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SVM Based Approach for Multiface Detection and Recognition in Static Images

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Abstract

Recognizing and identifying a face from the real world, capture data that senses images is the demanding process in this advanced world. Because of varied face appearances, lighting effects and illumination of the background of the images, perceiving and recognizing multiple faces in a single image is a challenging process. This paper proposes a method that recognizes multiple faces in a single image using a different face recognition algorithm. Here, different approaches of face recognition using OpenCV and SVM algorithm have been compared and implemented for recognizing the multiple faces in a single image. In this method, the Haar Cascade Classifier, which is given by Viola Jones is used to detect the multiple faces in a single image. Local binary pattern histogram, eigenfaces and fisherfaces and Support Vector Machine learning algorithms are used to recognize multiple faces in a single image. These multiple face recognition algorithms are compared and tested over a different set of images.

Keywords: *Multiple Face Recognition, Local Binary Pattern Histogram, Eigenfaces, Fisherfaces, Detection, SVM*

INTRODUCTION

Recognizing the human face is a significant study in the field of authentication and computer vision, the technology can predicts vital information from the image by identifying the various features in an image [1]. Face recognition is the technology that perceives the face in an image and overcome the other technologies with numerous advantages [2]. Face identification has broad applications and is extensively used in video supervision, robot intelligence, certification, authentication, remedial knowledge, smart cards, criminal investigation and so on [3][23]. Many different techniques have been achieved to recognize a face but some of them are failed due to its lighting and illumination effect [4]. Therefore, we need to study and understand these failures so that we can overcome them and achieve high accuracy factor [5]. High accuracy leads to better security, more reliable face recognition algorithm and becomes easy and accurate during criminal investigation [6]. Other face recognition applications are as follows:

1. Marketing - Filled with honest and right things to fastidiously assume about, selling could be a growing field of biometric identification innovations of recent things, and it's one we will expect to examine a lot of as facial recognition become existing anywhere [7].
2. The healthcare – Computer vision is being integrated with machine learning to greater exactly track persistent pharmaceutical utilization and support management procedure [8].
3. Face recognition is used to help and track addictive card sharks or gamblers.

Multiple face recognition frameworks incorporate four basic parts that are data learning module, feature extraction module, training and preparing classifier database module [9]. The knowledge about images are gathered by the data learning module will be utilized as a test sample for analysis. In the feature extraction, a sequence of the notable feature is identified which can represent human recognizing information. In the last, the trained classifier is utilized to figure out the uniqueness information about the image.

Proposed face recognition system, the SVM and the three face recognizer algorithms that are given in open source computer vision libraries have been considered [10]. These algorithms are tested and compared with different images that are contained multiple faces in an image. The rest of the paper is arranged as takes after section 2, discuss about the related work. In section3, methodology of multiple face detection, machine learning algorithm and the knowledge of three multiple face recognition algorithm would be described. In section 4, describes about the implementation. Module 5, the results and discussion of the proposed algorithm are discussed. At last, the conclusion would be examined.

RELATED WORK

ChengBing Wei in [11] proposed a modified LBPH face recognition algorithm to increase the recognition rate under illumination and lighting effect. The advance version of Local Binary Pattern Histogram algorithm is based on the neighborhood gray median. In this method, the pixel gray value is replaced by the neighborhood median value. After replacing the values, the feature's value is extracted by the sub blocks. To form the modified LBPH feature dictionary, the statistical histogram is to be established which is used to distinguish the human face identity. FERET database is used for testing. After performing testing, the result says that the modified LBPH is better than LBPH in recognition accuracy rate.

Shicheng Yang in [12] proposed an approach, based on the low quality of images. The novel SRC face recognition method is more vigorous to corrupted and disguised other face identification algorithm. In this approach, to create a dictionary, the low-rank and non low-rank modules are obtained from the training data set, which represents the vital information about the image. Augmented Lagrange Multiplier approach is used to get the result of the projected SLCR method. Based on the minimum class wise modernization enduring leads to a large improvement for the face recognition algorithm. This projected approach is tested on the CUM Multiply, AR and extended Yale B datasets.

