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Smart Attendance System Using CNN

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***Abstract*—The research on attendance system have been going on for a very long time, many solution have been proposed to make this system smart, but all those system have several weaknesses. In this paper we introduced Smart attendance system based on face recognition that can be used to take attendance of the students sitting in a classroom all at once. Our proposed system of smart Attendance System is divided into four steps. First, face detection is done based on Histogram of Orientation Gradient (HOG) algorithm. Second, face alignment is done based on face landmark estimation algorithm. Third, face encoding, Facenet algorithmbased approach is used for face encoding, it has an accuracy of 99.63% on LFW dataset. Each face is encoded with unique 128 values. Finally, SVM classifier is trained with these 128 dimension values for each face. Our system also makes a report of attendance with date and it is automatically mailed to the faculty.**

Keywords— Face Recognition, Histogram of gradient, Facenet, Attendance database

I. INTRODUCTION

Face recognition system is the most researched area nowadays. Many new methods have been discovered for efficient face recognition. Face recognition is being widely used in areas like security systems. It can also be used for taking attendance in a classroom. It is a tedious and time consuming task to take the attendance manually. Every classroom has on an average 60 students and each period is of approximately 50 minutes. If we calculate average time wasted for marking attendance in a single day is roughly 1 hour. Many solutions have been proposed to make this system smart, but they have several weaknesses.One popular method based on RFID is given in [1], but it has a limitation that it is equally time consuming as students have to come one-by-one for marking attendance and it is costlier to implement. Smart attendance based on low energy Bluetooth device is proposed by the students of Delhi Technical University [2], but this system is intrusive as student can easily give proxy by bringing other student phone. Also students can give attendance from outside the class.

An approach based on fingerprint scanner is proposed in [3]. It has a drawback that students have to stand in a queue to mark their attendance and that takes very long time for large number of students. Another solution based on barcode system is proposed in [4] where students have to show the unique barcode on their ID card to mark attendance and that also is a very time consuming task. Many other approaches like speech based attendance system [5] and NFC (Near-Field Communication)based attendance system [6] are proposed but all of them have some kind of limitations. Smart attendance system based on face recognition is one of the non-intrusive method. It requires a camera to take a classroom picture and the image captured is given as input to our system and our system recognize each face from the input image and create a report of the same. The camera is placed in such a way that every student is visible in the image captured.

In [7], face recognition based on PCA (Principle Component Analysis) is proposed. The process of face recognition is divided into four steps. First, in our proposed system face detection is performed based on the method given in [8]. In this algorithm gradient of the image is calculated and it is given as input to a SVM classifier.Secondly face alignment. In our proposed system face alignment is done based on the algorithm proposed in [9]. 68 landmark points are found on the face and the image is rotated and scaled to perform face alignment. The aligned faces are stored in a folder. Third, face encoding, researcheson face recognition conclude that using artificial neural network for face recognition has very high accuracy [11]. Face encoding is performed based on Facenet algorithm given in [12]. Facenet algorithm is best among all the CNN (Convolutional Neural Network) algorithm[10]. Aligned faces are given as input to the Facenet and it produces unique 128 dimension embedding for each face image. Fourth, train the classifier, SVM classifier is trained with the 128 dimension embedding produced in the previous step for the classification of students.

After training the system with the database of students. Test image of the classroom is taken by the camera and is recognized by the system and it creates an attendance database. The database is then mailed to the respective faculty.

The remainder of this paper is organized as follows. Section II Introduces with the block diagram and methodology of our system. In Section III, we propose the implementation of our smart attendance system. The conclusions are presented in Section IV and future work is presented in section V.

II. PROPOSED METHODOLOGY

A. Block Diagram

The block diagram of our smart attendance based on face recognition is mentioned in the fig.1. To make this system work first we need to take the classroom picture, for that camera should be placed in such a way that every student in the class is visible. We have used Linux operating system for our

project buteven raspberry pi can be used for the same. But, one think should be kept in mind that training on the raspberry pi is very slow.

We take the image with a high definition camera so that even the back benchers are visible. For raspberry pi, we need to use pi camera to get high definition image. The architecture of the system is very simple and easy to understand. After taking the image face detection is performed by the face detection algorithm.

For training the database we take 20 images of each student and on that the same face detection algorithm followed by alignment algorithm is performed. The images are cropped and stored as database with name.

While giving the test image also we need to perform face detection so that further process of face recognition can be performed.

