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Smart attendance using deep learning and computer vision

Vivek Seelam, Akhil kumar Penugonda, B. Pavan Kalyan, M. Bindu Priya, M. Durga Prakash *

Department of Electronics and Communication Engineering, Velagapudi Ramakrishna Siddhartha Engineering College, Vijayawada, Andhra Pradesh 520 007, India

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ABSTRACT

Attendance is an essential part of daily classroom evaluation. Traditional classroom follows a manual attendance marking system, i.e., calling a student's names or by forwarding an attendance sheet. This process is both time-consuming and error-prone, i.e., student proxy, etc. Hence a face recognition based smart classroom attendance management system using computer vision and deep learning implemented on a Raspberry Pi has been proposed. It has been proposed to mount a camera at the top of the blackboard so that the students are visible while they are sitting down. A face detection algorithm followed by face recognition has been used to mark the attendance of the detected student.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Materials, Manufacturing and Mechanical Engineering for Sustainable Developments-2020.

1. Introduction

Attendance is one of the most important metrics in any academic program. It often has a very high correlation with the grades a student gets and also his overall involvement in the class, which has a high impact on his future. Studies [1] show that in many developing countries, low attendance is directly linked with higher dropout rates, which are indirectly related to the level of unemployment, crime, etc. in the country. Therefore accurate methods to mark the attendance of the students are paramount importance to any educational institution. Many systems were adopted globally for marking attendance, one of the most familiar ones is to assign a person to mark the attendance manually, which is error-prone, not accurate, and consumes a lot of time. In this era of automation, automating manual tasks can get the tasks done with greater accuracy and reliability. Some of the methods that are generally suggested for automating attendance are the RFID system-based attendance and the Fingerprint Scanners; though they are accurate, the systems are not hygienic and the RFID system cannot avoid proxies in attendance marking. This paper presents a Smart Attendance marking system Built using RaspberryPi and Pi camera loaded with a trained Machine Learning model for Face recognition based on FaceNet algorithm which can recognize multiple faces in any given image. The model not being very large made it possible to deploy in RaspberryPi and the entire system being small made it deployable in a small space utilizing very low power.

2. Hardware

2.1. Raspberry pi

The raspberry pi is a series of single-board computers that are usually used for fast prototyping in many fields such as IoT, Robotics, etc. They were developed for educating school children but they became so popular that even professional engineers use them for fast prototyping. In this paper, the raspberry pi 3 Model B is used to implement the automatic attendance system. The complete specification list is provided in [12].

2.2. Pi camera

The pi camera is a 5 MP camera which supports 1080p recording at 30fps and 720p recording at 60 fps. The complete specification list is found in [11].

3. Related work

Decreasing the time taken to mark the attendance, along with increasing the accuracy and authenticity of the attendance logs has been studied and researched in the past. In [2], Aditi Agrawal et al. have proposed a CNN based face recognition system that uses Openface library, and it uses docker to run the program on any

* Corresponding author.
E-mail address: mdprakash@vrsiddhartha.ac.in (M. Durga Prakash).

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Table 1
Comparision in performance between Haar Cascades and MTCNN.

	Haar cascade	MTCNN
Number of images	24,111	24,111
No. of cropped faces	19,915	21,666
Total number of extra faces from a single image	947	428
Recall	82.60%	89.85%
Precision	95.24%	98.02%

machine, the authors also developed a Django application to create a web application for the entire program. In [3], Atuegwu Charity et al. have proposed a bi-modal system where-in face recognition along with the bio-metric fingerprints as an extra layer of authentication are used to take attendance. The face recognition is performed using PCA (for feature extraction) along with SVM (for classification). In [4], Shireesha Chintalapati proposed a use of face recognition based attendance system, which uses the Viola-Jones algorithm to detect face and PCA/LBPH for feature extraction and SVM for classification. In [5] Hamim Adal et al. have proposed an android application based attendance application that uses biometric finger authentication along with the connection of the mobile phone with the local WiFi network to confirm the attendance, this method uses the mobile phone as a smart-id card. In [6] Md. Milon Islam et al. have proposed an android application with an intuitive interface using which the teacher can mark the attendance of the student which is stored both in the phone locally as well as on the cloud so that the data can be accessed from anywhere; also further calculations can be performed like attendance percentages, SMS alerts, etc.

