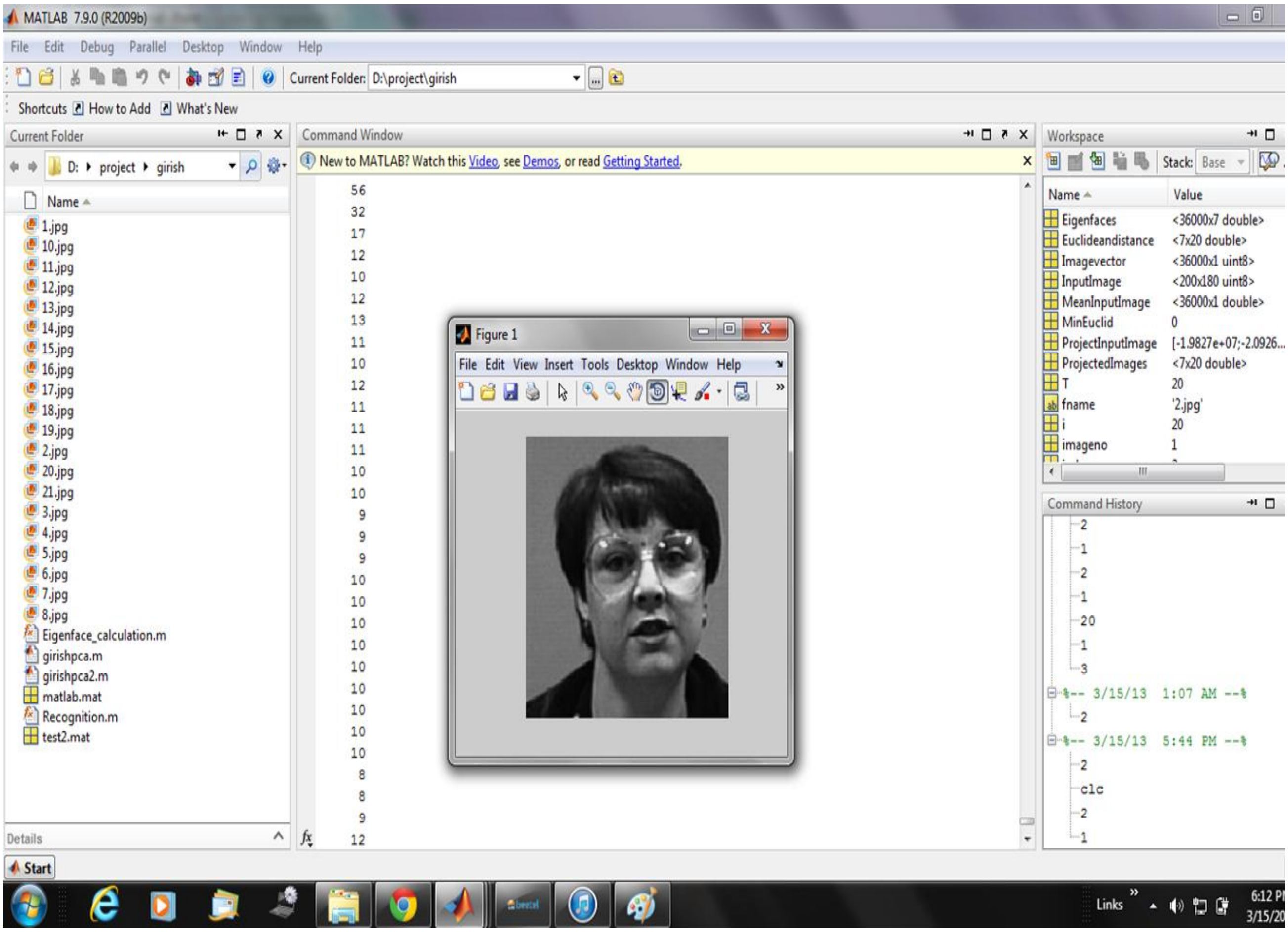

Figure 3. result for Eigen-face calculation of given image

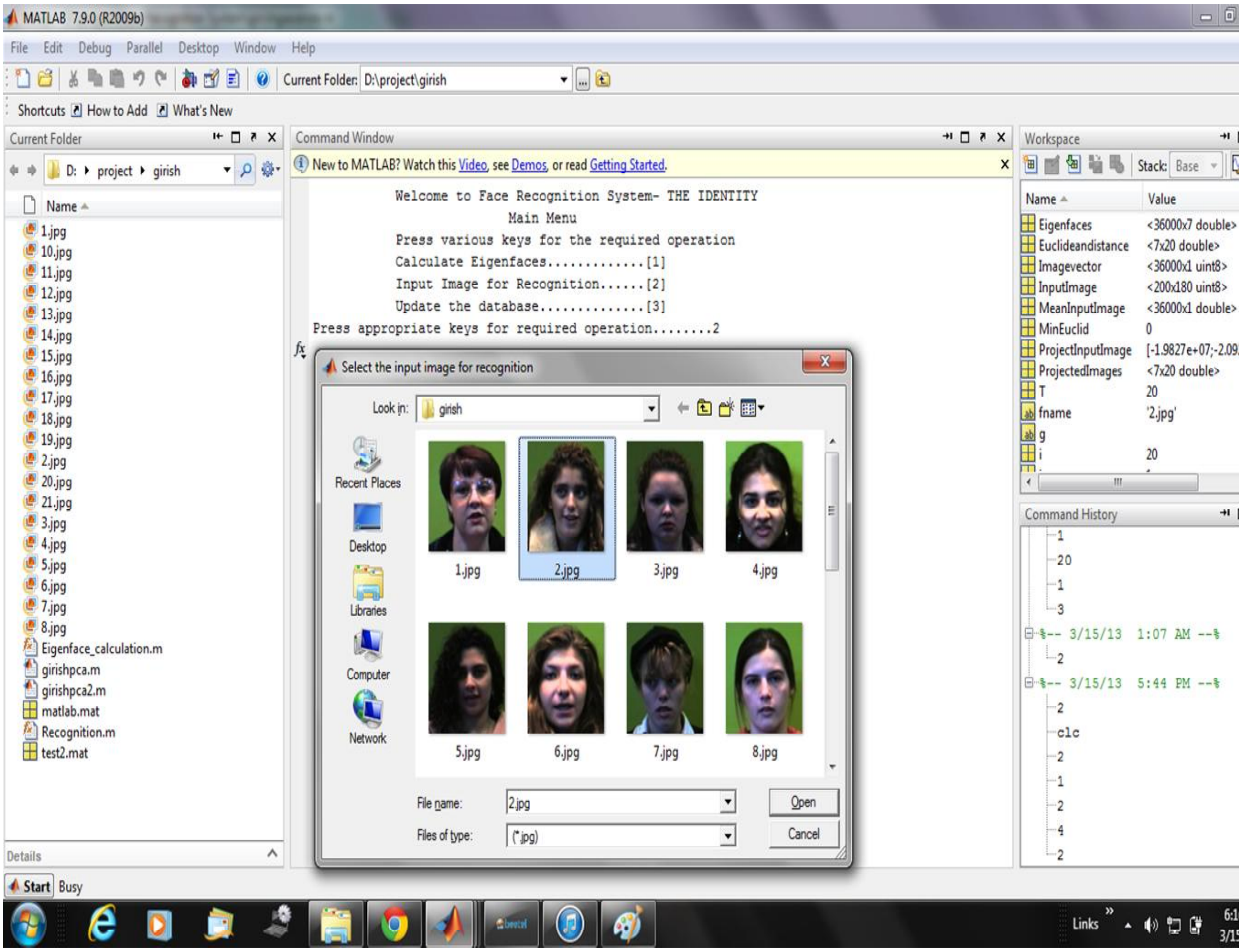

Figure 4. Input image for face recognition

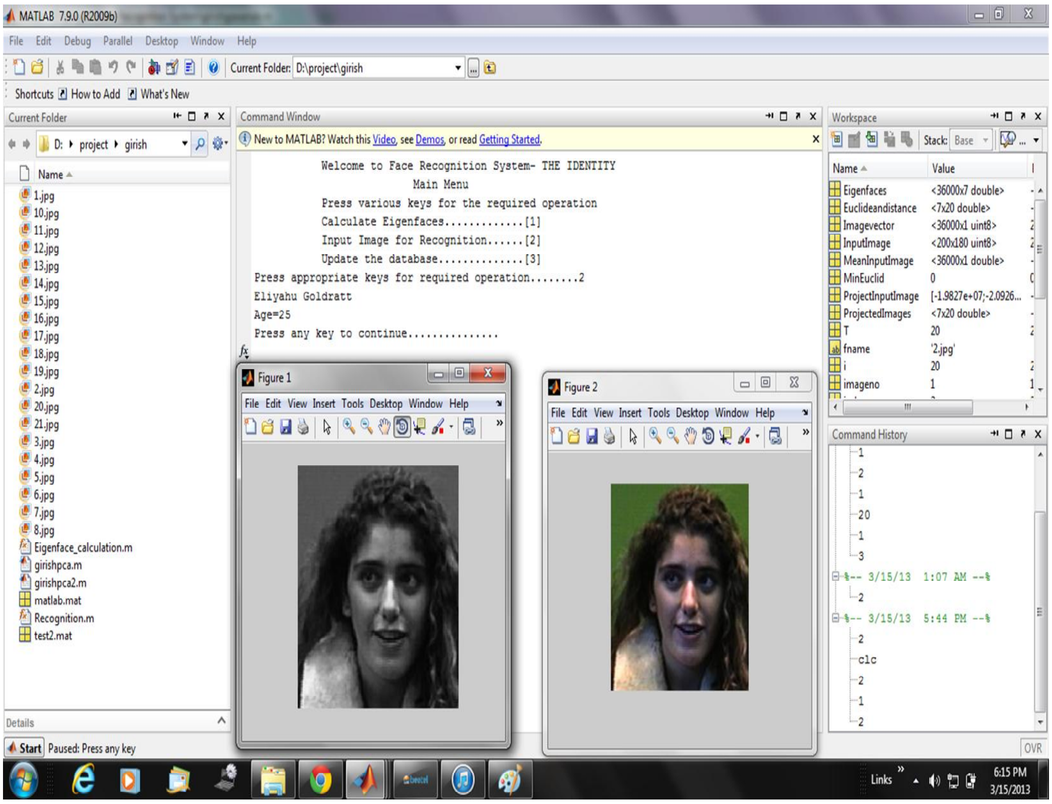

Figure 5. Result of the face recognition analysis for given input

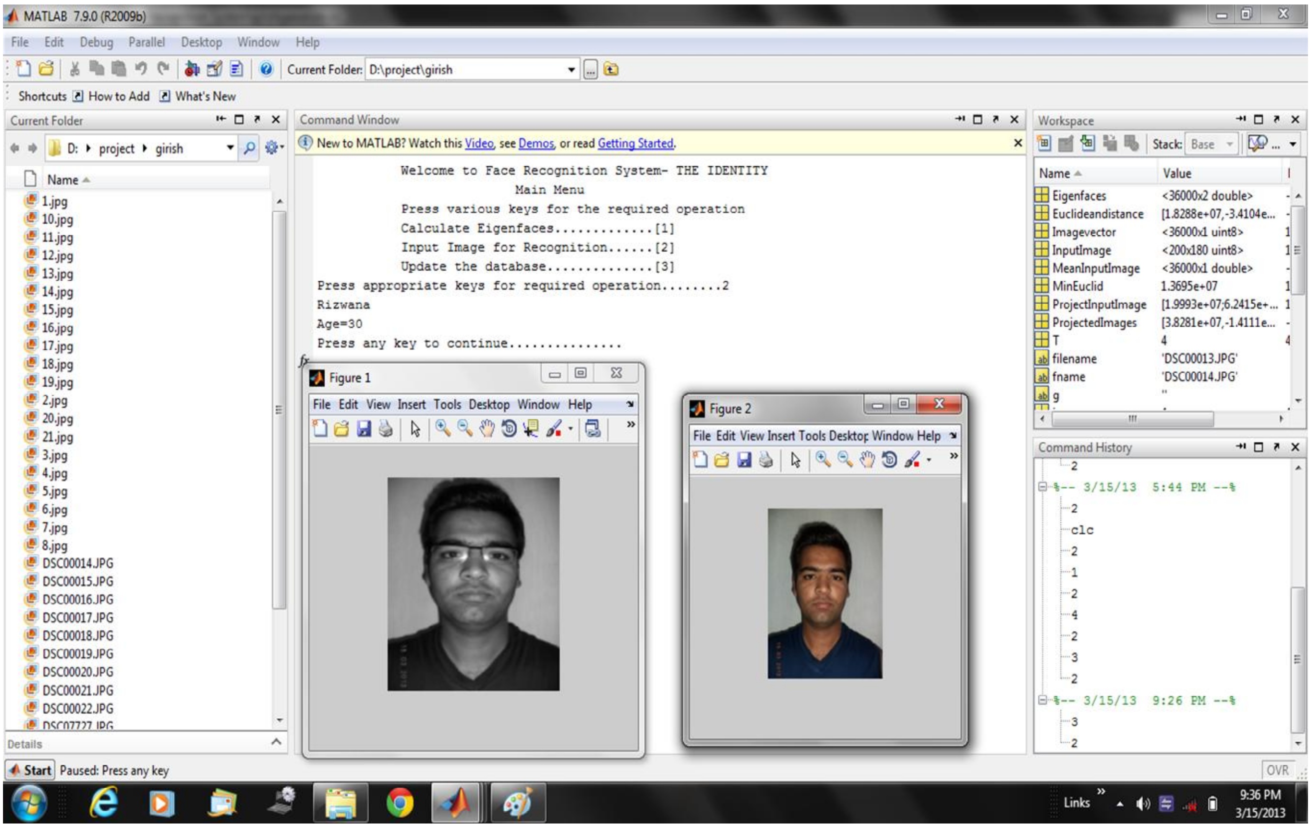

Figure 6. Result of the face recognition analysis for given input image

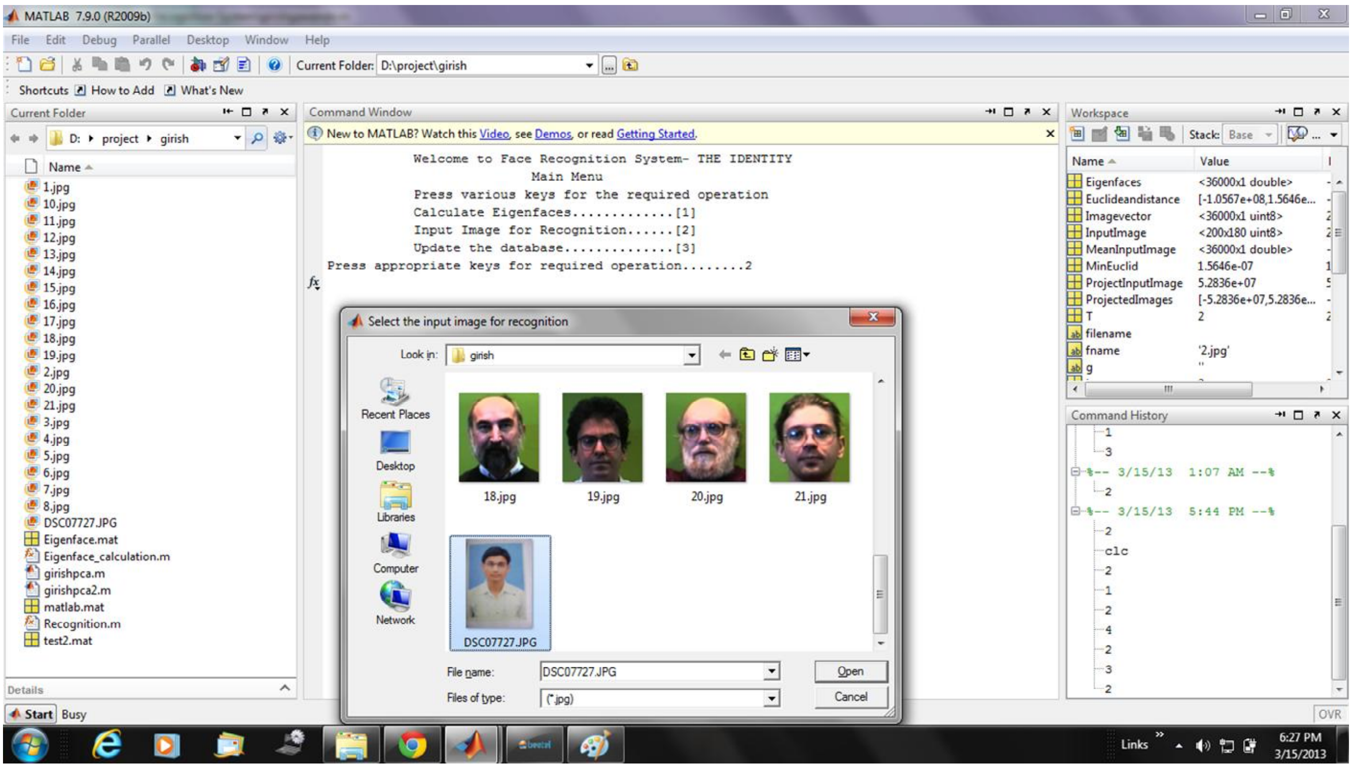

