Attendance Maintenance Using Face Recognition Technique

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Approval Sheet

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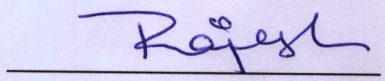

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Abstract

In any class room attendance maintenance is a hectic task for teacher, they need to call roll no or name. Based on the response and identification, they record the attendance for the student. Automatic attendance maintenance system is challenging task because person identification in images is a difficult task. To solve the problem of identifying a person in images, some statistical based techniques are used such as Independent Component Analysis (ICA), Principal Component Analysis(PCA), LDA(Linear Discriminate analysis) etc. Biometric based techniques such as identification by iris, finger prints, face detection etc., are the most widely used techniques in computers. Our main motive is to maintain attendance in an organization by using face recognition technique. In Face recognition technique, the system learns the facial features and identifies the human face in images. The Automation of attendance maintenance was implemented in two phases: image capturing and person identification . To capture the images we used Fire-i camera and for person face identification, we used PCA technique.

Contents

Chapter 1

Introduction

1.0.1 Problem statement

The main motivation of this thesis is to identify a person by his/her biometric based on physiological characteristics. We have consider the face of a person as biometric based physiological characteristic. We have used person face images to identify a person with computer by identifying latent factors in the image. Based on the facial properties in images, we can identify the person in the image. After identifying the person in the image, we record the attendance for the identified person and whoever people are not identified with the system, they are treated as absentees to the class.

1.0.2 Face Recognition

Biometric based identification technique generally uses physiological characteristics(face, finger prints, ear and voice) and behavioral characteristics (signature, keystroke dynamics, etc..) of a person. Face recognition is one of biometric based identification technique, that uses facial features for identifying a person. In iris based identification, user should stand in a fixed position before camera to give his iris information to the system which makes users get prostrated. Hand rests are used to scan the finger print information of user. But, face recognition can be done by acquiring the face images from a possible distance by a camera with less effort from the user. Some of disadvantages that we face with biometric based techniques are

- If the epidermis tissue is damaged, then data collection in general is of no use because that rely on hands and finger prints information.
- Iris and retina identification requires equipment, that are very expensive and more sensitive to any human body motion.
- Voice recognition has influenced by background noises, auditory fluctuations on a phone line.
- Signatures can easily modified.

The main advantage of face recognition is its cost effectiveness, facial images can be obtained by less expensive cameras. Face recognition is a kind of hard problem in object recognition. The difficulty of this problem comes from the fact that if faces appear to be roughly same, it is hard to capture in pattern recognition. Face images are frontal view form a very dense cluster (most of the images

map to same point) in image space which makes it difficult for the traditional recognition techniques to accurately discriminate among them to get a high degree of success. The human face is not a unique, rigid object. Various factors that influence the appearance of the face to vary. The source of the variation in the facial appearance can be categorized into two groups[1]

- Intrinsic factors
- Extrinsic factors.

Intrinsic factors are the factors that depend on the physical nature of the face and caused by changes in the face with respect to time and emotions. These factors can be further divided into two groups.

- Intra personal.
- Interpersonal.

Intra personal factors are responsible for varying the facial expressions of the same person like are age ,facial expression and facial paraphernalia. Interpersonal factors are responsible for the differences in the facial appearance of different people like ethnicity and gender. Extrinsic factors influence appearance of the face to alter via the interaction of light with the face. Example factors include illumination, pose, scale and imaging parameters (focus, imaging, noise, etc..). Age variations, illumination variations and pose variations are three major problems in current face recognition systems. Most current face recognition systems work well under constrained conditions. The performance of most of these systems degrades rapidly when they are put to work under conditions.