4. Algorithms used

4.1. Haar cascades

Haar cascades [6] is a machine learning algorithm that is used for object detection more popularly for detecting faces in a given photo. It is first proposed in the paper "Rapid Object Detection using a Boosted Cascade of Simple Features" by Paul Viola and Michael Jones in 2001. The Haar features need a lot of positive images (with faces) and negative images (without faces) to train the classifier and extract features from them. As there can be a lot of features available we use a concept of Adaboost which makes

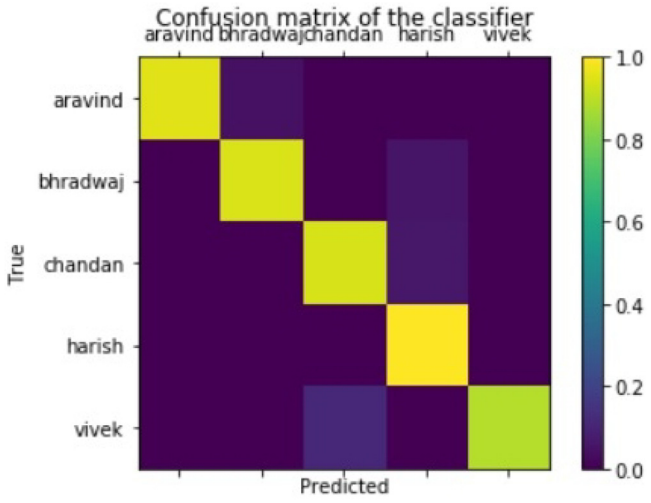


Fig. 2. Confusion matrix plot using FaceNet with linear SVM.

a strong classifier as a linear combination of weak classifiers. On the plus side, we do not need to train the haar features as compared to Convolutional Neural networks which require a huge dataset to train the kernels, The Haar Cascade classifiers are therefore much faster to run but are comparatively less accurate than Deep learning classifiers.

4.2. MTCNN algorithm

Multi Task Cascaded algorithm [7] is a deep learning algorithm that does both face detection and face alignment jointly allowing it to better detect faces that are not aligned, it is, therefore, more accurate than Haar cascades.

4.3. Haar cascades vs MTCNN

The following table shows the comparison between the performance by the two face detection algorithms on the UTK face dataset. The Table 1 has been used from the blog in [9].

It can be seen that MTCNN is much better than Haar cascade but it is computationally expensive and therefore was very slow to run on the raspberry pi without any hardware accelerator like google coral, Intel Movidius stick, etc. Therefore, a trade-off between

