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Attendance Marking System using Facial Recognition

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ABSTRACT

Marking attendance is of significant importance in many places such as classrooms, conferences, or even prisons. It is possible to have a system (application) which marks attendance of people with least possible human intervention.

This paper discusses on the face recognition methodologies using the concepts of image processing, computer vision and machine learning. The system is implemented using two different feature extraction techniques namely Histogram of Oriented Gradients (HOG) and Principle Component Analysis (PCA). The HOG features are classified using Support Vector Machine (SVM) classifier. Euclidean distance is used for classification in the case of PCA. The process of face detection is performed using Viola-Jones algorithm. Real-time or live facial recognition is also possible in the said system using HOG feature extraction and SVM classifier. The face detection and tracking in real-time face recognition is performed using Viola-Jones and Kanade-Lucas-Tomasi (KLT) algorithm respectively.

Key words: Acquisition, face tracking, face detection, feature extraction, classification.

1. INTRODUCTION

Automation is one of the fastest growing technologies that man has seen. The aim however, is primarily to reduce the human intervention to the maximum possible extent. It is evident that machines are more relentless, accurate and hence efficient in most of the cases. Therefore, it is but natural that we incline towards their aid in as many domains as possible.

One such primary domain is biometrics and its applications. Face detection and recognition [14] can be considered as one of the best methods to verify the identity of a person as it is very tricky to manipulate such a system. There are already several biometrics [11] in place to verify a person's identity such as finger print scan, retina scan etc.

The aim of this paper is to discuss the development of such a system that detects and recognizes faces both from a pre-acquired image [12] and in real-time using video surveillance. This system then marks the attendance of the recognized face and displays the list of all the students present. This system eliminates the need for manual roll call and automates the entire procedure of marking the attendance. The workflow is shown in Figure 1.

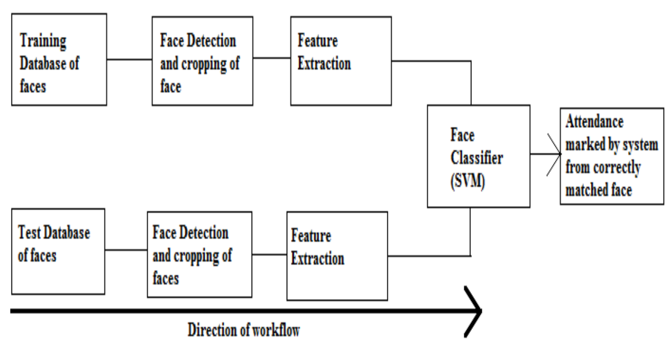

Figure 1: Workflow of the face recognition system

2. LITERATURE SURVEY

Facial recognition is a very popular research field with abundance of knowledge on various techniques and algorithms which help even a novice understand the depth of the field. However, the study of this field requires mathematical knowledge on an undergraduate level for understanding various concepts implemented using linear algebra, differential calculus and vector geometry. There are many research papers which analyse different methods of facial recognition, these methods being different either by usage of unique feature extraction methods or various classifiers.

One such paper "Image-based Face Detection and Recognition" by Faizan Ahmad, Aaima Najam and Zeeshan Ahmed compares Haar-like features extraction with

AdaBoost classifier, Local Binary Pattern (LBP) with AdaBoost classifier and Histogram of Oriented Gradients (HOG) with Support Vector Machine (SVM) on different datasets.This paper also provides an approach to detect tilted faces with the help of Histogram Equalization.

For object or face detection, “Robust Real-time Object Detection” by Paul Viola and Michael Jones device an algorithm using Haar-like features, AdaBoost classifier and a cascade of classifiers to improve the speed of face detection. This detection method called Viola-Jones detection algorithm is one of the most used object detection algorithms.

Besides these, research paper on PCA and SVM by Md. Omar Faruqe and Md. AI Mehedi Hasan provides information on methods of using SVM which is a binary classifier as a multiclass classifier. These methods are One-vs-All method, Bottom-Up decision tree and Top-Down decision tree. Besides these, there are other methods like One-vs-One approach and Error Correcting Output Codes (ECOC) which can be implemented.

