# HMM-SVD based Face Recognition and Hand Gesture analysis system

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***Abstract*— Now a day in increasing digital world, personal reliable authentication has become an important human computer interface activity. It is very important to establish a person's identity. Today existing security mainly depends on passwords, swipe cards or token based and attitude to control access to physical and virtual spaces passport. Tokens, badges and access cards can be shared or stolen. Passwords and PIN numbers can be also stolen electronically. In addition, they cannot distinguish between authentic have access to or knowledge of the user and tokens. So to make a system more secure and simple with the use of biometric authentication system such as face and hand gesture recognition for personal authentication. So in this paper, a Hidden Markov Model (HMM) based face recognition system using Singular Value Decomposition (SVD) is proposed, which have approximately 99% of recognition rate. Here by using skin segmentation perform hand gesture analysis.**

***Index Terms*— Face Recognition, Hidden Markov Model (HMM), Singular Value Decomposition (SVD)**

## I. INTRODUCTION

Existing security measures an knowledge based approaches like passwords or else token based approaches such as swipe cards and passports to control access to physical and virtual spaces. This method is not very secure. Tokens such as badges and access cards may be shared or stolen. Passwords and PIN numbers may be stolen electronically. Also they cannot differentiate between authorized user and a person having access to the tokens or knowledge. For that face recognition system is very useful.

Biometrics such as fingerprint, face and voice print offers means of reliable personal authentication that can avoid these problems. Biometrics is more reliable system than token or knowledge based authentication methods. The various biometric modalities can be broadly categorized as,

1. **Physical Biometric** which involve some form of physical measurement such as face, fingerprints, iris-scans, hand geometry etc.
2. **Behavioural biometrics** which are usually temporary in nature and involve measuring the way in how user performs certain tasks like speech, signature, gait etc.
3. **Chemical biometrics**, This is still a nascent field and involves measuring chemical cues such as chemical composition of human perspiration.

In Human already they have internal skill to recognize different faces. Face recognition system is the recognizing a special face from a set of different faces. Face has a significant role in human communications where, each person mainly distinguished by his/her face image.

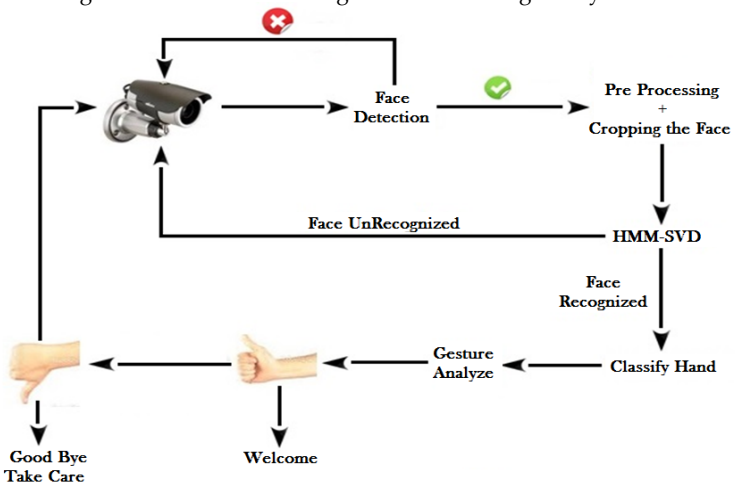
One can easily find out that one of the main problems in machine-human being interactions is the face recognition problem. A human face is a complex object with features varying over time. So a robust face recognition system must operate under different conditions. Face recognition article guide us step wisely from experts. Face recognition system has many application like security access control, Human computer Interaction, surveillance etc.