Figure 7. Input image which is not stored in the database

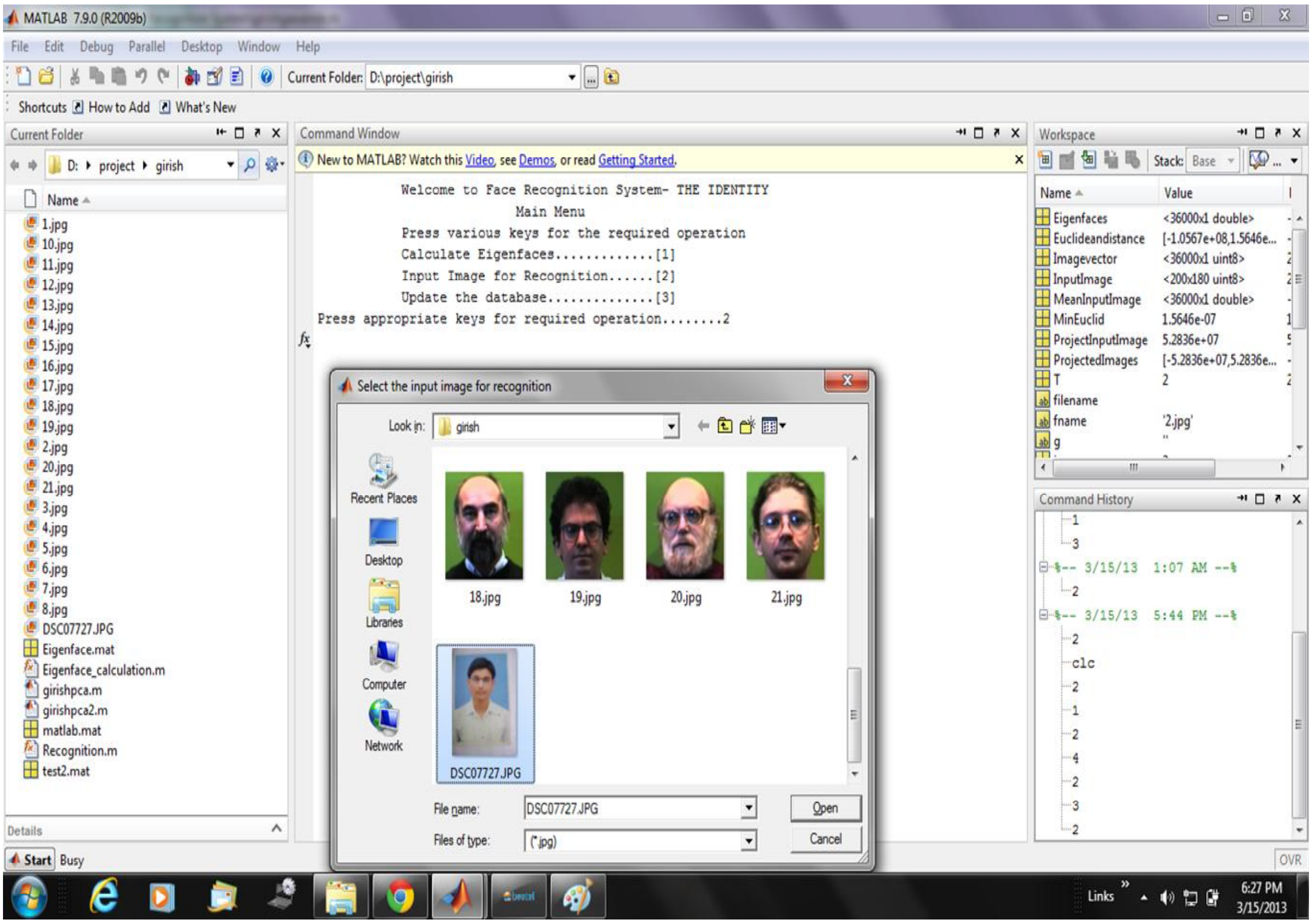

Figure 8. Input image which is not stored in the database

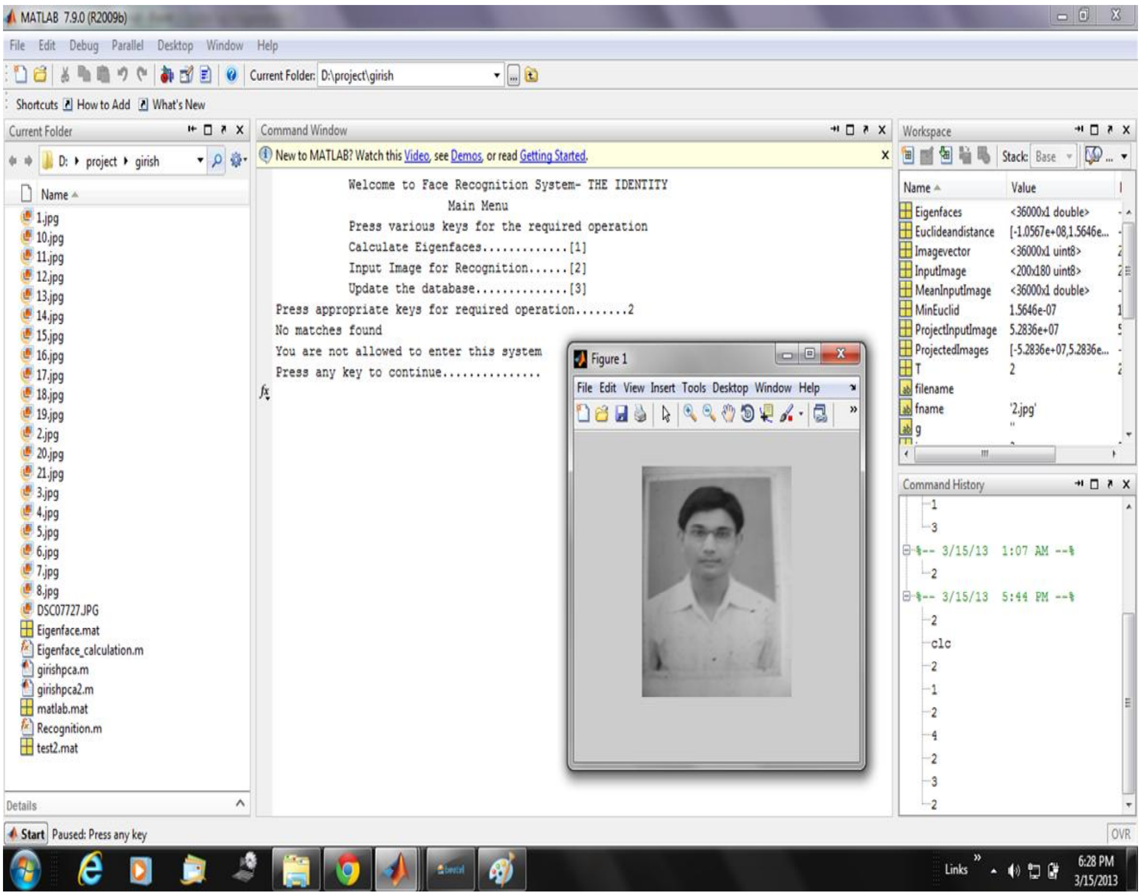

Figure 9. Output of image which is not stored in the database

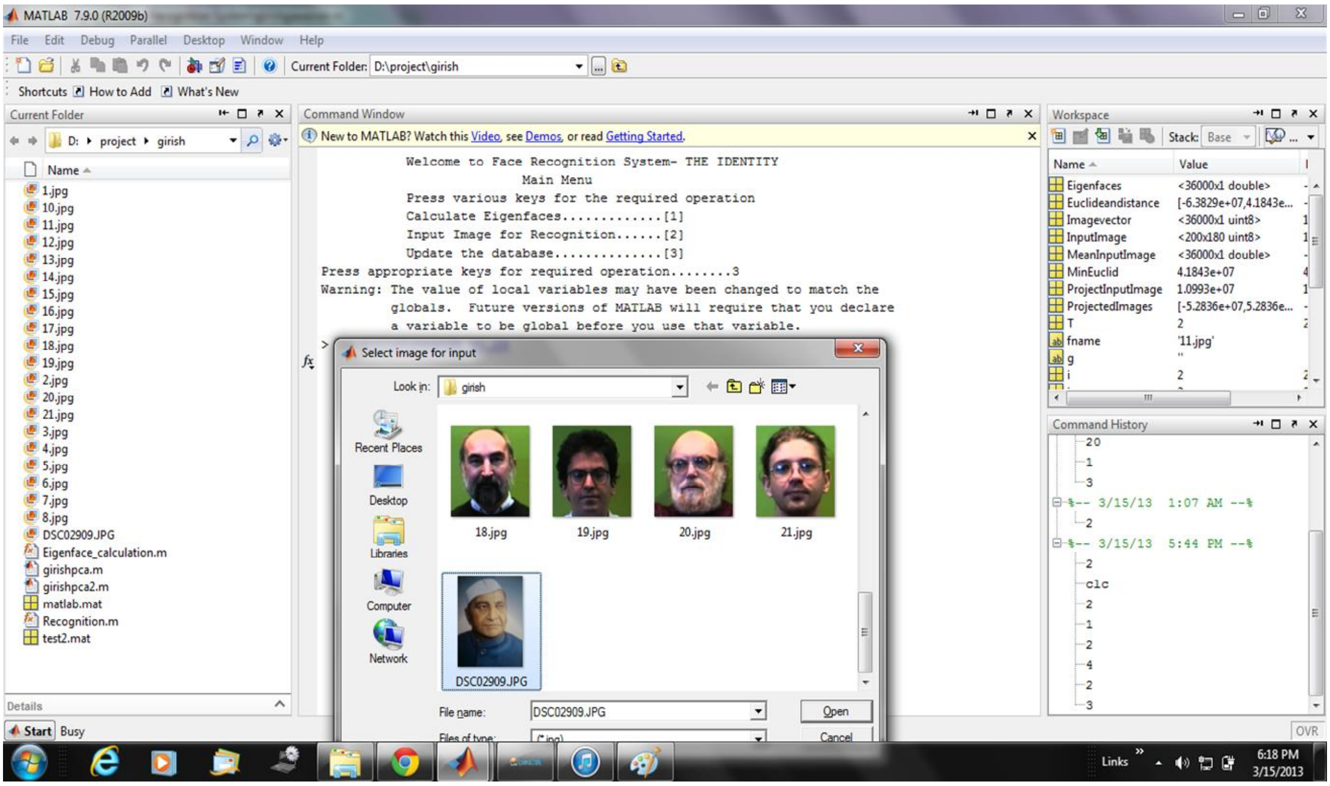

Figure 10. New image to be added to the database

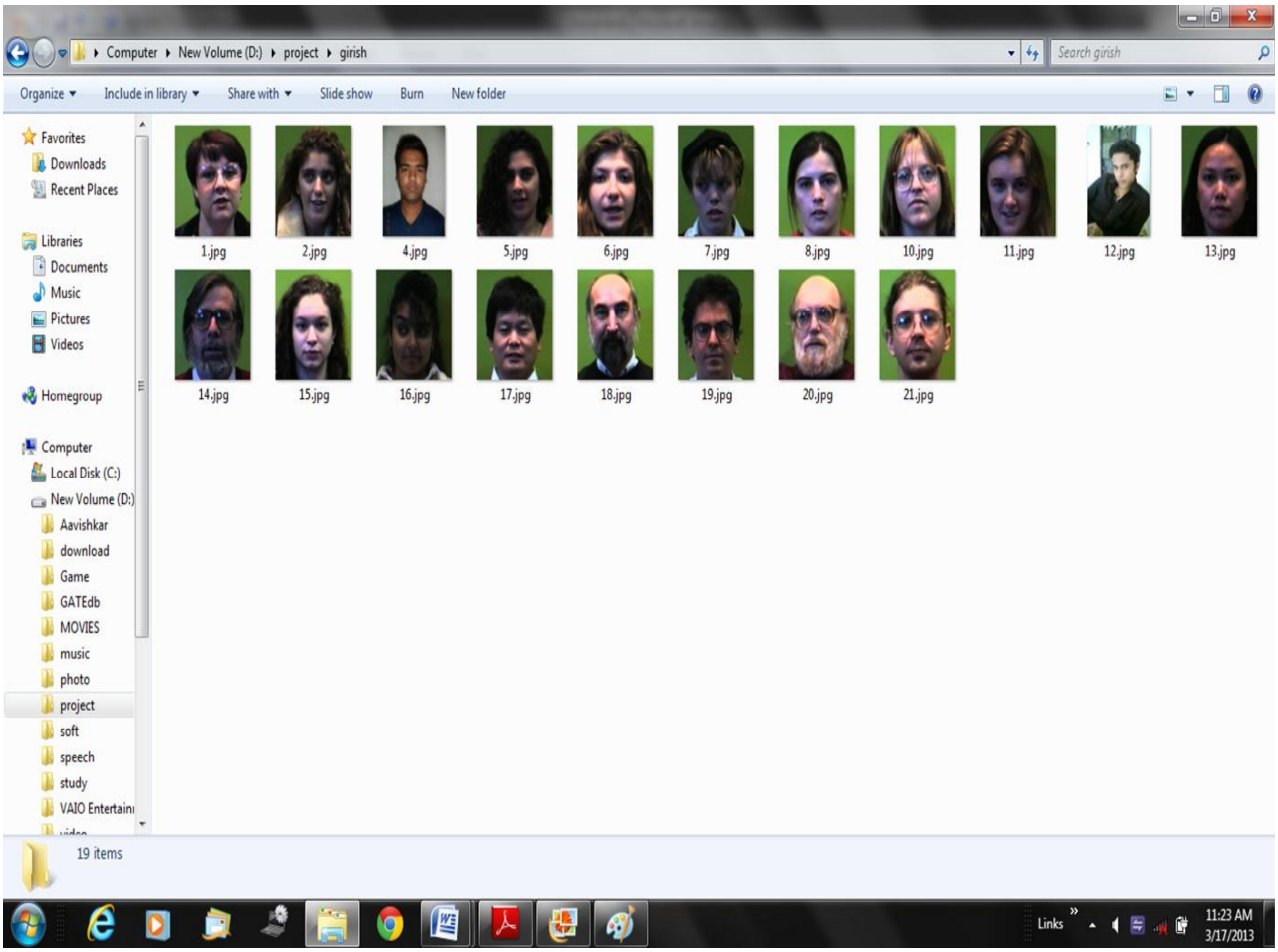

Figure 11. Updated database