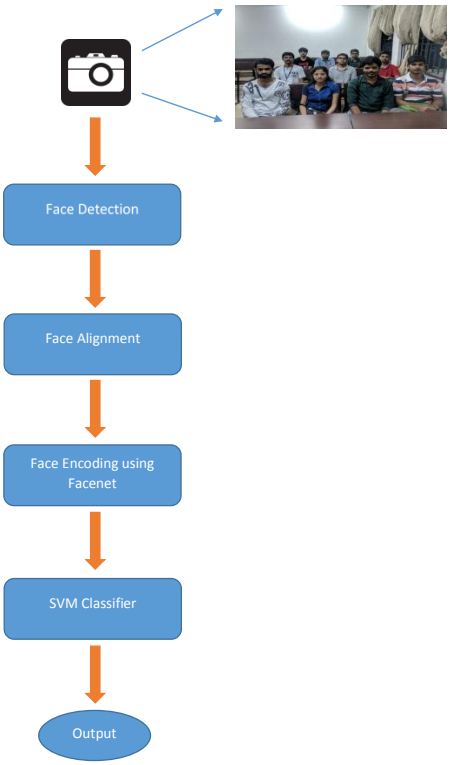

Fig.1. Block diagram of smart attendance system using face recognition.

B. Methodology

For implementing the smart attendance system using face recognition system, we have to follow the following steps in the same order. Those steps are as follows:

1. Enrollment of students
2. Train the system
3. Test image
4. Face detection
5. Alignment
6. Face Encoding
7. Recognition
8. Store attendance database

1. Enrollment

The person will be enrolled to the database using their name and 20 face images. The information will be stored in the folder with folder name as name of the person. The process of enrollment includes:

- Making a folder with person name as folder name
- Capture image from camera using opencv and python
- Stored the images in the folder

The image of the person is capture using high definition camera and stored in the folder.

2. Train the system

To train the system the image capture during enrollment is taken as input and the system is trained on these images.
Steps for training the system is as follows:

- Face detect
- Face alignment
- Generate encoding using Facenet
- Train the SVM classifier

Image captured in the previous stage is taken as input in this stage. First, face detection is performed followed by face alignment and the aligned faces are cropped and stored. Second, the heart of the system Facenet produce 128 dimension unique encoding per image. Finally, SVM classifier is trained on these 128 Dimension encoding.

3. Test image

After training the system on the database our system is placed in the classroom. Camera is adjusted in such a way that all the students faces are visible in the image. For this we require high definition camera. Classroom image is captured and stored.

4. Face detection

Many algorithms have been proposed for face detection. Viola – Jones is proposed in [13]. In our proposed system face detection algorithm is based on the work of Navneet Dalal and Bill Triggs in [8]. For face detection, we calculate the gradient of the image in both x and y direction and from that we finds the gradient vector of each pixel. Gradient vector include magnitude and angle of the vector. Both magnitude and angle are stored in a matrix form.

$$\nabla g = \begin{bmatrix} f_x \\ f_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \quad (1)$$

Where ∇g is the gradient of the image and $f_x = \partial f / \partial x$ is the gradient of the image in x-direction and $f_y = \partial f / \partial y$ is the gradient of the image in y-direction.

$$\rho = \sqrt{{f_x}^2 + {f_y}^2} \quad (2)$$

Magnitude of the gradient σ is calculated and it is stored in matrix form.

$$\emptyset = \frac{f_y}{f_x} (3)$$

Where $\emptyset$ is the angle of the gradient vector. The gradient vector is calculated for each pixel and stored in a matrix form. Fig. 2 shows how a gradient vector looks for each pixel. Gradient of a pixel is in the direction from brighter pixel to darker pixel.

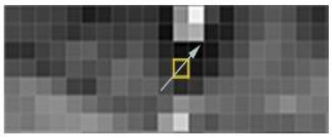

Fig. 2. Gradient vector for a pixel

We then make a histogram with 9 bins for the image. Fig. 3 shows histogram of an image whose gradient vectors angle and magnitude are in the matrix form.

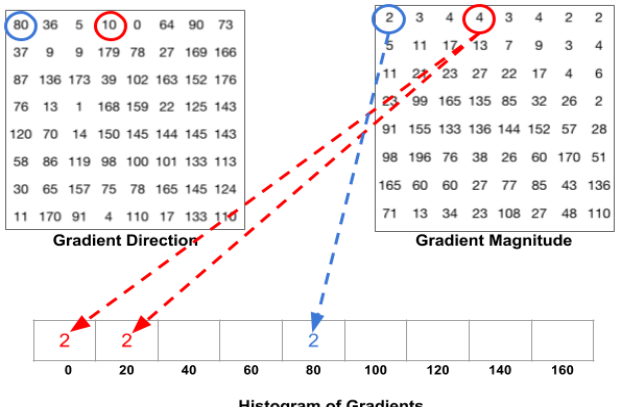

Fig. 3. Histogram of image with 9 bins.

The histogram output is given to a SVM classifier which is trained for face and non-face image and whenever a new face image is given as input it detects allthe faces in the image.

