ECE 415 Computer Vision and Image Analysis

Face Detection based Attendance System

Team Number: 10

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Summary

Abstract

Face recognition is one of the important biometric methods; it deals with automatically identifying or verifying a person from a digital image or video source by comparing selected facial features. It is a form of identity access management and access control. Moreover, face recognition is considered a passive and non-intrusive approach to verifying and identifying people. Though there are other forms of identification such as password, PIN (personal identification number), fingerprints and iris but in some cases it is better to have an identification approach that is closer to the way human beings recognize each other and this informed the application of the proposed hybridized face recognition algorithm to students' attendance taking in tertiary institutions. Attendance in institutions has traditionally been taken manually by writing and signing on attendance sheets and the lecturer keeping stock of the times the students sign the attendance sheets. This poses the following problems: Problem of keeping track of the number of times the student comes to the class using the attendance sheet; Lecturers manually recognizing students that are rightful for the class; Impersonation at lectures and examination; Students' identity management and access control problem. Though fingerprint authentication has been adopted in developing countries and has done very well but still not suitable in certain situation where people have no finger or the finger has been mutated; situations where identification needs to be done quickly during examination because of time; situations where identification needs to be done without intruding. These informed the need for a complimentary facial recognition system to take attendance in tertiary institutions.

Facial recognition has been used in several areas such as security and detection of criminals or suspects. It has been a means of authentication and access control and identity management in some private corporations but has not been applied in tertiary institutions to automatically take attendance in developing countries. That is, the technology has suffered from low adoption in educational institutions.

In view of this, there is a need for an automated system for taking attendance at both lectures and examination. This paper considers facial recognition system among other biometric systems. Automated facial recognition system proposed in this work will take attendance automatically by capturing the student's facial picture and perform necessary verification. The facial recognition system is envisaged to provide suitable and reliable way for detecting the face of the students, taking the attendance and verifying the studentship of the person. Face recognition is one of the few biometric methods that possesses the merits of both high accuracy and low intrusiveness.

Problem Statement and Introduction

“Face is used as a clue for identifying who a person is.” Facial recognition is a biometric software application capable of uniquely identifying or verifying a person by comparing and analyzing patterns based on the person's facial contours. Facial recognition is mostly used for security purposes, though there is increasing interest in other areas of use.

Attendance is an important part of daily classroom evaluation. At the beginning and ending of class, it is usually checked by the teacher, but it may appear that a teacher may miss someone, or some students answer multiple times. Face recognition-based attendance system is a problem of recognizing face for taking attendance by using face recognition technology based on high-definition monitor video and other information technology.

Objective: To build a system that can automatically punch registry of a person’s presence in a classroom. The wait time is reduced as the camera detects the face(s) of a person automatically from a group of people.

Implementation

Programming Language: MATLAB

Open source libraries and built-in functions: Computer Vision Toolbox, Image Processing Toolbox

Face Detection

Face detection can be regarded as a specific case of object-class detection. In object-class detection, the task is to find the locations and sizes of all objects in an image that belong to a given class. Examples include upper torsos, pedestrians, and cars.

Fig 1: Conversion of RGB to Grayscale image

Face-detection algorithms focus on the detection of frontal human faces. It is analogous to image detection in which the image of a person is matched bit by bit. Image matches with the image stores in database. Any facial feature changes in the database will invalidate the matching process.

A reliable face-detection approach based on the genetic algorithm and the eigenface technique.

Fig 2: Multiple Face Detection

a. Knowledge-Based

The knowledge-based method depends on the set of rules, and it is based on human knowledge to detect the faces. Ex- A face must have a nose, eyes, and mouth within certain distances and positions with each other. The big problem with these methods is the difficulty in building an appropriate set of rules. There could be many false positive if the rules were too general or too detailed. This approach alone is insufficient and unable to find many faces in multiple images.

b.Feature-Based

The feature-based method is to locate faces by extracting structural features of the face. It is first trained as a classifier and then used to differentiate between facial and non-facial regions. The idea is to overcome the limits of our instinctive knowledge of faces. This approach divided into several steps and even photos with many faces they report a success rate of 94%.

c.Template Matching

Template Matching method uses pre-defined or parameterised face templates to locate or detect the faces by the correlation between the templates and input images. Ex- a human face can be

divided into eyes, face contour, nose, and mouth. Also, a face model can be built by edges just by using edge detection method. This approach is simple to implement, but it is inadequate for face detection. However, deformable templates have been proposed to deal with these problems.

d. Appearance-Based

The appearance-based method depends on a set of delegate training face images to find out face models. The appearance-based approach is better than other ways of performance. In general appearance-based method rely on techniques from statistical analysis and machine learning to find the relevant characteristics of face images. This method also used in feature extraction for face recognition.