1.0.3 Face recognition from Intensity Images

Feature based:

Feature based identification is based on the identifying the fiducial in the face image. The first step is to process the input image and identify the locations and points of eyes, nose and mouth. Use this locations and points like fiducial features and extract these feature values from images and compute the geometric relationships among those fiducial features. Make these information as a vector of geometric features for dimensionality reduction purpose. Standard statistical pattern recognition techniques are used to match faces using these measurements. Automated face recognition was mostly based on these techniques. A well-known feature-based approach is the elastic bunch graph matching method proposed by Wiskott et.al[2]. This technique is based on Dynamic Link Structure [3]. A graph can be constructed for each individual face as follows, a set of fiducial points on the face are chosen and each fiducial point is represented as a node in a fully connected graph, the Gabor filter responses applied to a window around the fiducial point. In the graph each arch is labeled with the distance between the correspondent fiducial points. A representative set of such graph for each person is constructed by combining into a stack-like structure called a face bunch graph. Once the system has a face bunch graph, graphs for new face images can be generated automatically by elastic Bunch Graph Matching. Recognition of a new face image is performed by comparing its image graphs with the existing known face images. Identification is done by selecting the one with the highest similarity value.

1.0.4 Advantages of matching based approach

- Extraction of the feature points follows the analysis done for matching the image to that of a known individual. It is robust.
- The feature based schemes can be made invariant to size, orientation and lighting.
- Compactness of the representation of the face images and high speed matching.

1.0.5 Difficulties

- Difficulty in automatic feature detection.
- Deciding which features are to be important.
- If the feature set doesn't have proper discrimination ability, the amount of subsequent processing cannot compensate for the intrinsic deficiency.

1.0.6 Purpose

Face recognition scenarios can be classified into two types[1].

- Face verification: It is a one-to-one match that compares a given face image against a template face image. To evaluate the verification performance ROC curves are used. A good verification system should balance between FAR and FRR.
- Face identification: It is a one-to-many matching process that compares a given face image against all the images in database. The identification of the test image is done by finding the image in the database that has the highest similarity with the test image.

1.1 Performance Evaluation Metrics

False Rejection Rate(FRR) and False Acceptance Rate(FAR) are two metrics that indicate the face recognition system identification power. FRR is Type-I error and FAR is called Type II error. They are inversely proportional to each other. Every recognition system should give a proper thresholding between the two to achieve good performance. Balancing between FRR and FAR can vary from system to system. The threshold between acceptance and rejection of a person to be identified varies from application to application. Giving a proper threshold is responsibility of the designers of face recognition system. Recognition system developers always put effort to reduce the area under the FAR-FRR curve. Developers need to have a proper feature extraction scheme and a powerful pattern matcher to solve this problem.

1.2 Applications

- Face recognition can be used to provide network security and different level of authorizations can be provided.
- Face recognition can be used in biometric analysis.

- Face recognition can be used in content based image retrieval and content based video retrieval.
- There are cases where the same person have more than one identification number in a nation-wide voter registration face recognition can be used to eliminate the duplicates.
- To provide security to computers by preventing unauthorized access with face recognition based authentication.
- Searching image in databases have the applicability in many ways. Police can use this database for finding the licensed drivers, missing children, immigrants etc.
- In Electoral registration, banking, electronic commerce applications, identifying newborns, identification of national IDs, passports, employee IDs etc...

1.2.1 Note

The face recognition is challenging task because of problems like illumination pose and orientation aging and different conditions like wearing glasses causes more variations in the face images. The features used in the pattern classification have more influence on the performance of the system. The features used decides the success rate of the recognition system.

Chapter 2

Review of Previous work

Based on the face data collection methodology the face recognition can be divided into three categories.[1].

- Methods operate on intensity values of images.
- Methods operate on video sequences.
- Methods that uses 3D information or other infra-red imagery in sensory data.

2.0.2 Statistical

Baron et.al presented a simple holistic approach, each image is a 2D array consisting of intensity values and each image is compared with the all other images in database, they used the direct correlation comparison for similarity measure[4]. In this approach, the authors have used the system in constrained environment like less scaling and assumption of equal illumination in all the images. This method is computationally expensive and its performance degrades when lighting conditions are varying, sensitive to face orientation, noise and background clutter, size. These are the major shortcomings of straightforward correlation based approaches, the major drawback is it is computationally expensive because the direct correlation based matching is done on high dimensional space[5].