5. Face alignment

Face alignment is an important step because if a person face

is not aligned properly then computer will consider it as a different person. So, face alignment for our proposed system is based on work of Vahid Kazemi and Josephine Sullivan in [9]. In this for every image detected in the previous stage 68 points are searched on the face and these points are called landmark points as shown in fig. 4 and after finding those 68 landmark points on the image, the image is scaled and rotated for alignment.

Fig. 4. 68 landmark points for face alignment.

These aligned faced are stored in as a database in aligned face folder. These aligned faces are used in the further steps of smart attendance system.

6. Face Encoding

Face encoding is an important step in face recognition. In our system face encoding is based on the work of Florian Schroff*et al*in [12]. Fig.5 shows the Facenet model.
While training the neural network each aligned face image is input to the Facenet and unique 128 Dimension embedding for each face is produced as output. In our proposed system the CNN is based on NN4 architecture mention in [12].
Facenet uses triplet loss as cost function to adjust weights.

$$J = \sum_{k=1}^{n} L(A(i), P(i), N(i)) \qquad (4)$$

Where J is the cost function.

$$L(A,P,N)=\max(\|f(A)-f(P)\|_2^2-\|f(A)-f(N)\|_2^2+\alpha, 0) \qquad (5)$$

L(A,P,N) is the triplet loss function. Triplet loss uses three images from the data base in which one image is an anchor image i.e. A and second image is anchor positive i.e. P, the image similar to the anchor image and third image is anchor negative i.e. N, the image different from the anchor image.

$$d(A,P)=\|f(A)-f(P)\|_2^2 \qquad (6)$$

$$d(A,N)=\|f(A)-f(N)\|_2^2 \qquad (7)$$

Where d(A,P) is the distance between anchor image A and anchor positive image P and d(A,N) is the distance between anchor image A and anchor negative image N.

$$\|f(A)-f(P)\|_2^2 - \|f(A)-f(N)\|_2^2 \leq 0 \qquad (8)$$

The above equation shows the difference between d(A,P) and d(A,N).

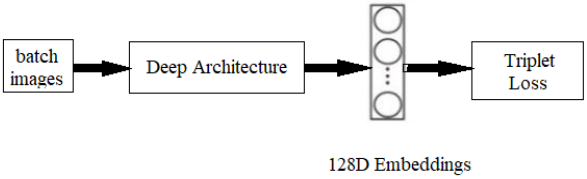

Fig. 5. Facenet model

Once the weights of the neural networks are found they are stored and whenever we give a new image, the neural network gives 128 dimension unique values for each face image. These 128 dimension values are stored with name in a database.
Once the encoding database is created, then these 128 values are given as input to a SVM classifier for training.
For the test image same 128 dimension encodings are generated and trained linear SVM (Support Vector Machine) classifier classify them.

7. Recognition

Output of the Facenet Encoding is given as input to a SVM (Support Vector Machine) classifier and it is trained with 128 dimension embedding for each face image and when the test image is given as input then 128 dimension embedding is calculated for each face detected and these embedding is compared with each class in SVM classifier and the person name isrecognized.

8. Store attendance database

After the classification is done by SVM classifier, a csv file
is created using python withname as one column and attendance in the next column and it is send to the faculty email id through SMTP protocol with file name as date on which the attendance is taken.

III. Implementation

Our system is tested in a classroom as shown in fig. 6.
All the students present in the class are marked present and the database in the form of csv file is sent to the email id with the date on which the attendance was taken.

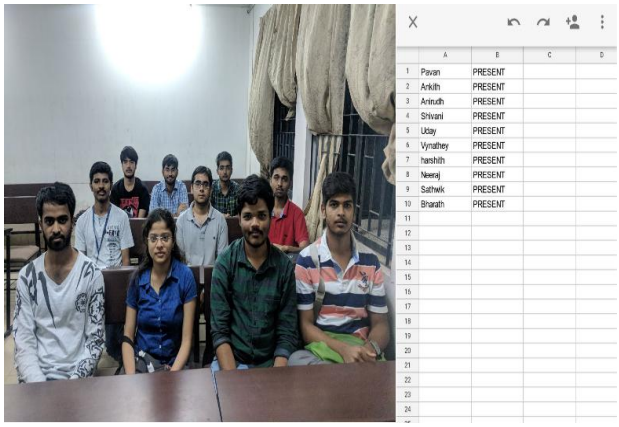

Fig. 6. Smart attendance system implementation

IV. Conclusion

The smart attendance system is proven to be an efficient system for classroom attendance. This system is non-intrusive and it reduces the chances of proxies and fake attendance. Many approaches for smart attendance system have been proposed but face recognition based approach is found to be the best method for smart attendance system. To take attendance a reliable system has to be made. We have implemented the same successfully in a classroom. Our system setup is very simple and easy to use, it requires a simple camera module and a pc to perform facial recognition. Also our system can be implemented on raspberry pi with internet enabled.

V. Future Work

The future work is to improve the recognition rate of our system when the faces of the students are half covered or when they are partially visible.

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