A Framework for Automatic Attendance Monitoring System

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***Abstract*—Attendance is a vital component in educational institutions and is taken manually in the registers. This leads to wastage of resources such as paper, time and money. Due to COVID-19 pandemic, the classes for students are conducted online rather than classroom-based study. Hence, automation in the manual process is the best solution for the present system. In this paper, a framework named Automatic Attendance Monitoring System (A2MS) has been proposed to monitor students using Convolutional Neural Networks (CNN) with Haar Cascade Classifier (HCC). Datasets were collected using a laptop equipped with a webcam and undergo processing for segmentation and feature extraction. Implementation of the above idea is carried out using Python 3.7 and the attendance is automatically marked in MS Excel. From the results, it is observed that, the accuracy in detecting the students faces and managing attendance is a function of confidence level and accuracy rate, which is in the range of 70-90% and also above 90% depending on the conditions and surroundings.**

Keywords—CNN, HCC, AMS, A2MS, Face-recognition, Machine Learning, AdaBoost Algorithm.

I. INTRODUCTION

Over the years, the manual attendance system was carried across most educational institutions. Even, evaluation, assessment and also performance estimation of students were done manually. The information is sorted by the teachers, instructors and advisors, as provided by the student for a particular day throughout a complete semester. The major challenges faced by this system was time- consuming, resource wastage and maintaining the records over a long period of time. This system enables the evaluation of students' regular presence in various lectures which will determine the eligibility of the student to take up semester examination.

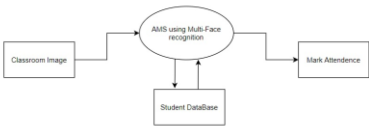

Fig. 1 Simplified AMS

Attendance Monitoring System (AMS) is a software-based system for monitoring daily student attendance in schools, colleges and institutions. It facilitates access to the attendance information of a student in a particular class. The purpose of AMS is to computerize the traditional way of taking attendance to generate the report automatically at the end of the session or in between the session. AMS maintains attendance of a student in the college and attendance report can be generated for each student individually on a daily, weekly, monthly or even subject based or student-wise. Fig. 1 represents a simple AMS.

Face recognition based on depth images is widely studied in [1-3] due to its advantages of 3-D information and environment illumination insensitivity. The traditional recognition methods in this field mainly focus on hand-crafted feature design, which cannot achieve satisfactory results. In [4-5] , authors propose a method based on Convolutional Neural Networks (CNN) model and perform certain experiments on databases and suggest that the proposed CNN architecture has better recognition performance than some traditional manual feature extraction methods, such as HOG and LBP [6]. The conventional methods practiced in most of the institutions are by calling names or signing on papers, which is highly time consuming and insecure. Therefore in [7-9] authors present A2MS for convenience or data reliability. The system is developed by the integration of ubiquitous components to make a portable device for managing the students attendance using face recognition technology. Face recognition has been thought-provoking in object detection, digital image processing and pattern recognition. Face recognition plays a significant role in real time surveillance systems. A comprehensive survey on face detection and recognition and the performance analysis of students AMS using CNN with various face recognition approaches were discussed and concluded in [10].

From the previous works, it is observed that there are many weaknesses in the system such as: not user friendly, difficulty in report generation, manual controlling, paper work and time consuming. Hence, to avoid the above issues, we developed a framework for monitoring the student's attendance using ML algorithms. The integrated framework aims at easing the job of teaching staff to generate student's attendance accurately by reducing the paperwork and saving time. This is achieved by a set of three steps:

1. Collection of data i.e., live streaming of video through a web camera.
2. Developed an algorithm for detecting the faces of students and finding the confidence levels. Later the collected data is trained with our developed algorithm using Haar Cascade Classifier (HCC) and adaboost algorithm.
3. Face recognition and mapping of attendance in excel sheet: A new image/ face is given to the trained algorithm which recognises the face_id. The recognised face_id is searched in the attendance sheet and 'P' is marked against the face_id for the given class number in the excel sheet which basically represents an attendance sheet.

The above three steps are done automatically which makes the proposed system automatic attendance monitoring system (A2MS).

Organization of the rest of the paper is as follows: Section II briefs about the working of CNN Classifier and a detailed description on the implementation of HCC for feature extraction that is involved. Section III explains about the proposed methodology, and the experimental set up used. Analysis of results were discussed in IV. Finally, conclusion and future scope are discussed in section V.