“Independent Comparative Study of PCA, ICA, and LDA on the FERET Data Set” by KresimirDelac, MislavGrgic and Sonja Grgic gives an insight on implementing subspace projection methods for facial recognition using Principle Component Analysis (PCA), Independent Component Analysis (ICA) and Linear Discriminant Analysis (LDA). Classification of the image is performed using different vector distance metrics such as L1 (City block),L2 (Euclidean), cosine and Mahalanobis distance.

3. IMAGE ACQUISITION

Image acquisition involves capturing and saving the captured images to the database[15]. This database is spilt into the training and test databases. There are two types of recognition system that is implemented in the paper:

1. Face detection and recognition from a pre-acquired images
2. Face tracking, detection and recognition of a in real time.

4. FACE TRACKING FOR REAL TIME FACE DETECTION

In a live or real-time facial recognition system, it is important to have a tracking algorithmto detect a face in a scene where the face is in slight motion in comparison to the background.Optical flow or Optic flow is the pattern caused by the apparent movement of the object (here, a face) and is a 2D vector. This vector is nothing but a velocity vector that represents the apparent motion of an object in two consecutive frames.

Kanade-Lucas-Tomasi (KLT) algorithm as discussed in [2] and [3]is an efficient tracking algorithm which works by first detecting feature points from an initial frame and tracks thesefeature points in the successive frames using calculated displacement.

Figure 2: Continuous face tracking

Figure 3: Continuous face tracking

Figure 2 and Figure 3 depicts the transformation of the rectangular boundary box due to the motion of the face from one position to the other.

For the implementation of the face tracking system, KLT algorithm is used. The webcam is used to capture a frame to measure the frame size and the video player displays the live tracking environment depending on the frame size measured.Initially, to acquire the database for training the model an adjustable frame count (say 100) is set to provide sufficient time for face tracking and KLT algorithm is used to measure the displacement between two consecutive frames. The frame is captured and converted to a greyscale image for faster computation. A rectangular boundary box is drawn around the face that is being continuously tracked in each frame. The corner points are detected for the boundary box in each frame and are converted to an MX2 matrix. This matrix gets transformed to different scaled values of itself each time there is a movement in the tracked face.

The process mentioned above is used twice during real-time face tracking, once for training image acquisition and again for tracking the test face.

5. FACE DETECTION

Figure 4: An example of Viola-Jones face detection.

Viola-Jones algorithm as discussed in [4] is one of the most popular object detection mechanism used. The training process using this algorithm is slow and tedious whereas the detection is fast and efficient. Viola-Jones algorithm requires the face to be frontal and upright for successful detection.

Viola Jones Algorithm available in the Computer Vision Toolbox in MATLAB is used in the project for face detection of a person in a given image as shown in Figure 4. In the case of pre-acquired images, this algorithm is used for face detection in both the training and testing datasets. In case of real-time, it is used for face detection simultaneously along with the face tracking algorithm. This algorithm uses the concept of computing integral images from the given image which helps in faster computation of a few feature extraction algorithms.

6. FEATURE EXTRACTION

The basic way of processing any image is by processing the corresponding pixels of the image. The processing of pixels is however very difficult if the image is of very high resolution. In case of high-resolution images, the pixel density is more and the processing of these pixels by a local system takes a longer time. Face recognition process involves the processing of such images to get the data on the corresponding faces in the image. One way to solve this problem is by using the method of feature extraction which reduces the dimensionality of data (pixels) by discarding redundant information. Reducing the dimensionality of pixels also makes it easier for the classifier to classify faces. Feature Extraction is an important part of any facial recognition system.

6.1 Histogram of Oriented Gradients

Histogram of Oriented Gradients (HOG) [5] is a very useful algorithm used for object recognition. HOG is specifically used in case of human detection or face detection [10]. The basic concept behind this algorithm is that any shape in an image can be described by the gradient magnitude and direction. The descriptor is the combination of the histogram of these gradients.The histograms across a region of image called blocks can be contrast-normalized or histogram equalized to make it invariant to changes in illumination. Since HOG features are found for small portions of the image, they are invariant to geometric and photometric transformations but are not invariant to object orientation[1].