Bhanu Tekwani in [13] proposed a neural network approach for face detection and identification. This experimenter has been done in MATLAB. ORL database is used for testing the face detection and recognition algorithm. As a result, Bhanu concludes that neural network algorithms are more constructive when there is not a proper face in an image. Due to hidden layer dependency, neural network is more accurate as compared to other face detection and recognition algorithm.

Osman Nuri UÇAN in [14] proposed a face recognition algorithm based on extraction of multiple features. In this method, to extract the edges of the face in an image, the three edge detection filters are used. The three edge detection filters are: Roberts filter, Sobel and Prewitt filter. The projected system is stable and more beneficial during the illumination effect, as it not affected by the noise. The result of this algorithm is more accurate as

compared to the Principal Component Analysis method.

M Hakeem Selamat in [15] proposed a model called Hybrid Multiclass Support Vector Machine. In this model, there are different types of phases that are preparing data, extracting features and classification. The principal Component Analysis approach is used for reducing the dimensions and Discrete Wavelet Transform is used to extract features of the human face in an image. Hybrid multiclass support vector machine is used to deal with the problems faced during identifying faces in an image. This method is tested on ORL database. Comparison is done on classic HM-SVM. The result of the proposed algorithm is more accurate and shows the improvement by 3.13% - 6.56%.

METHODOLOGY

Multiple face recognition has two essential phases that are multiple human face detection and multiple human face recognition. Multiple human face detection is the procedure of finding the multiple faces in an image. For multiple face detection, the Haar cascade algorithm is used in this projected system. The other significant feature is the multiple face recognition. It is the procedure of identifying or recognizing the multiple faces in an image. The different recognition algorithm has been tested and compared to determine the overall accuracy and the performance of the system. Following is the flow chart for the human face recognition system as shown in fig.1.

Face Detection

The effective and successful multiple face detection strategy was proposed by Viola and Jones. Multiple face detection is done using Local Binary Patterns and Haar like features based on cascade classifier [16]. Firstly, it reads the human face images that are stored in our database, which are to be detected and converts these human face images into gray scale face images. After converting the face image into grayscale, it loads the cascade classifier to find out whether it contains human face in an image or not. And then it detects the face in an image and draws a rectangular box on the detected part of the face in an image.

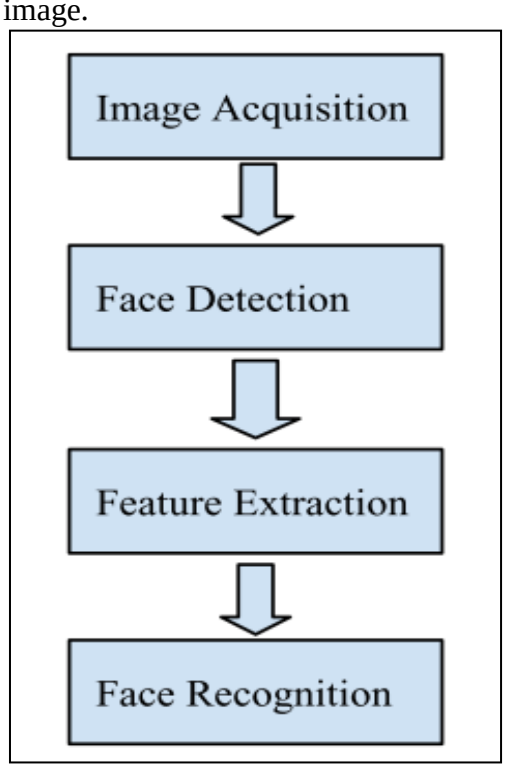

Fig.1 *Flow chart of the face recognition system*

Local Binary Pattern Histogram

In LBPH, we analyzed the images, by characterizing the local binary pattern in the image. The first step in this algorithm is to create an intermediate image that highlights the important facial feature. LBPH algorithm uses a concept of a sliding window and local binary patterns to extract features from the image [17]. Ahonem introduces the basic texture description method as a LBP, which divides the facial image into local region and extracts the description of the binary patterns independently. For each local region, the pixel of the image are labeled with the decimal values. These decimal