In this paper we are going to study three stage of authentication system ,

1. Face Detection
2. Face Recognition
3. Hand Gesture detection and recognition

This project will contain some phases, which is given above, in phase one it detect the face, the camera will be set on video streaming once person is coming it takes a snapshot after detecting the face, whereas in phase two which will be to extract the features necessary to recognize the face, by using Gabor features, phase three will be making the right decision based on a data-base trained models, phase four will make the system say "Hello Mr/Miss….". and then it is wait for the employee hand gesture, after the hand gesture was make the system will analyze the hand gesture, if thumbs up than system send message, “Welcome Mr/Miss…” and if thumbs down than system send message, “Goodbye. Take care”.

Figure 1 : General block diagram of Face Recognize system




## II. LITERATURE REVIEW

There are some face recognition methods. Some common face recognition methods are Geometrical Feature Matching; Eigen faces method, Neural Networks (NN), Support Vector Machines (SVM), Elastic Matching and Hidden Markov Models (HMM).

The first approach, proposed by Kanade in the 70's, were based on geometrical features. Geometrical Feature Matching techniques are based on the extraction of a set of geometrical features forming the picture of a face. Their system achieved approx 75% recognition rate on a database of twenty persons, using two images per person: one for training and the other for test. In summary, geometrical feature matching techniques is not a high accurate method and also are rather time-consuming. The other one of the well-known face recognition algorithms, is Eigen faces method. This method uses the Principal Component Analysis (PCA) to project faces into a low dimensional space. This method proved to be not robust against the variations of facial orientation. The authors reported 90.5% correct recognition on ORL database. In short, Eigen faces method is a fast, simple and practical method. However, it generally does not provide invariance over changes in scale and lighting conditions. Next one, Neural Networks is one of the approaches which have been used in many pattern recognition tasks. The attractiveness of using neural networks could be due to their ability in nonlinear mapping. This had been capable to recognize up to 200 people and could achieve up to 96% correct recognition rate. In general, neural network approaches encounter problems when the number of face classes increases. The last approach is the stochastic modeling of non-stationary vector time series based on Hidden Markov Models (HMM) which has been widely used in recent years.

## III. METHODOLOGY

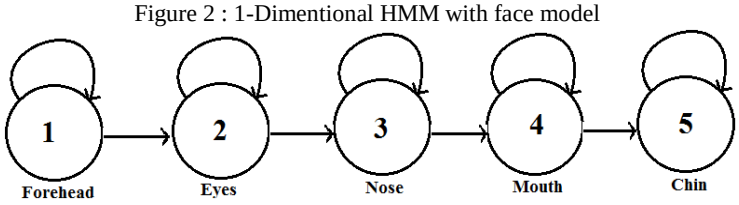
### Hidden Markov Model (HMM)

The Hidden Markov Models are stochastic models which provide a high level of flexibility for modeling the structure of an observation sequence. They allow for recovering the (hidden) structure of a sequence of observations by pairing each observation with a hidden state. Hidden Markov Models (HMMs) used to represent and characterize the statistical property of a signal. They are used not only for speech and handwriting recognition but they are involved in modeling and processing images too. This is the case of their use in the face recognition.

The HMM work on sequences of symbols called observation. Extension to a fully connected two dimensional HMM has been shown to be computationally very complex. For frontal face images, the significant facial regions like hair, forehead, eyes, nose, and mouth come in a natural order from top to bottom, even if the images are taken under small rotations in the image plane and rotations in the plane perpendicular to the image plane. Each of these facial regions is assigned to a state in a left to right 1D continuous HMM.

Below Figure-2 shows signal dimensional HMM for the five segments for face recognition.