HOG algorithm consists of the following steps:

- The first step is to calculate gradient magnitude and direction of the image cell by cell (one cell can be an 8x8 image). These gradients are calculated in ‘x’ (horizontal) and ‘y’ (vertical) directions separately and resultant vectors are obtained corresponding to each pixel in a cell. These vectors are called feature vectors that have both magnitude and direction. They are also known as oriented gradients
- The next step is to make a histogram of the oriented gradients obtained for every 8x8 cell. Each cell has 64 feature vectors. These values are split into 9 bins. For easier representation 360□ is divided to 9 sectors of 60□ each and each sector represents the number of feature vectors present in that direction. Therefore 64 gradient values or feature vectors are now reduced to 9 values (for every 8x8 cell) by the process of voting which is based on the gradient magnitude values of the pixel.
- These features that are extracted are invariant to slight movements, both translation and rotation. Hence, this method is most suitable for human detection or face detection. HOG features when fed to a machine learning algorithm gives us a very

efficient classifier, either binary (human detection) or multiclass (facial recognition).

Figure 5: A normalized and cropped image

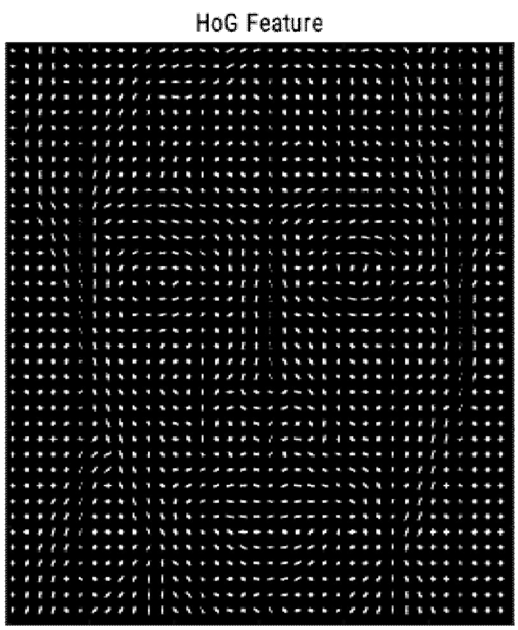

Figure 6: The HOG features for the image in Figure 5

Figure 6 shows the HOG features that have been extracted for the face in Figure 5.

In this paper the same algorithm is implemented in two scenarios. One, where there is a live video feed from which faces are to be identified [6] and the other, where there is a pre-acquired image from which a face is to be detected and recognized.

In the case of detection and recognition from pre-acquired images, multiple face recognition is implemented using HOG. This is done so by detecting multiple faces using Viola-Jones algorithm described in section *IV*and applying HOG for each of the detected faces. These features are then compared with that of classified training dataset. The closest matched face is then recognised from the training dataset.

6.2 Principle Component Analysis

Principle Component Analysis [7] is one of the feature extraction methods used most commonly in face recognition systems. It uses the concept of finding eigen vectors from a covariance matrix. The highest eigen values are then projected into a sub-space. PCA converts an n-dimensional feature matrix into a smaller matrix i.e it reduces the number of features to only the significant ones.

In this paper PCA [8] is implemented as one of the feature extraction methods for face recognition. A set of NXN (say 300 X 300) dimensional training images are loaded from the pre-acquired training dataset containing M images. The 2D images in the training dataset are then converted to a matrix of integers. Each image is then converted to a 1D vector form i.e a N^2 X 1 matrix. Each of these 1D face vectors are then concatenated column by column and made into a single matrix or face vector space of N^2 X M dimension.

In the next step all the faces are normalized where the common features of all the faces in the face vector space are extracted and combined to form an average face vector. These common features are then eliminated by subtracting them from each of the faces in the vector space. The eigen vectors are obtained from the calculated covariance matrix. The covariance matrix is calculated by multiplying the normalized face vector space of N^2X M dimension and its transpose of M X N^2 dimension. But this matrix multiplication proves to be computationally very expensive since the covariance matrix turns out be of N^2X N^2 dimension. Thus to reduce the dimensions, the transpose (M X N^2 dimension) is matrix multiplied with the normalized face vector space (N^2X M) which results in a M X M covariance matrix. This will result in M eigen vectors obtained from the covariance matrix containing M X 1 Eigen faces.