II. CONVOLUTIONAL NEURAL NETWORKS AND HAAR CASCADE CLASSIFIER

CONVOLUTIONAL NEURAL NETWORKS

Convolutional Neural Networks (CNN) are most widely used in image processing, segmenting, and classification. CNN is advantageous as they consider images in the form of vectors and constrain their architecture in the most efficient manner. The neurons in CNN will be connected to the required layers of the network, instead of being a fully connected network. Hence the final layer will have a lesser number of dimensions and hence lesser weights when compared to a regular neural network. The last fully-connected layer is called the "output layer" and classification represents the class scores.

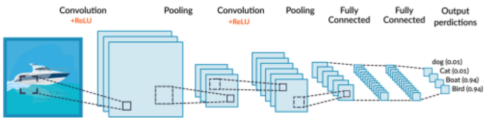

Fig. 2. Convolutional Neural Networks

Fig. 2 shows CNN arranging the neurons in three dimensions i.e., width, height and depth. Every layer of a CNN, transforms the three-dimensional input to a three-dimensional output upon neuron activation. The layers of CNN are discussed below briefly.

1. INPUT will hold the raw pixel values of the image, and in this case an image of width 32, height 32, and with three color channels Red (R), Green (G), Blue (B) (RGB) are considered.

2. CONV layer will compute the output of neurons that are connected to local regions in the input. Each neuron computes dot product of weights and a small region they are connected to in the input volume.

3. RELU layer will apply an element wise activation function, such as the max(0,x) thresholding at zero. This leaves the size of the volume unchanged.

4. POOL layer will perform a down sampling operation along the spatial dimensions (width, height), resulting in volume.

5. FC (i.e. fully-connected) layer will compute the class scores, resulting in volume of size [1x1x10].

HAAR CASCADE CLASSIFIER

Training the NN is done using Haar-Cascading weights. Haar-Cascading algorithm is a machine learning classification algorithm used to identify the objects from a video or an image. In this a cascade function is trained using many positive and negative samples, i.e., images of students. Once the training is completed, the trained model is used for identifying the images belonging to one particular student and marking the attendance.

The HCC is trained in four stages:

A. Haar Feature Selection

This feature detects and considers the adjacent rectangular regions in the given image segment, and it adds to the pixel intensities in each image and calculates the difference between the two sums. Fig. 3 representing the haar features extraction in the process.

$$F(haar) = \Sigma F(white) - \Sigma F(black) \quad (1)$$

Where, ΣF(white) is the number of pixels in brighter region, ΣF(black) is the number of pixels in dark region, and F(haar) represents haar features. The region is considered brighter (white) and darker (black) depending upon some threshold values.

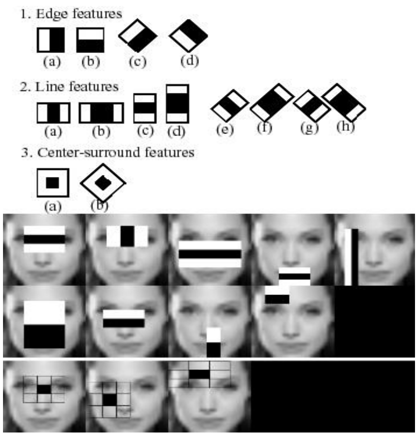

Fig. 3. Haar Features Networks

B. Creating Integral Images

Integral images boost the speed of the classifier making the computations super-fast. Fig. 4 represents how an integral image is formed, Row '*A*' represents the feature to be selected and row '*B*' represents how the selected feature can be used to implement the feature selection on the face. For instance: edge feature can be used to represent eyes and line feature can be used to represent nose and forehead.

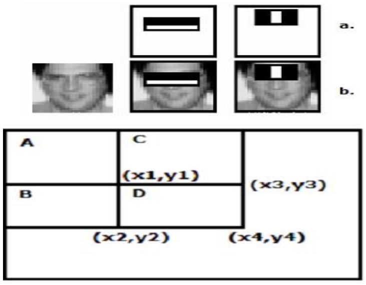

Fig.4 Integral Images and Calculations

$$Sum=(D+A)-(B+C) \quad (2)$$

For a pixel present on area D, the feature is calculated using

$$Sum=((x4,y4)+(x1,y1))-((x3,y3)+(x2,y2)) \quad (3)$$

Where x1, x2, x3, x4 are x coordinates of the pixel and y1, y2, y3 and y4 are the y coordinates of the pixel.