values are collected as histogram and then computed as a histogram similarity for a classification method. With the help of the sliding window, LBP assigns each local region into the size of the 3*3 neighborhood as shown in fig.2. This method works on the gray scale images and for every pixel a neighborhood is selected in the region of the current pixel. After selecting the neighborhood pixel, the LBP value is computed and the equivalent pixel location is reorganized. In the face image the value of the centered pixel is measured as a threshold and a result is considered as binary no. If the resultant value is greater than the threshold value, then the binary value is set as "1" else "0". The eight digit binary number is computed and converted into decimal number which represents the LBP code.

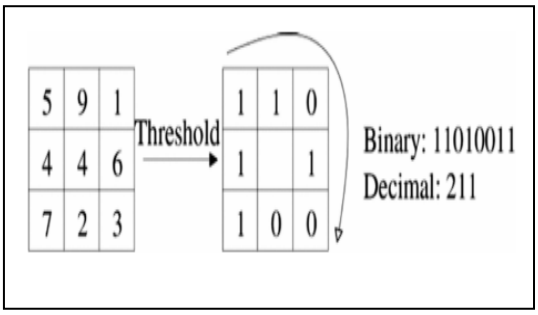

Fig.2 *Basic LBP Operator [18]*

The LBP histograms are used for human face recognition. The value of computing histogram is compared to find out, whether human face image belonging to the same person or not. Chi square statistic similarity measures are used to compare the histogram values and can be defined as:

$$X_w^2(S,M) = \sum_{i,j} w_j \frac{(S_{i,j}-M_{i,j})^2}{(S_{i,j}-M_{i,j})} \quad (1)$$

Where j = 0, 1,.., m-1, i = 0, 1…, n-1, $w_j$is referred as the weight of j region, M is referred as the query of the face image and S is the target of the face image histogram.

Eigenfaces Face Recognizer

One of the face recognition algorithm that OpenCV provides us is the Eigenfaces face recognizer. Set of eigenvectors corresponding to the largest eigenvalues in face recognition is called eigenface [19]. These are derived from the covariance matrix and are similar to the face. The Eigenface recognition algorithm is based on the Principal component analysis, which was proposed by the lingerie and the Pearson. It turns a set of possible correlated variables into an uncorrelated variable. It suggests a notion that the high-directional dataset is frequently described by the correlated variables and hence only a few meaningful dimensions account for the most part of the information. The PCA approach finds the greatest variable in the data called principal components. Consider, if the human face image represents in p-directional space, the PCA method is used to reduce the dimensions of the image into a q-directional space, where (q<p) via linear transformation. The total covariance matrix S_T is defined as:

$$S_T = \sum_{i=1}^{N}(x_k - \mu)\cdot(x_k - \mu)^T \quad (2)$$

Where μ is referred as mean image, N is the no. of the image and x_k is the K^{th} image among its column concatenate in a vector. Now to calculate the mean centered image, we need to subtract the normalize trained image from the μ. If W is referred as the matrix of the mean center of the training images, then Wi (i = 1,2, 3,…..l) , where i is the no. of the training images [18]. The covariance matrix Y is computed as shown in equation 2.