To overcome this curse of dimensionality, several other dimensionality reduction methods are proposed. Its main focus is retaining the most useful information in the image. Sirovich et.al uses Principal Components Analysis(PCA) to represent the face images economically in a less dimensional space[6]. Any particular face can be efficiently represented along the eigen face coordinate space, any face can be approximately reconstructed by using just a small collection of eigenpicture with the corresponding projection along each eigen faces. Turk et.al. realized, based on Sirovich and Kirby's findings, that projection along eigenpicture could be used as classifier to recognize faces[7],[8]. By using the covariance matrix of images they find eigenvectors with the dominant eigenvalues, with that they build eigenpicture. Use this for recognition system and recognition is done by projecting the query image onto the eigenspaces and comparing the face class obtained in the eigen space of each individual known. The eigenface space is less dimensionality space compared to original image space. The face identification can done in reduced dimensionality space(eigenface space).

The capabilities of Turk and Pentlands system have been extended in many ways, one of these is tested on a database of 7,562 images of approximately 3,000 people. A multiple observer method has been suggested to deal with large changes in pose of a face. Given N individuals and each individual with M different pose variations, pose elimination and recognition can be done in a universal eigenspaces, the eigenspaces can be obtained by combining NM images and calculating the eigenspaces for all images or alternatively can build a set of M separate eigenspaces, one for each of the N views(the view based approach).

The view based approach is reported to give better results than the parametric based recognition. To deal with the variations in the facial appearance a modular Eigen features approach is proposed. The features used are localized, salient facial features are augmented (low resolution description of the face is augmented with high resolution details). By using this system, slightly better results are obtained than the basic eigenfaces approach. Multi-scale eigenfaces or rescaling input image to multiple sizes is used for variations in scale and uses the scale that gives smallest distance measured to the face space. Whenever a single image of each individual is available, PCA appears to work well. Choosing the projection which maximizes total scatter is the technique works whenever multiple images per person is available. Lighting and facial expression changes can cause unwanted variation retains if PCA is used[9].

Moses stated that lightning and illumination on a face gives more variations between the images then the change in a face identity in image variations[10]. Therefore, Moses et.al proposed that using Fisher's Linear Discriminant Analysis[11], which maximizes the ratio of the between-class scatter and the within-class scatter and is thus the method gives better results for classification than PCA. They named it Fisher faces and reported that this method is simultaneously handling variations in expressions and lightning, this method uses subspace projection prior to LDA projection(to solve the problem of within class scatter matrix becoming degenerate). They conducted this experiment on 330 images of 5 people(66 images of each people) and they reported Fisher faces capture discriminatory information better than eigenfaces.

Martinez et.al shows that when the training data set is small and also the PCA is less sensitive to different training sets. PCA can outperform LDA[12]. The assumption of existence of an optimal projection is carried by the standard eigenspaces and fisher spaces for optimal projection that projects the face images to distinct non-overlapping regions in the reduced subspace where each of the regions corresponding to a subject in unique. Since the images of different people may frequently map to the same region in the face space. In that case this assumption fails. Different individuals may not always be disjoint in the space. The PCA and LDA methods work on the Euclidean structure, other than the euclidean structures these can't discover if the face images are in a non-linear sub manifold in the image space, then these techniques fail and it has shown that face images possibly reside on a nonlinear sub manifold. Latha et.al conducted experiments in similar lighting conditions using PCA for dimensionality reduction and Back Propagation Neural Network Algorithm for training[13]. They used the Yale dataset of 200 images and the acceptance ratio is 90% with back propagation neural network and it is improvement over standard eigenface with execution time of only few seconds and their experiment results say that using Back propagation neural network training nonlinear face images can be recognized.

BPNN : Back propagation neural network is a kind of supervised learning network. The network is a multi layer feed forward network. This algorithm is based on the statistical approach called gradient descent learning rule. The BPNN is a computationally efficient method for learning the network by changing the weights in feed forward network. It uses differentiable activation function units, to learn the pattern in the training set of input-output data. By using gradient descent it minimizes the total squared error of the output computed by the network. The aim of this NN is to train the network that get an ability to respond correctly to the input patterns in the training and ability to provide a good response to the input that are similar. Shang-Hung et.al. says most of the cases, a face recognition algorithm can be divided into the two functional modules:

- Find the location of human faces with a simple or complex background in an image. This is called face image detector.
- Find who is the person in the face image. This technique is face recognition[14].