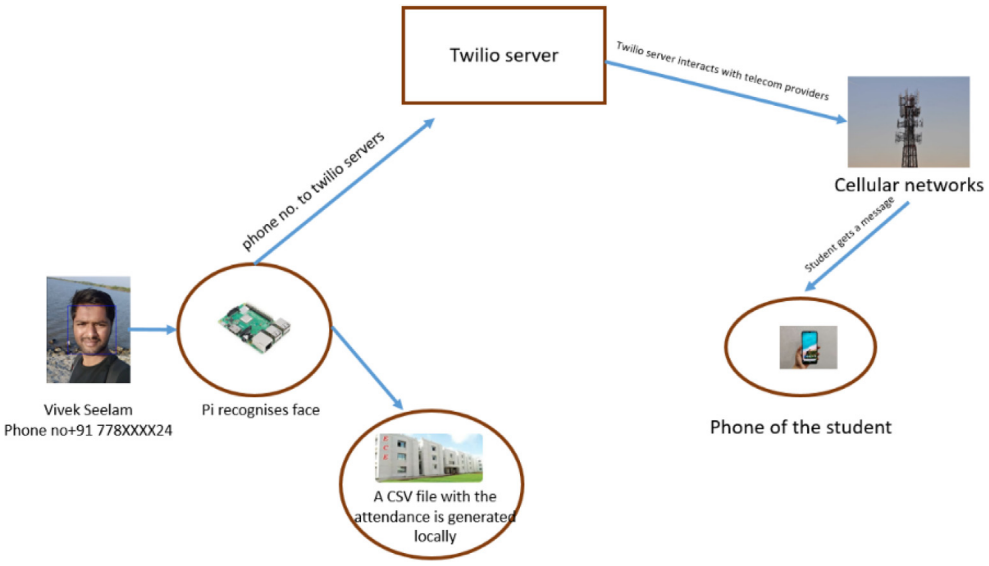


Fig. 1. Block diagram of the proposed system.

Fig. 3. Photo taken in the classroom to test performance under natural lighting conditions.

accuracy, execution speed, and hardware has to be made. It has been found practically that Haar cascade provides reasonable accuracy for the proposed application in this paper.

4.4. Facenet

The FaceNet [8] algorithm is developed by researchers at Google in 2015, it is similar to a Siamese network in which the network maps a given face to a 128-dimensional vector in the Euclidean space. It maps each face into a 128-D point in Euclidean space in such a way that the distance between each point corresponds to the similarity of the faces. It uses a series of convolution layers along with triplet loss function to train the network and achieve the state of the art recognition performance. Facenet has already been trained on millions of images and the network weights have been open-sourced [10] so that we need only a few images to fine-tune the network for our database.

5. Proposed system

The proposed system automates the attendance marking process and hence saves a lot of time in the process. The working can be better explained in 3 phases:

Phase 1:

All the required libraries and dependencies like OpenCV are installed on the Raspberry pi and it is installed on top of the blackboard where all the students' faces are visible to the camera along with the pi cam along with the power supply.

Phase 2:

5.1. Face detection

After the frames are captured from the pi camera the haar cascade classifier detects all the faces present in the photo and sends them to the face recognition software.

5.2. Face recognition

The detected faces are then passed to the Facenet algorithm which recognizes the faces from a given database. We then pass the unique embedding of the detected face to a linear SVM which finally classifies the person detected.

Phase 3*:*

We used the CSV writer library and time module in python to write the attendance from a dictionary format to a CSV file along with the date and time. We then send the phone numbers of the people who are present to the Twilio cloud. Using the Twilio rest API we send SMS to all the people who have been marked present so that they can be sure if their attendance has been marked in

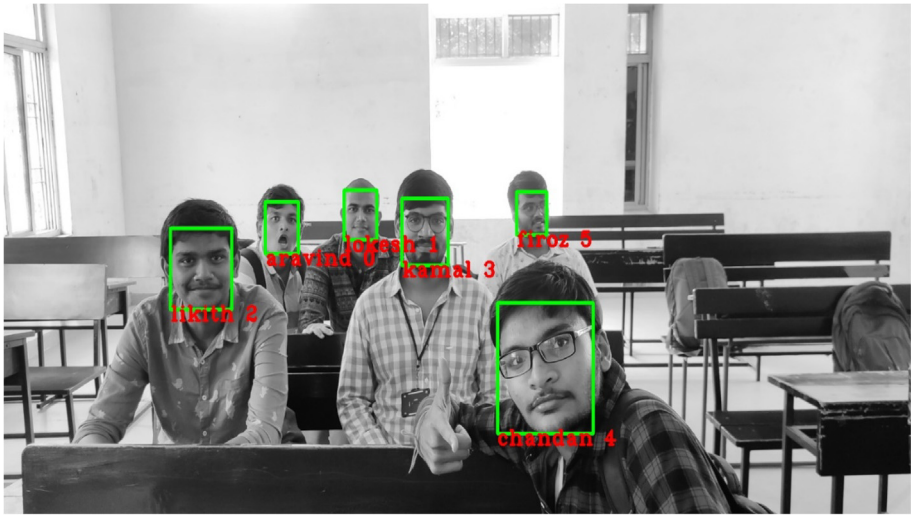
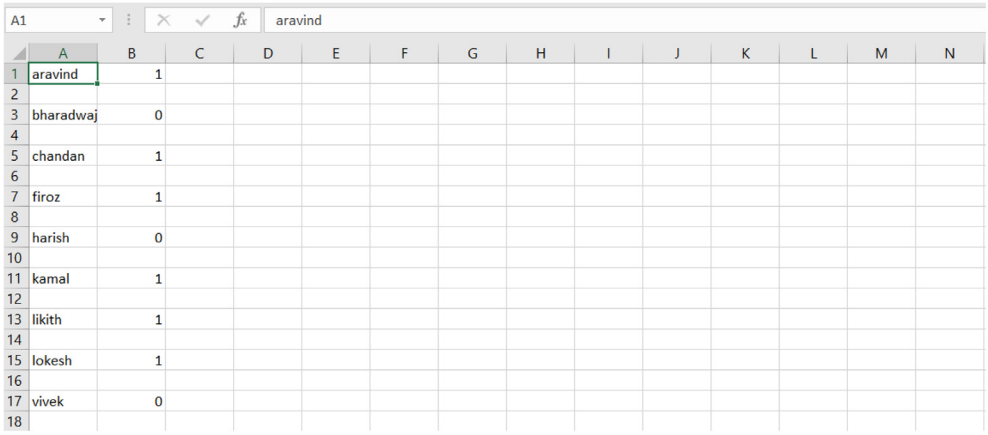