Face Detection using Viola-Jones Algorithm

The Viola-Jones algorithm is a widely used mechanism for object detection. The main property of this algorithm is that training is slow, but detection is fast. This algorithm uses Haar basis feature filters, so it does not use multiplication.

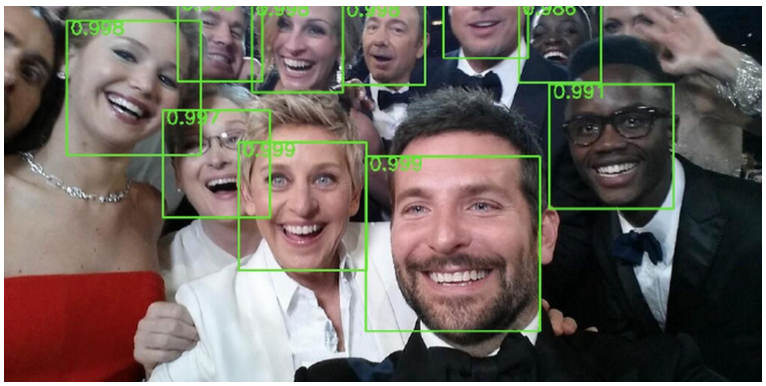


Fig 3: Viola-Jones Face Detection

The efficiency of the Viola-Jones algorithm can be significantly increased by first generating the integral image.The integral image allows integrals for the Haar extractors to be calculated by

adding only four numbers. For example, the image integral of area ABCD is calculated as II(yA,xA) – II(yB,xB) – II(yC,xC) + II(yD,xD).

Detection happens inside a detection window. A minimum and maximum window size is chosen, and for each size a sliding step size is chosen. Then the detection window is moved across the image as follows:

Set the minimum window size, and sliding step corresponding to that size. For the chosen window size, slide the window vertically and horizontally with the same step. At each step, a set of N face recognition filters is applied. If one filter gives a positive answer, the face is detected in the current widow.

If the size of the window is the maximum size stop the procedure. Otherwise increase the size of the window and corresponding sliding step to the next chosen size and go to step 2.

Each face recognition filter (from the set of N filters) contains a set of cascade-connected classifiers. Each classifier looks at a rectangular subset of the detection window and determines if it looks like a face. If it does, the next classifier is applied. If all classifiers give a positive answer, the filter gives a positive answer and the face is recognized. Otherwise the next filter in the set of N filters is run.

Each classifier is composed of Haar feature extractors (weak classifiers). Each Haar feature is the weighted sum of 2-D integrals of small rectangular areas attached to each other. The weights may take values ±1. The classifier decision is defined as:

$$C_m = \begin{cases} 1, & \sum_{i=0}^{i_m-1} F_{m,i} > \theta_m \\ 0, & \text{otherwise} \end{cases}$$

$$F_{m,i} = \begin{cases} \alpha_{m,i}, & \text{if } f_{m,i} > t_{m,i} \\ \beta_{m,i}, & \text{otherwise} \end{cases}$$

fm,i is the weighted sum of the 2-D integrals. αm,i and βm,i are constant values associated with the i-th feature extractor. θm is the decision threshold for the m-th classifier.

Face Recognition

Face Recognition is a Biometric Artificial Intelligence based application that can uniquely identify a person by analysing patterns based on the person's facial textures and shape

Fig 4: Pictorial representation of Face Recognition

Face Recognition methods

a. Geometric Based methods

The geometry feature based methods analyze both local features and their geometric relationships. This approach is often called feature based method. Examples of this approach are some of the Elastic Bunch Graph Matching algorithms developed in.

b. Piecemeal methods

Piecemeal approach is a type of approach in facial feature detection which deals with minimalism; the idea is to use very few facial features detected, instead of waiting to get all features. It assumes it is a face as long as those few features have been detected.