Figure 2 : 1-Dimentional HMM with face model



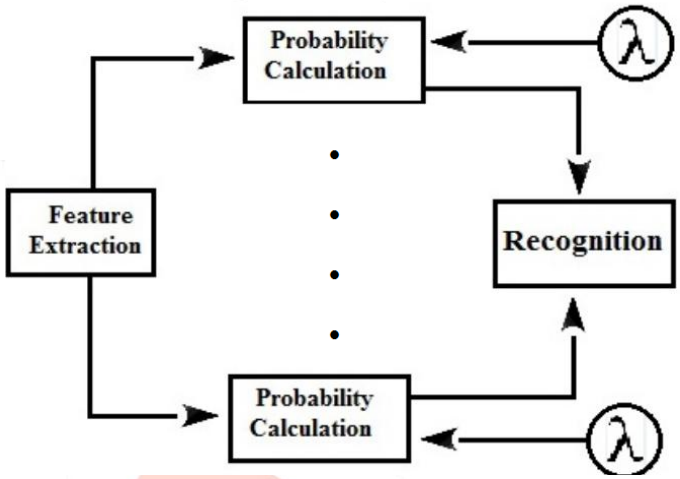

### Training and Recognition

The face images of every subject in the database is identified by a HMM face model. A dataset of five image vectors representation different instances of the same face image are put to train each of the 5-level HMM. The HMM $\lambda = (A,B,\pi)$ is initialized. The training data is segmented in N=5 states and the observation vectors associated with each individual state

are used to obtain the initial estimation of matrix 'B'. The initial values of matrix 'A' and 'π' are assumed to given the sliding window structure of the model. The next step is to re-estimate the face model using Expectation Maximum algorithm to increase the probability. This iterative process is terminated after the convergence is achieved.

A transform the face image to a uniform by level and size normalized. Then transform the face image to fractal matrix, use the matrix of fractal coding into HMM to calculate the probability. Choose the max matching probability recognition. If all of the matching probability is minor consider as the face image can't find the matching face in this face database.

Figure 3 : 1-D HMM for Face recognition




## Singular Value Decomposition (SVD)

The Singular Value Decomposition (SVD) has been an important tool in signal processing and statistical data analysis. Singular values of given data matrix contain information about the noise level, the energy, the rank of the matrix, etc. As singular vectors of a matrix are the span bases of the matrix, and orthonormal, they can exhibit some features of the patterns embedded in the signal. Singular Value Decomposition (SVD) provides a new way for extracting algebraic features from an image.

A SVD of a m×n matrix X is any function of the form:

X=$UWV^T$

Where U(m×m) and V(m×m) are orthogonal matrix, and W is and m×n diagonal matrix of singular values with components $\sigma_{ij}$=0, i ≠ j and $\sigma_{ii}$ > 0. Furthermore, it can be shown that there exist non-unique matrices U and V such that σ1 ≥ σ2…≥ 0.

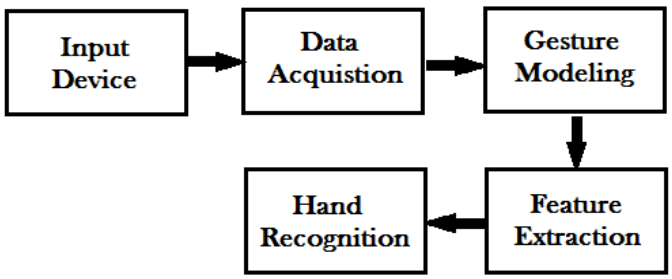
The columns of the orthogonal matrices U and V are called the left and right singular vectors respectively, an important property of U and V is that they are mutually orthogonal. The main theoretical property of SVD relevant to face image recognition is its stability on face image. Singular values represent algebraic properties of an image. So because of these reasons and some experimental results, we find out that SVD is a robust feature extraction technique for face images.

This table shows proposed system has a recognition rate of 99%, a high rate that can simply be approximated to 100%. The significance of this result is that such a high recognition rate is achieved using HMM+SVD parameter.

| Method (Learning algorithm) | Percentage of Error (%) |
|---|---|
| Pseudo 2D HMM + Gray tone | 5% |
| Sliding HMM + Grey tone | 13% |
| Eigenface | 10% |
| Gabor filter + rank | 9% |
| EBGM | <20% |
| Continuous n-tuple classifier | 3% |
| Up-Down HMM + DCT | 16% |
| Markov Random Fields | 13% |
| SVM+PCA | 3% |
| 1D HMM+SVD | 1% |