From this set of Eigenfaces[10] only the significant ones are retained which contain most of the essential information about each face in the training database and the rest are eliminated. If K eigen faces are significant from the obtained set of M Eigen faces, then these K Eigen faces are matched back into the original dimensions of the face (N^2 X 1 dimension).

Each of the faces from the training dataset are represented as a weighted sum of these above obtained K Eigen faces and the average face that was subtracted in the previous steps is added back.To recognize unknown faces from the pre-acquired image dataset, each of the detected faces are converted to a face vector. Each of the face vectors are then normalized in a similar way as was done with the training dataset. The normalized face vectors are then represented as a weighted sum of the K eigen faces in a similar fashion as was with the training dataset. The weight vector obtained for the test images is compared with the weight vector obtained for the training images and the Euclidean distance is calculated. If the distance is greater that the set threshold value then it is recognized as a known face in the training dataset and the name of the face of the recognized person is returned along with the face.

7. FACE CLASSIFIER- SUPPORT VECTOR MACHINE

Support Vector machine[9] is one of the machine learning algorithms. It performs supervised learning. It is a binary classifier and can be implemented for both classification and regression models. If there are two features that the data needs to be classified into, then the SVM algorithm uses a linear decision boundary or hyperplane to separate the two sets of features. Multiple decision boundaries can be drawn to separate the features in the feature plane but SVM selects the decision boundary with the largest margin.SVM is sometimes referred to as a large margin classifier because it uses a safety margin called support vectors on either side of the decision boundary while classifying the features. In this way SVM ensures more accurate results while classifying data. A non linear decision boundary can also be chosen depending on the type of data being classified[13].

In this paper the face classification is done using the SVM classifier and multiclass SVM is used instead of binary SVM in-order to classify a face among multiple faces. This uses the one-vs-all classifier i.e, each class (face) has a separate binary SVM classifier trained to separate that particular class (face) associated with it from the rest of the classes (other faces) by selecting the decision boundary with the largest margin for that particular classification. Thus it can be considered as several binary classifiers fitted into one model to become a multiclass classifier. Training the multi-SVM occurs in two stages:

1. Transforming the input dataset into a high dimensional feature space.
2. Fitting the decision boundary to the multiclass model to correctly classify the respective class associated with each SVM classifier.

SVM was implemented with HOG feature extraction to get better accuracy while recognizing faces.

8. EXPERIMANTAL RESULTS

All the following methods of facial recognition were initially tested using a simple database by AT&T to test the working of the algorithms. All the images are of low resolution and of the same dimensionality. This is then implemented for the dataset acquired using good resolution cameras and webcams.

8.1 Output for pre-acquired images using HOG

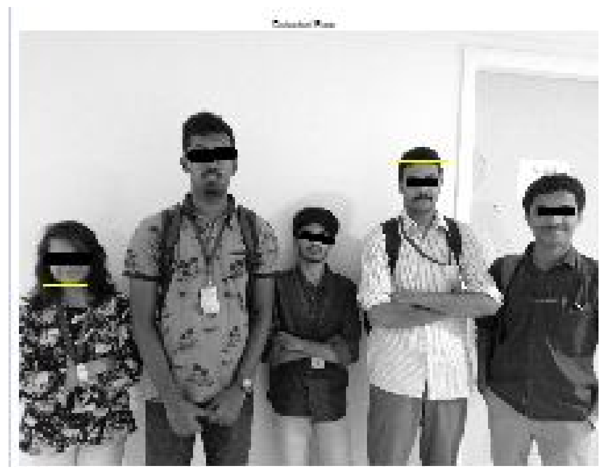

Figure 7:The detected faces from the image in the test set

Figure 7.1: Face 1 correct matching

Figure 7.2: Face 2 correct matching

Figure 7.3: Face 3 correct matching

Figure 7.4: Face 4 correct matching

Figure 7.5: Face 5 incorrect matching

It can be observed thatin Figure 7, four out of five images(faces)i.e Figure 7.1-7.4 are matched properly to the training dataset whereas the last onei.e Figure 7.5 is improperly matched. After testing on various other datasets it can be concluded that HOG performs face recognition with a 96.25% accuracy.