c. Appearance-based/Model-based methods

Appearance based methods represent a face in terms of several raw intensity images. An image is considered as a high-dimensional vector. Then statistical techniques are usually used to derive a feature space from the image distribution. The sample image is compared to the training set. On the other hand, the model-based approach tries to model a human face. The new sample is fitted to the model, and the parameters of the model are used to recognize the image. Appearance methods can be classified as linear or nonlinear, while model-based methods can be 2D or 3D.

d. Template matching face recognition methods

Template matching process uses pixels, samples, models or textures as pattern. The recognition function computes the difference between these features and the stored templates. It uses correlation or distance measures.

e. Statistical approach to Face recognition algorithm

In statistical approach, each image is represented in terms of the features. It is viewed as a point (vector) in a dimensional space. Therefore,the goal is to choose and apply the right statistical tool for extraction and analysis of the underlying manifold. These tools must define the embedded face space in the image space and extract the basic functions from the face space. This would permit patterns belonging to different classes to occupy disjoint and compacted regions in the feature space. Consequently, a line, curve, plane or hyperplane that separates faces belonging to different classes could be defined.

f. Eigenface (or Principal Component Analysis (PCA)) method

The basic concept behind eigenface method is information reduction, when an evaluation of a small image is done; there is a great amount of information present. This method generates base-faces and then represents any image being analyzed by the system as a linear combination of the base faces. Once the base faces have been chosen, the problem has been reduced to a standard classification problem. Euclidean distance measure is used here for classification. This Facial recognition method can be broken down into the following components: Generate the eigenfaces; Project training data into face-space to be used with a classification method; Evaluate a projected test element by projecting it into face space and comparing to training data.

Eigen Feature Extraction and Face Recognition

The task of facial recognition is discriminating input signals (image data) into several classes (persons). The input signals are highly noisy (e.g. the noise is caused by differing lighting conditions, pose, etc.), yet the input images are not completely random and in spite of their differences there are patterns which occur in any input signal. Such patterns, which can be observed in all signals could be - in the domain of facial recognition - the presence of some objects (eyes, nose, mouth) in any face as well as relative distances between these objects. These characteristic features are called eigenfaces in the facial recognition domain (or principal components generally). They can be extracted out of original image data by means of a mathematical tool called Principal Component Analysis (PCA).

By means of PCA one can transform each original image of the training set into a corresponding eigenface. An important feature of PCA is that one can reconstruct reconstruct any original image from the training set by combining the eigenfaces. Remember that eigenfaces are nothing less than characteristic features of the faces. Therefore one could say that the original face image can be reconstructed from eigenfaces if one adds up all the eigenfaces (features) in the right proportion. Each eigenface represents only certain features of the face, which may or may not be present in the original image.

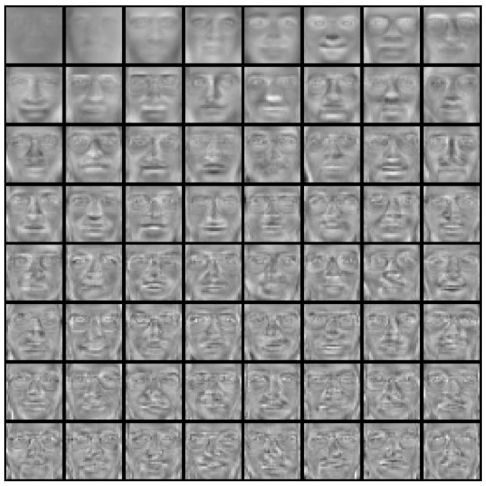


Fig 5: Eigen faces

If the feature is present in the original image to a higher degree, the share of the corresponding eigenface in the ”sum” of the eigenfaces should be greater. If, on the contrary, the particular feature is not (or almost not) present in the original image, then the corresponding eigenface should contribute a smaller (or not at all) part to the sum of eigenfaces. So, in order to

reconstruct the original image from the eigenfaces, one has to build a kind of weighted sum of all eigenfaces. That is, the reconstructed original image is equal to a sum of all eigenfaces, with each eigenface having a certain weight. This weight specifies, to what degree the specific feature (eigenface) is present in the original image.