## Hand Gesture Recognition system :

Figure 3 : 1-D HMM for Face recognition




- **Data Acquisition :**
  For efficient hand gesture recognition, data acquisition should be as much perfect as possible. Suitable input device should be selected for the data acquisition. There are a number of input devices for data acquisition. Some of them are data gloves,

marker, hand images (from webcam/ stereo camera/ Kinect 3D sensor) and drawings. Data gloves are the devices for perfect data input with high accuracy and high speed. It can provide accurate data of joint angle, rotation, location etc. for application in different virtual reality environments. At present, wireless data gloves are available commercially so as to remove the hindrance due to the cable. Coloured markers attached to the human skin are also used as input technique and hand localization is done by the colour localization. Input can also be fed to the system without any external costly hardware, except a low-cost web camera. Bare hand (either single or double) is used to generate the hand gesture and the camera captures the data easily and naturally (without any contact). Sometimes drawing models are used to input commands to the system. The latest addition to this list is Microsoft Kinect 3D depth sensor. Kinect is a 3D motion sensing input device widely used for gaming. It consists of a laser projector and a CMOS sensor for operation in any lighting conditions.

- **Gesture Modeling:**
  It is the next step after data acquisition and the success of the gesture recognition mostly depends on this stage. Different data received through the input devices are to be modeled properly depending up on the type of applications. Gesture modeling has four different steps, viz. hand segmentation, filter/ noise removal, edge/ contour detection and lastly normalization.
- **Gesture Extraction:**
  Features are the crucial elements for hand gesture recognition. Large number of features, such as, shape, orientation, textures, contour, motion, distance, centre of gravity etc. can be used for hand gesture recognition. Hand gesture can be recognized using geometric features, like, hand contour, fingertips, finger detections. But these features may neither be always available nor reliable due to occlusions and illuminations. Some non-geometric features (such as colour, silhouette and texture) are also available for recognition. But they are inadequate for the purpose. Therefore, the image or the processed image can be fed to the recognizer to select the features automatically and implicitly, rather than using single type of feature alone. Following three approaches are useful for extraction of features.
- **Hand Gesture Recognition:**
  Once the appropriate features as mentioned above, have been extracted from the images and a suitable data set have been selected, the gestures can be recognized using standard machine learning techniques or a special-purpose classifiers. Several methods have been used for gesture recognition: template matching, dictionary look-up, statistical matching, linguistic matching, neural network and ad hoc method.

## IV. SIMULATION RESULTS

**Stage 1:** Run code in mat-lab file. This code is made by using HMM+SVD algorithm.
**Stage 2 :** After running the code it will show one box which ask to train face of employee.
HMM+SVD technique is used because in this error ratio is only 1% comparing to other system. And rate of recognition is about to 99%.
Here it works contain some phase, i.e.
a) Training & b) Face Recognition
**Stage 3:** Enter the employee‘s name. Block is shown in figure.5

Figure 4 : Train Person

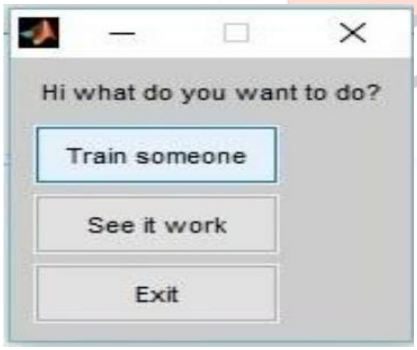
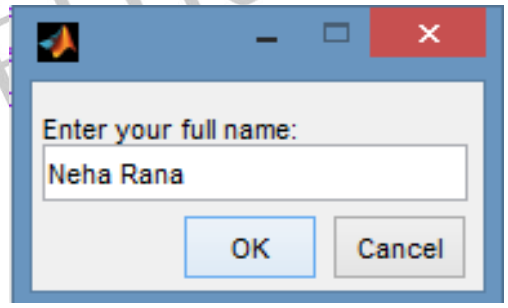