Conclusion

In this project first we input a known image and observe the Euclidian distance with respect to the distance of the saved image. This distance tells us how close the input image is from the images which are stored in the data base. Based on the maximum and minimum distances we can make a decision of whether the face is a known face or not. Based on that result we display the output as the face is matched or face is unknown that is no match found. This model can be designed using other various programming techniques and languages such as C++, JAVA etc. but we are doing this project of face recognition in MATLAB because MATLAB can do above very easily using its image processing applications and tool box. Face recognition has several advantages over other biometric such as finger print, voice etc. Besides being natural the most important advantage of face recognition is that it can capture at a distance. This project can be used in setting the passwords in the personal computers, where your face is taken as the password.

Application

- This can be used in the various offices to maintain the records of the employees with their face as their account identity.
- Verification for self serviced immigration using E-passport. Based on these factors, face recognition applications may be divided into two broad categories in terms of a user's cooperation:
- Cooperative user scenario non Cooperative user scenario.

The cooperative case is encountered in applications such as computer login, physical access control, and e-passport, where the user is willing to be cooperative by presenting his/her face in a proper way (for example, in a frontal pose with neutral expression and eyes open) in order to be granted the access or privilege. In the non cooperative case, which is typical in surveillance applications, the user is unaware of being identified. In terms of distance between the face and the camera, near field face recognition (less than 1 m) for cooperative applications is the least difficult problem, whereas far field non cooperative applications in surveillance video is the most challenging. Applications in between the above two categories can also be foreseen. For example, in face based access control at a distance, the user is willing to be cooperative but he is unable to present the face in a favorable condition with respect to the camera. This may present challenges to the system even though such cases are still easier than identifying the identity of the face of a subject who is not cooperative.

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