$$Y = WW^T \quad (3)$$

If you want to reduce the dimensions or the size of the covariance matrix Y, you can have Y = W^TW. Eigenvalues λ_i and eigenvectors v_i are derived from covariance matrix as

$$S_{TV_i} = \lambda_i v_i, \text{ Where i = 1, 2, 3….n} \quad (4)$$

Fisherfaces Face Recognition

The Fisherface recognition algorithm is based on the Linear Discriminant Analysis which was independently proposed by the R. A. Fisher. With the help of the linear method, the fisherface recognition algorithm is used to resolve the difficulties faced during lighting condition [17]. Classifier and specific linear method are used to reduce the feature space and the dimensions of the image respectively. The ratio of between-class scatter to that of within-class scatter is maximized using LDA. LDA is better than PCA as LDA can be used for any type of classification problem. The inter class scatter matrix is defined as:

$$S_b = \sum_{i=1}^{C} N_i(\mu_i - \mu).(\mu_i - \mu)^{\mathrm{T}} \quad (5)$$

The mathematical representation of intra class scatter matrix is:

$$S_w = \sum_{i=1}^{C} \sum_{xk \in X_i} N_i(\mu_i - \mu).(\mu_i - \mu)^{\mathrm{T}} \quad (6)$$

In equation 4 and 5, μ_i is regarded as the mean image of the class X_i, N_i is the no. of sample images in class X_i, C is the no. of classes. In equation 2 S_b is the maximized value and in 3 S_w is the minimized value for the classification. The fisherface recognition algorithm is more accurate as compared to the eigenface recognition algorithm. The fisher algorithm is mainly depends on the input data [18].

The algorithm wants to maximize the mean distance of different classes and minimize the variance within the classes.

Support Vector Machine

One of the highly accurate supervised methods in machine learning is the Support Vector Machine. In 1995, Vapnik and Cortes proposed this method to identify different patterns and to resolve classification problems [20]. SVM is a boundary which segregates the two classes. The goal of SVM is to separate the data of two dissimilar classes by a line or a hyper-plane. Boundaries between the classes of different data or the hyper-plane are known as "support vectors". Along with the linear classification, we can also execute nonlinear classification via eight kernel function. Consider the two different classes of data, i.e. (+,-). Now with the SVM, we can draw a hyper-plane or a line to separate the data as shown in Fig.3 [21]. The figure illustrates the linear classification between the classes of data. The line or the hyper-plane between the classes is characterized by wx + b = 0 where b is constant. The dotted line as shown in the figure is called as the boundary and the space between these dotted lines is known as margin. The data on the boundary is known as Support Vectors.

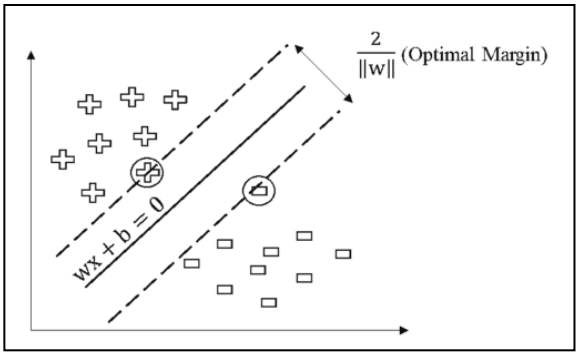

Fig.3 *Example of linear classification [21]*

Example: Suppose we have an algebraic representation with the positive data marked as 1 and negative data marked as -1. To perform the classification mathematically, we can classify by using the formula $w^T x + b \geq 0$, where x = 1 and $w^T x + b \leq 0$, where x = -1. The margin between two dotted line is maximum of $\frac{2}{\|w\|}$. It means in order to have a maximum margin we need to have a minimum $\|w\|$, which turns out as an optimized quadratic equation 1 with equality constraints in equation 2.

$$\max_{\lambda}(\sum_{i=1}^{N} \lambda_i - \frac{1}{2} \sum_i \sum_j \lambda_i \lambda_j y_i y_j (x_i x_j)) \quad (7)$$

Subject to the constraint (2)

$$\sum_{i=1}^{N} \lambda_i y_i = 0 \text{ and } C \geq \lambda \geq 0 \quad (8)$$