. The above two modules use same framework. Transform the pixels of the facial image into a vector representation. This transformation is called feature extraction. Finding the best match for the incoming image by searching the database is called pattern recognition. In the face detection scenario, pattern recognizer categorizes the input image into any one of the two classes, face image and non-face image. Henry et.al used CMU and Harvard database of 1050 face examples and achieved 90.5% accuracy of the face recognition with acceptable number of false positives[15]. They used gray scale images of faces and non face image for discrimination and added non-face images to the training set. Whenever new non-face images occur in the testing set, they add those images to training set because the non face image space is increases very rapidly. They used Neural Network based filters for preprocessing the image. In the preprocessing step they send a window image to the Neural Network, then the Neural Network tests weather the image has a face or not. The next step is histogram equalization, which nonlinearly maps the intensity values to the range of intensities in the window. For pixels inside an oval region in the window the histogram is computed. This compensates for differences in camera input gains and improves the contrast in some cases. For each image apply rotation, transformation and scaling. All the images which are get by applying above operation are given to Neural Network training.

Real faces are often detected at multiple nearby positions and scales, because there is a small amount of position and scale invariance in the filter, where as false detections can only appear at a single position. False detections can be eliminated by setting a minimum threshold on the number of detections, if an overlap is occur in detectors, the detector with higher confidence can be considered. This arises from the heuristic faces rarely overlap in images. Rabia et.al, says that, the eigenvectors obtained by PCA depend only on pair wise relationships between the pixels in the image database[1].

By considering the higher order relationship among the pixels Independent Component Analysis finds the basis vectors. Utilizing such a technique would give a better recognition results with a reasonable expectation[16]. This method is a generalization of PCA technique. AI based approaches use Neural Networks for pattern identification, MLP (Multi Layer Perception) is a Neural Network approach, Hidden Markov models (HMM), embedded HMM, SVM (Support Vector Machine) classifier, Convolution Neural Networks are the AI based approaches most popular in face recognition[1].

Prabhakaran et.al used DCT (Discrete cosine transform) for image compression and SOM (Self Organization Map)[17], for classification. Their motive is to generate a fast recognition of faces[18].

Shamla et.al used SOM, the database they used is AT&T database for recognition and achieved 92.40 % accuracy[19].

2.0.3 Multiple Classifier Systems

Most of the classifiers consider only some of the factors and for other factors they are invariant. The performance of the individual classifier is always lower. Combining the individual classifiers i.e integrating different classifiers into a single classifier, we can achieve better performance by considering the more factors into account. With this complexity of the classification system may increase but the performance of the system also enhances. This is the new trend in pattern recognition systems. These type of systems are called Multiple Classifier Systems[1].

2.0.4 Advantages and Disadvantages of Holistic approach

- By concentrating on points of interest and limited regions, the holistic approaches doesn't destroy any information in the image. All the pixels in the image have the same important assumption is basis for this and this is a drawback in holistic approaches.
- They do not perform well under large variations in pose illumination and scale.
- These techniques are computationally expensive.
- Assumes a high degree of correlation between the training and test images.

Sirovich et.al, used image enhancement technique, each pixel and its neighboring pixel are processed by converting it into binary images and using neural networks genetic algorithm for training the inputs images[6]. Crossover and mutations are performed in training the neural network. They use the skin color extraction methods and feature detection methods. With this they reduce the feature dimensionality from 3D RGB to 1D space advocating it fussiness and the construction of a rapid classifier.

2.0.5 Skin detection

The process of finding skin colored pixels and regions in an image is called skin detection. The skin detection process is generally used as preprocessing step to find regions that potentially have a human face to reduce the noise in the image and reduce the dimensionality.

Algorithm

- step 1: Identify the skin regions in the image by checking whether the pixel values are in the specified range of values.
  $r > 95$ AND $g > 40$ AND $b > 20$ AND
  $Max\{r, g, b\} - min\{r, g, b\} > 15$ AND
  $|r - g| > 15$ AND
  $r > g$ AND $r > b$
  OR
  $r > 220$ AND $g > 210$ AND $b > 170$ AND $|r - g| <= 15$ AND
  $r > b$ AND $g > b$.