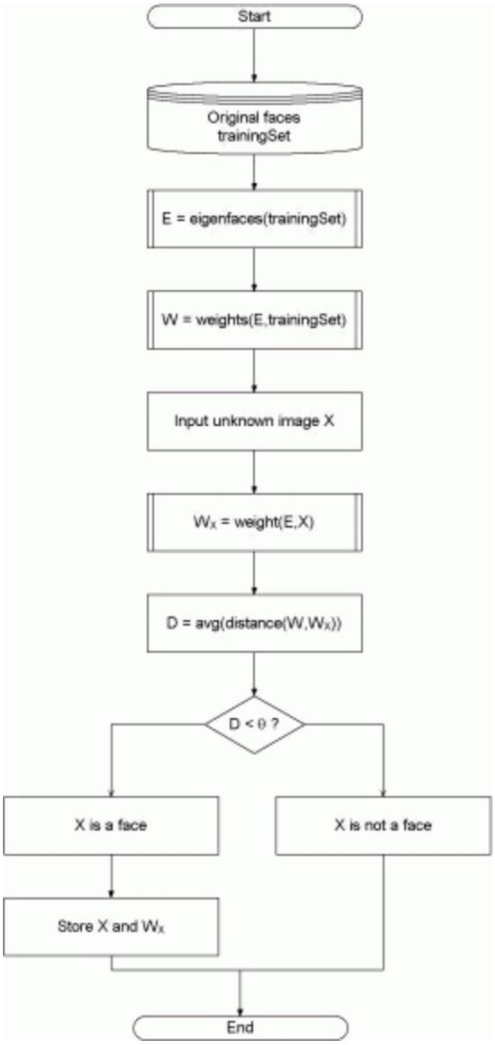


Fig 6: Eigen Feature Extraction and Face Recognition

If one uses all the eigenfaces extracted from original images, one can reconstruct the original images from the eigenfaces exactly. But one can also use only a part of the eigenfaces. Then the reconstructed image is an approximation of the original image. However, one can ensure that losses due to omitting some of the eigenfaces can be minimized. This happens by choosing only the most important features (eigenfaces). Omission of eigenfaces is necessary due to scarcity of computational resources.

Face Recognition based on Eigen Feature Extraction

The algorithm for the facial recognition using eigenfaces is basically described in figure 4. First, the original images of the training set are transformed into a set of eigenfaces E. Afterwards, the weights are calculated for each image of the training set and stored in the set W .

Upon observing an unknown image X, the weights are calculated for that particular image and stored in the vector W_X. Afterwards, W_X is compared with the weights of images, of which one knows for certain that they are faces (the weights of the training set W). One way to do it would be to regard each weight vector as a point in space and calculate an average distance D between the weight vectors from W_X and the weight vector of the unknown image W_X (the Euclidean distance described in appendix A would be a measure for that). If this average distance exceeds some threshold value , then the weight vector of the unknown image W_X lies too ”far apart” from the weights of the faces. In this case, the unknown X is considered not a face. Otherwise (if X is actually a face), its weight vector W_X is stored for later classification. The optimal threshold value has to be determined empirically.

Face Recognition Algorithm

Steps for Training -

• Create A matrix from training images
• Compute C matrix from A.
• Compute eigenvectors of C.
• Compute eigenvectors of L from eigenvectors of C.
• Select few most significant eigenvectors of L for face recognition.
• Compute coefficient vectors corresponding to each training image.
• For each person, coefficients will form a cluster, compute the mean of cluster.

Steps for Recognition -

• Create a vector u f or the image to be recognized.
• Compute coefficient vector for this u.
• Decide which person this image belongs to, based on the distance from the cluster mean for each person.

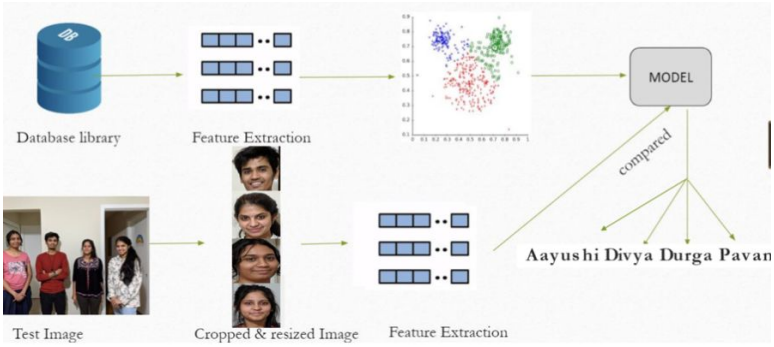


Fig 7: Face Recognition Workflow

Architecture

The architecture of this face recognition based attendance system is shown in the above mentioned diagram. The working of this smart attendance system is very simple and easy to understand. To bring this system into work, we will need some hardware devices for our project. Firstly, we will need a high definition camera which has to be fixed in the classroom at a suitable location from where the whole class can be covered in the camera.