Figure 5 : Enter Person’s name




**Stage 4:** Now it will take up to 400 photographs of different angles of face in 5 seconds. And ask for train these photographs. This is shown in figure.6

Figure 6 : Image Capturing

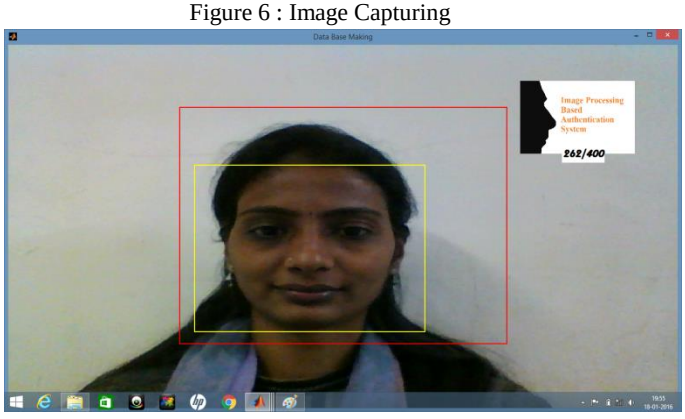
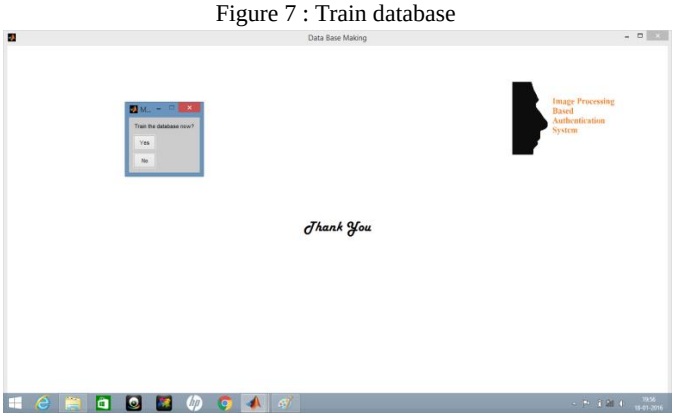
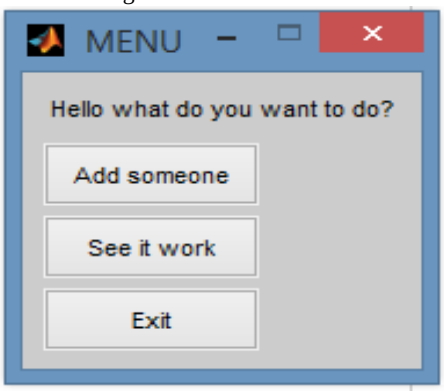



Figure 7 : Train database



**Stage 5 :** For first time training the 400 photographs it will take around 12 to 15 minutes.
As soon as training of photographs was completed, data base is ready of that employee. And it will show message of training were done using SVD parameter. It will save all data in .mat type database file. It is shown in fig.7
**Stage 6:** After training the face system is ready for the work. It will ask for see the work. It is shown in fig.8.

Figure 8 : See its work




**Stage 7:** When person will come in default area, camera automatically captures the image of person and try to recognize person from their database and show the message "Hello Mr/miss...". And If person is outside of the default area or in between that it will show "No Person Found".