- step 2: After identifying the continuous region follows the skin tone values. we draw a bounding box on the image.
- step 3: Extract the image surrounded by bounding box.
- step 4: Identify the Skin region based on rgb values of pixels within bounding box.

For each pixel check whether the above condition is true or not, if it is true and its neighboring pixels are also holds the condition put it in the skin tone region. With this identify the skin tone region and proceed to step 2 and step 3.

Chapter 3

Our approach

The solution for the problem consists of three phases.

- Acquire the image.
- Recognizing the face in the image and identifying the person in the face image.
- Maintain the attendance database.

3.0.6 Acquire the image

Acquiring the image can be done by using any digital camera, which can be operable through a computer for processing the image. We used Fire-i camera for collecting the images. This camera features are

- Have the capability of collecting the motion video as well as individual images with the speed of 30 frames for second.
- White balance: Automatic or manual control.
- Supports video modes YUV, RGB-24 bit, monochrome-8 bit etc..

We collected RGB-24 bit images and videos with a speed of 15 frames/sec. To provide an interface through camera a 2m thin firewire cable is connected to the firewire port. The firewire port comes in two formats.

- 4 pin connector.
- 6 pin connector.

We have 4 pin connector firewire, 2 meter thin cable to connect to the system. We need a driver to provide interfacing through camera, the firewire camera uses IEEE1394 driver stack built in computer. This driver stack provides different modules to provide interfacing through camera. Two types of driver stacks are available on supporting Operating Systems IEEE1394a and IEEE1394b. The supporting Operating Systems are

- Linux.

- MAC.
- Windows.

The major difference between two driver stacks is supporting format specifications. IEEE1394a doesn't have the support for format-7 where as this support is included in IEEE1394b. In each driver kernel different modules are present and each module operate on the basis of register set available for device. Based on the register status value any operation can carry out or they will fail, if the support is not provided. Whenever the support is available for the driver and also for the camera then only the action will take place. For example, format-7 image reading is not possible if the underlying driver is IEEE1394a. The status will be indicated by the register. Based on the driver stack available and the futures supported by the camera different APIs are developed to acquire the images and videos. Fire-API and ubcore are the APIs we are using for our application.

3.0.7 Hardware used

- IEEE1394a built in driver stack.
- 1394 bus host controllers(built in).
- Fire-i camera.

3.0.8 Software requirements

- Windows-7 Operating System.
- .NET framework.
- Matlab
- Postgre sql 9.3
- ubcore.
- Fire-API.

3.1 Experimental setup

We have used Windows 7 Operating System and IEEE1394a driver for getting the images and videos. Fire-API and ubcore are the two APIs developed for Fire-I camera. we have modified this APIs to get the images and videos. By using ubcore, we get the video of 5 seconds with 15 frames for second speed. We used Fire-API for getting the images for testing. We modify the source code to get the images in a sequential manner. Each user, face images are taken by clicking on the save image(our button in .NET framework). The API process the required actions and store the image in a directory. Whenever a new user image is taken, it will increment the count and adjust the name of the image file in database accordingly.

Ubcore APIs are used to get the videos for training the System. Ubcore is an API developed in .NET framework. When you call this API, GUI is prompted for selecting the video mode. The camera captures the video and stores in the directory selected on the GUI.

3.1.1 Training

For training the system we used Matlab. After gathering the videos of people we extracted 22 images continuously from the video of each individual and stored in a directory. Our training algorithm goes in different phases.

- Extract frames from the videos stored and store in a directory.
- Extract face part from the images and store all extracted images in another directory.
- Find out mean of images for the face extracted images..
- Calculate the deviation of each image from the mean.
- Put all deviation images in a matrix.
- Calculate the covariance for deviation images.
- Calculate eigenvectors and eigenvalues for the covariance.
- Arrange eigenvectors in non increasing order according their eigenvalues.
- Choose few first eigenvectors.
- Project the number of face extracted deviation images onto the eigenvector(this will give you weights associated in eigenspaces for each image).
- Calculate the average image of each person in the class and make it as a class representation in the person in the eigenspaces.
- Get class representatives for each person.