Fig. 4. The output photo after recognizing the faces.



	A	B
1	aravind	1
2		
3	bharadwaj	0
4		
5	chandan	1
6		
7	firoz	1
8		
9	harish	0
10		
11	kamal	1
12		
13	likith	1
14		
15	lokesh	1
16		
17	vivek	0
18		

Fig. 5. Excel sheet generated after marking the attendance.

case of any occlusion or any other practical mishap. The architecture block diagram depicting the process is shown in Fig. 1 The pseudo-code for the whole process is given below

5.3. Pseudocode

1. Start the python code.
2. Capture frame from Pi camera.
3. Detect all the faces present in the photo using Haar cascades.
4. Generate the face embeddings using the FaceNet algorithm.
5. Compare each embedding with the ones in the database and determine the name of the person.
6. Mark the value corresponding to the name as 1.
7. Write the attendance to a CSV file and save it.
8. Send all the people who were present, an SMS confirming their attendance.
9. Exit

6. Experimental results

The accuracy of the FaceNet face recognition has been determined by splitting the dataset into train and test sets randomly in the ratio 80:20 and then training on the train set and testing on the test set. We get an accuracy of nearly 98 percent. A confusion matrix (Fig. 2) has been plotted to identify the class of faces the classifier frequently makes an error.

The photo in Fig. 3 has been used to test the accuracy of the system in a real classroom setting and the detected faces are fairly accurate under good lighting conditions. The classifier does make a mistake when the face is turned away from the camera or is occluded by any object or under poor lighting conditions. The Fig. 4 shows the output image after recognizing all the photos. The Fig. 5 shows the attendance marked in a CSV sheet.

7. Conclusion

Considering the amount of time that is wasted in taking attendance and then analyzing it, our solution saves an enormous amount of time in the long run of any academic institution. The proposed automatic attendance using face recognition has been implemented on a raspberry pi and is therefore very portable and requires very little maintenance. The system even sends a confirmation SMS to the students present, so the proposed system is fairly accurate given that the faces in the images captured contain properly posed and are not occluded.

CRediT authorship contribution statement

Vivek Seelam: Conceptualization, Writing - review & editing, Visualization. **Akhil kumar Penugonda:** Conceptualization, Data curation, Writing - original draft, Writing - review & editing, Visualization. **B. Pavan Kalyan:** Investigation, Data curation, Writing - original draft, Writing - review & editing. **M. Bindu Priya:** Investigation, Data curation, Writing - original draft, Writing - review & editing. **M. Durga Prakash:** Conceptualization, Investigation, Resources, Writing - review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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