Figure 9 : Face detection & Face recognition

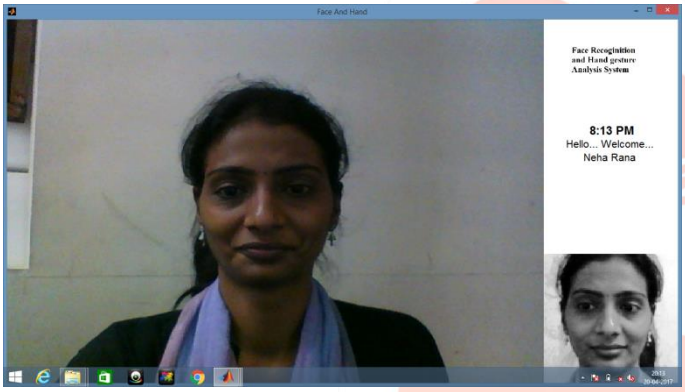
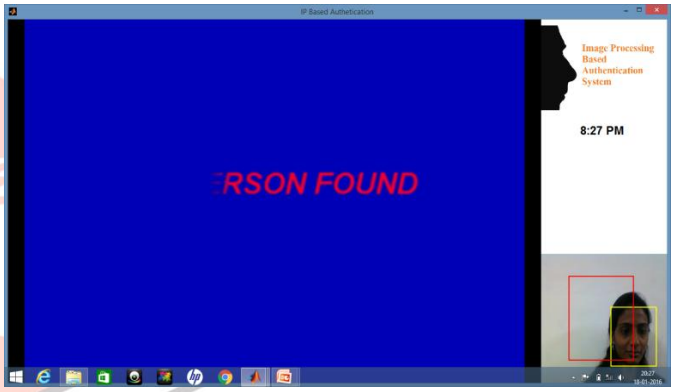



Figure 10 : Face outside default area




**Stage 8:** After recognitioning the person system will ask for hand gesture. It show the message "Try for Gesture".
**Stage 9:** If person will rise hand with thumbs up than system show message "Hello…Welcome Mr/Miss……" and if person thumbs down than system show message "Good Bye…Take care"

Figure 11 : Person recognition with UP hand gesture

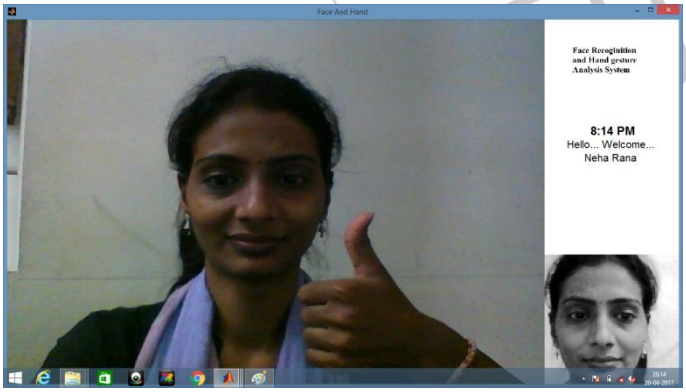
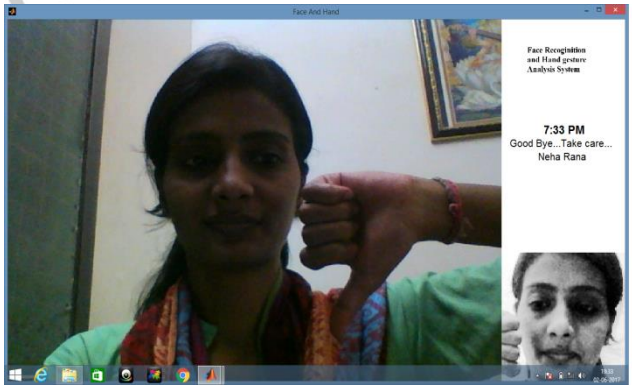



Figure 12 : Person recognition with UP hand gesture




## V. CONCLUSION

In the above system, we discussed about to make a system more secure and simple with the use of biometric authentication with the help of HMM algorithm with SVD parameters. We have categorically achieved our goal of recognizing face image from a large dataset with few set of training images. The experiments carried out indicate that, the HMM work efficiently when there is more learning detail and takes more time to recognize. In this system, approximately having a recognition rate of 99%, the system was very fast. This system could be useful in E-Government services, National Security, Airport, Bank, Offices, colleges, Biometric Time Attendance System.

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