In equation 2, C is the constant and used to make the margin maximum and give lesser no. of margin failure. W is the vector for an optimal solution, combines with feature vector (x) which relates to λ_i , Where $\lambda_i \neq 0$

IMPLEMENTATION

In this paper, multiple face detection and recognition are performed on the system with configuration as follows: Intel Core duo, 2GB ram and windows 10.1. Python 2.7.14 is used to implement multiple face recognition by using open source computer vision library. The advantage of using Opencv in this proposed system provides the three built in face recognizer algorithm and compare the overall accuracy and the time taken by these eigenfaces, fisherfaces and LBPH algorithms with the SVM multiple face recognition algorithm. This process is divided into 3 modules as follows.

Data Gathering

In this step, we collect the data from dataset Essex face94, face95 and some google searched images of the Bollywood actors. The face 94 and face 95 images [22] are captured from the camera with a fixed distance, whereas Bollywood dataset is collected from basic google search. In our database, the total number of individuals are 36, where each individual has 20 images. This combination of data sets is used to test and compare the multiple face recognition algorithms.

Preprocessing

Before the images are processed for recognition, first the human face is to be detected from an image and then, they are converted into grayscale images. In LBPH, Eigenface, Fisher face, the images are in .jpg or .png image format, but in support vector machine, as it does not processes .png and .jpg image format, therefore, we need to convert them into .pgm format. The images are further processed for face recognition as shown in fig. 5. First the original image is processed for human face detection from where we obtain the essential features of the human face in a cropped image. Then the cropped image is trained to extract features using PCA, LDA, Histograms and SVM. Following are the extracted features for implementing Support Vector Machine multiple face recognition, as shown in fig. 4.

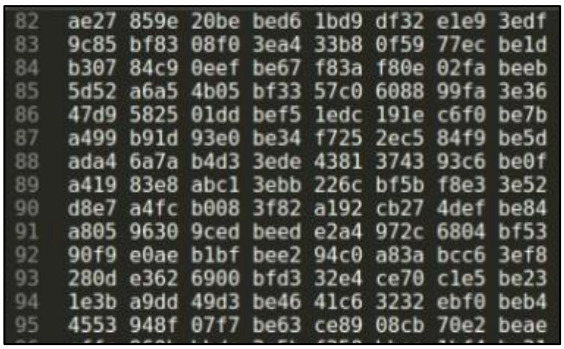

Fig.4 *Extracted features for SVM algorithms.*

After feature extraction, the extracted features are used for multiple face recognition. The flow chart for the entire process of multiple face recognition is shown in fig. 5.