In the training phase, we gather the videos and store in a directory. We use the Fire-API simple viewer which is developed in .NET frame work and modified it to get the images for testing (giving attendance). Video is taken for each user, whoever comes before the camera. From the videos, we extract 22 frames of each person and will give it as input for the training phase. We extracted the face part in the image by skin color identification in the image using the algorithm explained above. This 22 face images of each person are used for obtaining weight vector of each person in eigenspaces.

Face recognition techniques give more accuracy on standard datasets. Real life image processing is different from the experiments done on the standard datasets because each standard data set is mainly focused on some of the problems in face recognition like lightning effects, pose, orientation etc. All variations are not covered on any single data set. So we rely on the statistical method (Eigen values) which are more sensible to noise in the images.

Our first part of the application is to reduce the noise so that we can find Eigen vectors formed by the face images only. Less effect of noise like background lightning (we are not elimination the lightening effect on the faces). For this we extracted the face part of the humans in the images based on the skin tone values. The RGB values of skin tone follow a range of values and it is continuous in the image. Based on this we extracted the faces from the images and write back it as images. These extracted face images goes through a training phase. In the training phase follows method of eigenfaces[8].

3.1.2 Testing

As training can be done off line, image acquisition for testing or verification can be done with out regretting the people. We change the Fire-API source code such that the GUI can generate or store the images fast and in a convenient way. Fire-API is developed in .NET framework, a GUI is used to show the simple image at the time of running. We use this source and modified such that when ever an image of user is taken, it will be stored in a specified file directory. This directory is used for verification purpose. The process follows.

- From the directory get each image.
- For each image extract the face part from the image.
- Calculate the deviation image face, use the mean face calculated in the training phase to get the deviation.
- Project the deviation image onto eigenvectors generated in the training phase.
- Obtain weight vector.
- Find out the euclidean distance between the weight obtained and the class weights or person weights calculated in the training phase.
- Find the minimum distance and declare that person belonging to the class which gives minimum euclidean distance.

This work is done by using the Matlab. We have created dll for program and used this dll in .NET assembly. One should take care of Proper dll references while designing this type of systems.

3.1.3 Maintaining database

We used Postgre sql 9.3 to create a database for attendance. Each person in the system is identified by the number corresponding to the occurrence of people in the training phase. Whenever a person is identified by above process, we record that person attendance as present in the database

3.2 Experimental Results

We conducted this experiment with 8 volunteers and we got 86.7% accuracy for the system identification. We analyzed the results, one person is always misclassified and identified as another person in the system. We tested the original images directly. For comparison using euclidean distance, the original images shown in Figure 3.1(b) and Figure 3.1(c) are the images of same person and Figure 3.1(a) is an other person in the database. The test image Figure 3.1 (b) is classified as belonging to the class of Figure 3.1 (a). We calculated the original image similarity by using euclidean distance measure and found Figure 3.1(a) and Figure 3.1(b) are more similar than Figure 3.1(b) and Figure 3.1(c). Fig 3.2 is the image after extracting the face part from the image with size 300×300 width and height and we calculated the image similarity after extraction found that it was same, from this we identified that in Figure 3.2 (b) and Figure 3.2(a) belonging to the same person but they

Figure 3.1:

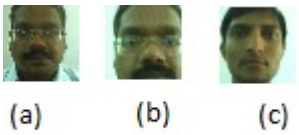

Figure 3.2:

are variant in scale. Those two images are recognized as belonging to different people. The scale variation in Figure 3.2(a) and Figure 3.2(b) are more compared to Figure 3.2(b) and Figure 3.2(c), and we identified that eigenface recognition is not scale invariant.

Chapter 4

Conclusion and future work

We use the eigenface approach for face recognition with constrained environment such as the face images within same lightning conditions and achieved good results. We use face detection based on skin tone values, this may fail when background is also follow the same skin tone values range and it is found that our approach fails whenever scale variation in images are more. In recent convolution networks and other methods are giving more accuracy than eigenfaces and there can be so much to done on preprocessing to reduce the complexity.

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