8.2 Output for pre-acquired images using PCA

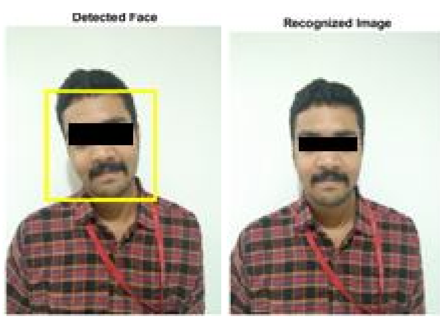

Figure 8: Shows the detected image with correct recognition

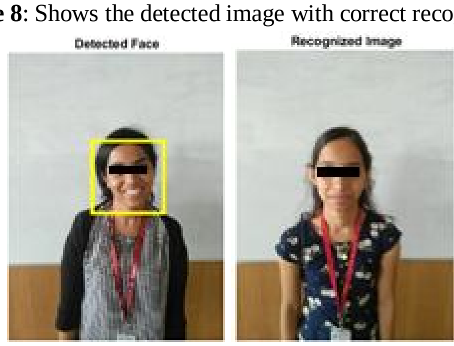

Figure 9: Shows the detected image with incorrect recognition

Here PCA correctly classifies every 19 out 20 tested images. Figure 8 shows an example where the image(face) has been properly recognized and Figure 9 shows an incorrect recognition. After testing on various other datasets it can be concluded that PCA performs face recognition with a 95% accuracy.

8.3 Output of real-time face recognition

With HOG proving to give better accuracy than PCA, it was further implemented into real time face tracking, detection and recognition.

Figure 10: Face being tracked and then detected.

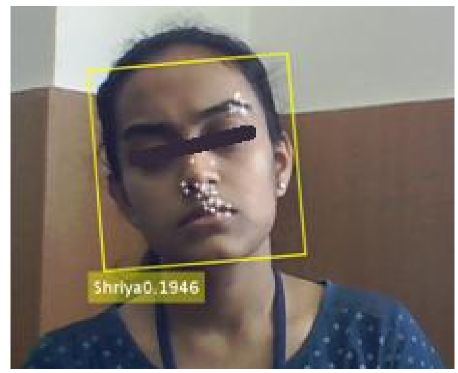

Figure 11: Face correctly recognized

Figure 10 shows a face being detected in the image and Figure 11 shows the correct identification of the image(face).

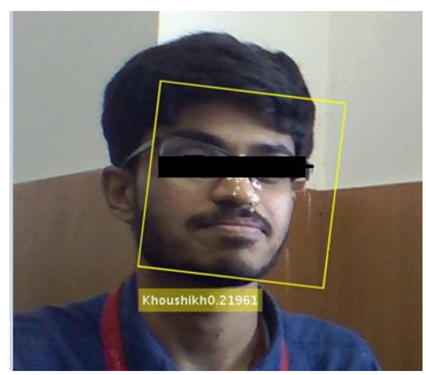

Figure 12: Correct recognition of the face

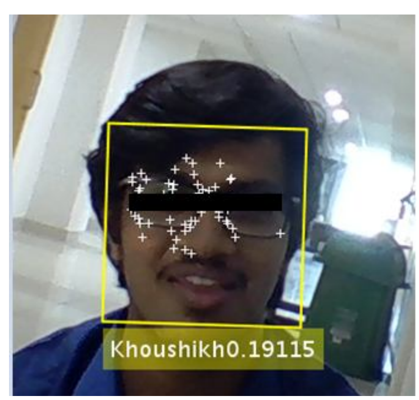

Figure 13: An incorrectrecognition of the face

Figure 12 and Figure 13 show two images of two different faces being recognized as the same face.

9.CONCLUSION

This paper discusses the various procedures involved in building an attendance marking system using Facial Recognition. The above discussed methodologies are implemented using MATLAB. A comparative analysis was done between the efficiency obtained by the two feature extraction methods - HOG and PCA. The facial recognition system was further implemented to detect faces in real time by using face tracking and detection.

It can also be implemented in other areas where face recognition proves to be a useful tool. Its use ranges from face unlock feature on smart phones to real time monitoring of high alert areas using CCTVs to detect and recognize wanted criminals, terrorists and to alert the concerned authorities. It thus proves to be an essential tool in various fields and has a wide range of applications.

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