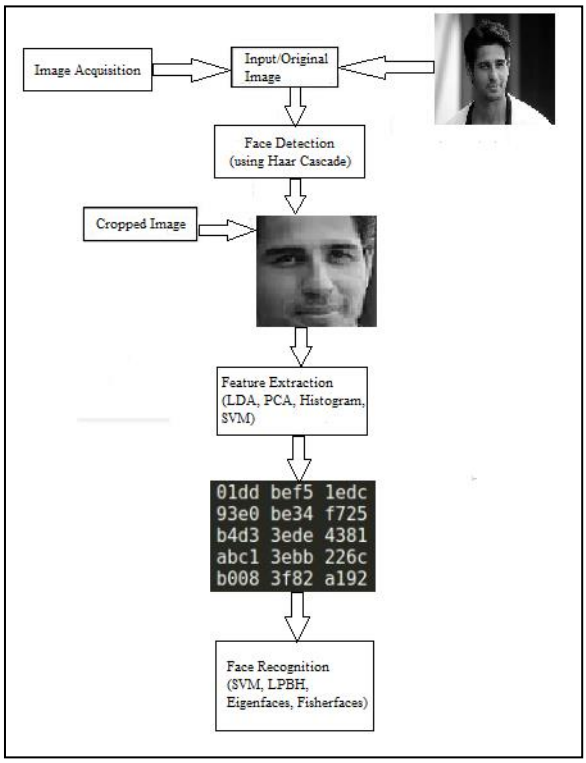

Fig. 5 *Flow chart of proposed work*

RESULT AND DISCUSSION

This paper shows the implementation of multiple human face recognition on datasets using Local Binary Pattern Histogram, Eigenfaces, Fisherface and Support Vector Machine algorithms. As we discussed earlier, the first phase in multiple face recognition is multiple face detection. In the proposed algorithms, we used the Haar cascade classifier for multiple face detection. Following are the results for the multiple face detection as shown in fig. 6:

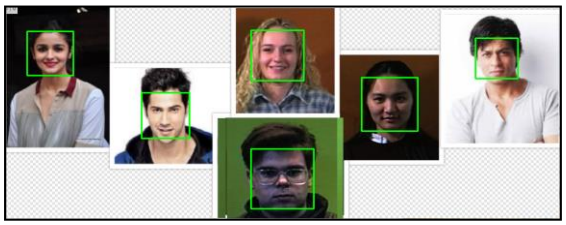

***Fig. 6** Multiple face detection*

After detecting the faces in the image, the mentioned algorithms perform Multiple Face Recognition using the extracted data from the detection phase. Following are the results for the implemented multiple face recognition algorithms are:

1. The fig. 7 shows the multiple face recognition using Local Binary Pattern Histogram algorithm. As the human face is recognized from the image we also calculated the confidence value. The confidence value is the distance measure from the predicted level. As low as the confidence value, the prediction will be more accurate. For the successfully recognized algorithm the confidence value is to be lower than the threshold value. The threshold value for LBPH is 2000. We displayed the confidence value for each human face during the time of execution as shown in the fig.7.
2. Following fig.8 is the result using eigenface recognition algorithm. As the human face is recognized from the image we also calculated the confidence value. The confidence value is the distance measure from the predicted level. As low as the confidence value, the prediction will be more accurate. For the successfully recognized algorithm the confidence value is to be lower than the threshold value. The threshold value for Eigenface algorithm is 15000. We displayed the confidence value for each human face during the time of execution as shown in the fig.7.
3. The fig. 9 shows the multiple face recognition using Fisherface recognition algorithm. As the human face is recognized from the image we also calculated the confidence value. The confidence value is the distance measure from the predicted level. As low as the confidence value, the prediction will be more accurate. For the successfully recognized algorithm the confidence value is to be lower than the threshold value. The threshold value for Fisherface algorithm is 2500. We displayed the confidence value for each human face during the time of execution as shown in the fig.7.
4. The fig.10 shows the multiple face recognition using Support Vector Machine. The SVM algorithm processed on .pgm format of the images. For implementing the SVM, sklearn library is used.

After implementing the multiple face recognition, we compare the performance of 4 algorithms on the basis of their overall accuracy and time taken by them during execution. The table 1.1 mentioned below specifies the total no. of faces, overall accuracy (in %) and the training and testing time for the respective algorithms. We have taken 106 human face images to process and test the algorithms. After we implemented the algorithms, we calculated the overall accuracy for each. As shown in the table 1.1, we observed that the SVM algorithm gives the highest overall

accuracy, i.e. 90.61%, whereas Fisherface algorithm shows the least accuracy among all the mentioned algorithms. Fig.11 plots the graph to show the comparison between the accuracy rate of the implemented algorithm.

CONCLUSION

In this paper, we discuss four different algorithms for multiple face recognition from an image stored in a database. Local binary pattern histogram, eigenfaces and fisherfaces and Support Vector Machine learning algorithms are used to recognize multiple faces in a single image. After the testing and implementation, we conclude that the SVM algorithm is more accurate with overall_accuracy 90.61% and takes less testing time than the other implemented algorithms whereas Fisherface algorithm shows the least accuracy with accuracy rate 76%. The accuracy rate of any recognition algorithm depends on the quality and the face variance.