When the camera takes the picture of all students, that picture is enhanced for further processing. In the enhancement, the picture is first transformed in grayscale image, and then it will be equalized using histogram technique.After enhancement, the picture will be given for detecting the faces of students which will be done by face detection algorithm.

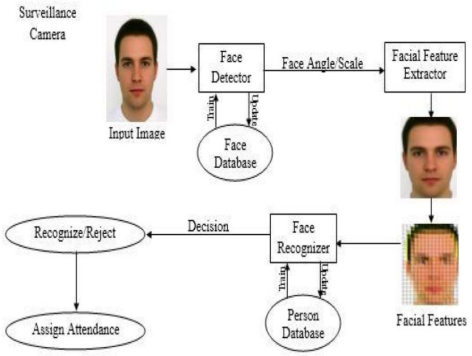


Fig 8: Attendance System Model

Then after detection of faces, each student's face will be cropped from that image, and all those cropped faces will be compared with the database of faces. In that database, all students' information will already be maintained with their image. By comparing the faces one by one, the attendance of students will be marked on server.

Database Workflow

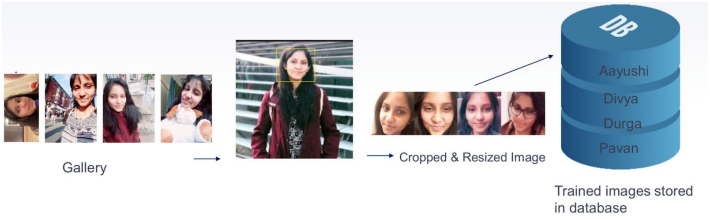
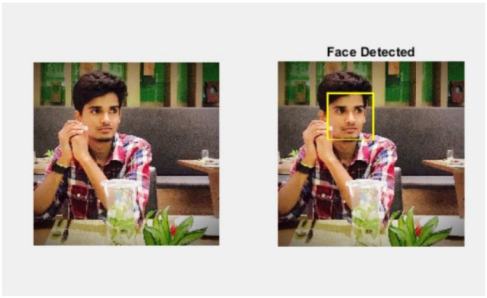
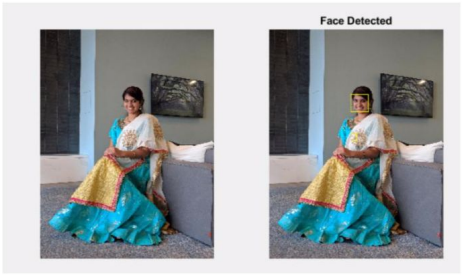


Fig 9: Database Workflow

Results

Face Detection:





Multiple faces in a group picture

Individual faces detected and cropped

Face Recognition:

Fig 10: Hypothetical classroom

This was the final result of the project. Here, a snap of a hypothetical classroom is taken for attendance. We have assumed the total class strength to be five and four of us were present. As we can see the model is able to detect the four people with their respective names and mark the attendance for them by generating an attendance register.

Aayushi	Divya	Durga	Pavan	Yazhini	
Present	Present	Present	Present	Absent	

Fig 11: Attendance sheet

Challenges

Face Detection (camera orientation): This challenge was overcome by rotating the image until the face was detected, and when the face was detected the rotation was stopped.

Face Detection (false detection) : This was overcome by passing the first input through a lower threshold to detect the maximum number of faces and then passed through a suitable higher threshold to filter out the false faces detected.

The most challenging part for face recognition using Eigenface is the changes in the details like, background, illumination, facial expression, pose, scale sensitivity etc. These problems decrease the efficiency of the system. These problems can be somewhat manageable but not totally avoidable. Though a tremendous amount of research has been done in this field, upgrades can be done to the PCA based Eigenface method.

Conclusion

The Face recognition system that has been implemented works as expected with promising results. All the faces are recognised and the attendance is marked in the register. It's highly possible that in a couple of years such systems would be able to process gestures, expressions, gait patterns, palm & ear prints, voice and scent signatures.

Like every technology face recognition has it's pros and cons. Pros - Improved security, High accuracy, Fully automated. Cons - Data storage, privacy. As a future scope we would like to work on proxy attendance and train our model using different ML techniques.

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