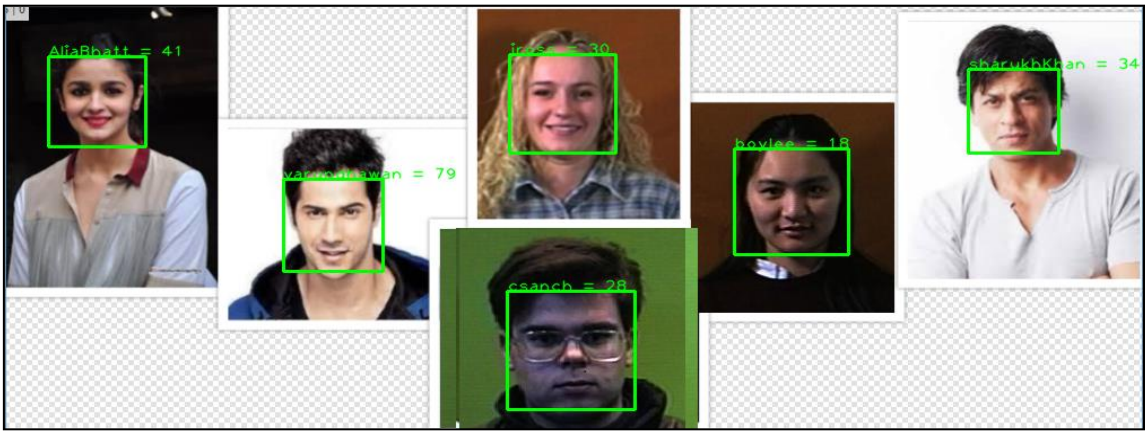

Fig.7 *Multiple face recognition using LBPH*

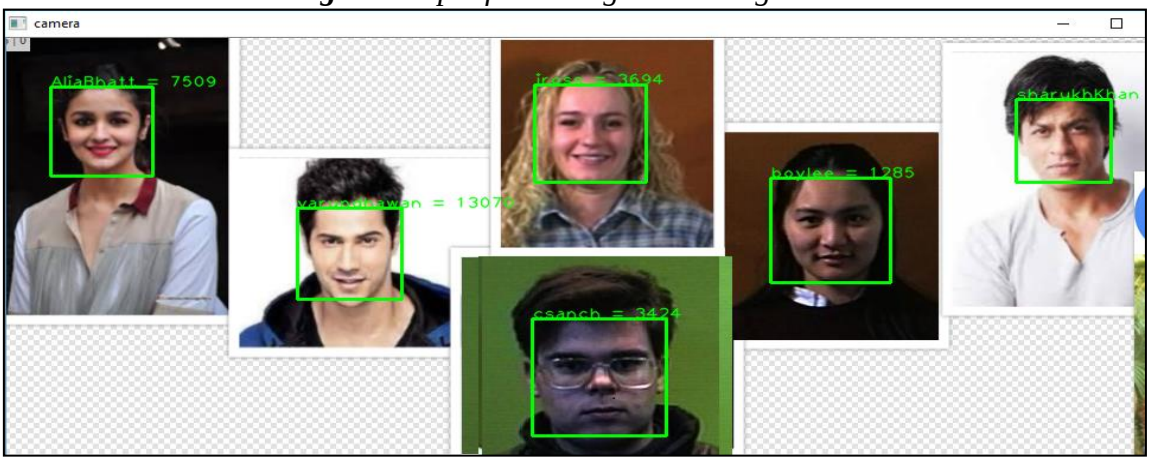

Fig. 8 *Multiple face recognition using Eigenface*

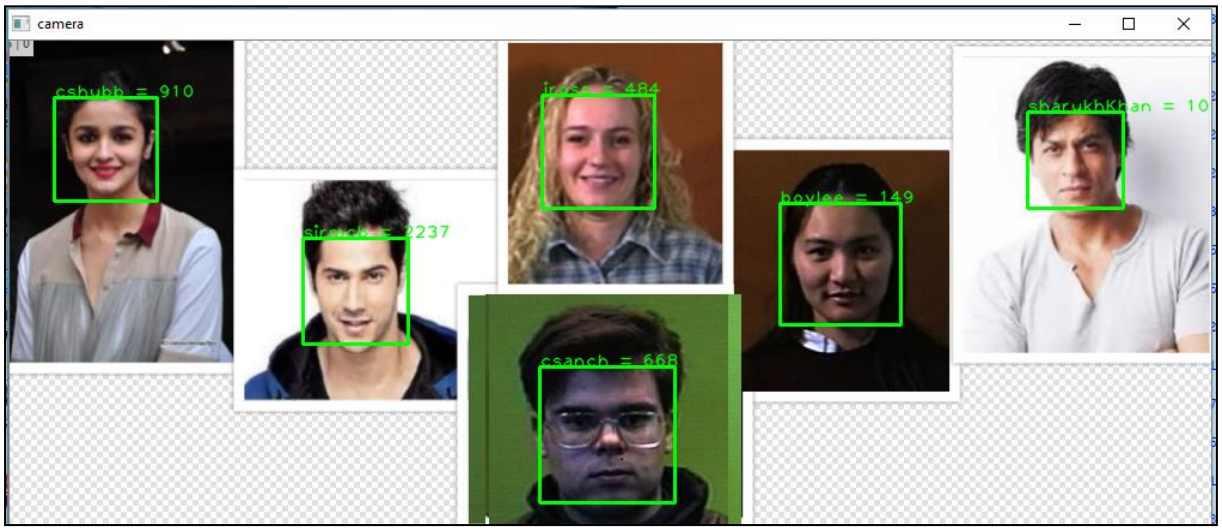

Fig. 9 *Multiple face recognition using Fisherface*

Fig.10 *multiple face recognition using Support Vector Machine*

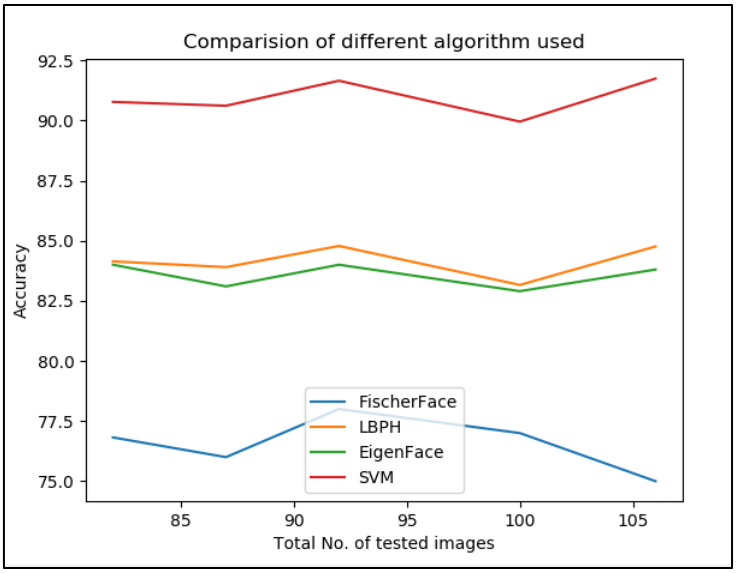

Fig. 11 *show the comparison of the implemented algorithms*

Table 1 *Test Results*

Algorithms	Total no. of faces	Overall_Accuracy (In %)	Training Time (In ms)	Testing Time (In ms)
LBPH	106	83.168	71.4380099943	109.200999975
Eigenface	106	83.0	426.019000053	131.492000103
Fisherface	106	76.0	227.089999914	96.7960000038
SVM	106	90.6119	346.370356083	40.0419998169

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