C. Adaboost Algorithm

This algorithm is used to select best features among the available features and helps in training the classifiers depending on the performance. Moreover, it creates a very robust classifier by linearly combining the simple weak classifiers with weights.

$$H(X)=sign\Sigma t_t=1\alpha_t.h_t(x) \quad (4)$$

where $h_t(x)$= output of weak classifier, αt= weight assigned to a character and it is given by:

$$\alpha_t=0.5ln((1-E)/E) \quad (5)$$

where E= Error rate and weights are updated using the formula:

$$D_{t+1}(i)=D_t(i)\ exp(-\alpha_t h_t(x_i))/Z_t \quad (6)$$

Where, $Dt(i)$= weight of i^{th} sample and Z_t is sum of all weights

D. Cascade Classifiers

The classifier consists of many stages and each stage represents a weak classifier commonly referred to as decision stumps. These decision stumps are trained by using boosting technique, having the ability to train a highly accurate classifier which uses a weighted average of the decision made by the decision stumps as shown in Fig 5.

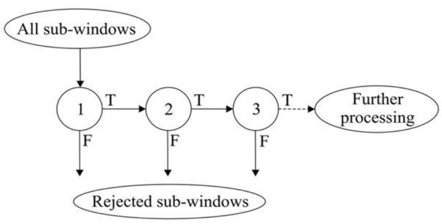

Fig. 5. Cascade Classifier

The stages of the classifier are given by current locations of the sliding window and can be either positive or negative. When an object is detected, the region is considered to be positive and when there is no object detected, the region is considered to be negative. When the classifier detects a negative region, the classification is said to be complete, when the classifier detects a positive region it is passed on to the next stage as shown in table 1. When the final region is detected as positive, the detector reports the object as found. There are some cases where a classifier might give an error with respect to the classification.

TABLE.1- CLASSIFICATION PARAMETERS

Classification	***Parameters***
Positive	Object detected and recognized
Negative	Object not detected and not recognized
False Positive	Object not detected but recognized
False Negative	Object detected but not recognized

III. PROPOSED METHODOLOGY

An Automatic Attendance Monitoring System (A2MS), is a software based AMS which can be employed in places where a group of people work together like in schools, colleges, offices to monitor the attendance of students, faculties and officials. A2MS aims at facilitating the attendance information of the student in a class and to sort the information obtained using learning algorithms. The purpose of this system is to generate a framework which emphasizes on generation of an attendance report between lectures, and to computerize these records as to maintain them for a longer time. A2MS is an independent product and will handle various tasks related to students' attendance ensuring the smooth and uninterrupted work environment for students as well as teachers. Fig. 6 illustrates the flowchart of the proposed methodology.

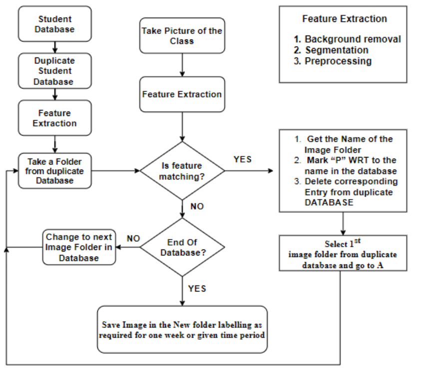

Fig. 6. Flow-Chart of Methodology

- The idea of the paper is to mark the attendance using facial recognition techniques and update the database in a classroom of 40.
- A set of five images of each person's face are collected and saved in the “Training Image” folder assigned to the specific person. So, a total of 200 images are collected and are stored in the training image folder.
- After that we train the model using learning algorithms; is a one-time process during installation and can be altered depending on the requirement.
- A picture of the whole classroom of students is captured and the image is segmented according to the requirement for further processing.
- The default attendance is marked with absent i.e., 'A'
- The segments are compared to the images in the database and the attendance is updated by facial recognition technique using the trained model, according to time & subject which was loaded previously in the database.
- The captured image is stored in the database for a period of one day or a week accordingly for retrieval.

IV. EXPERIMENTAL SIMULATIONS

Datasets were collected using a camera in the form of images. A total of 100 images are taken per individual as shown in Fig 7. The collected data is stored in a folder with a face ID say University Seat Number (USN)/ Name. The collected data images are used for training the algorithm.

Second part is training the Haar cascade classifier with the collected samples. The classifier as explained before creates a weak classifier of all the samples taken and then combines them to form a robust classifier. The weights of the training algorithm are stored in a file *trainer.yml* in a given path as shown below in Fig. 8. This file is used in the recognition later.

Fig. 7. 100 samples required to train the classifier for student 1 and student 2.

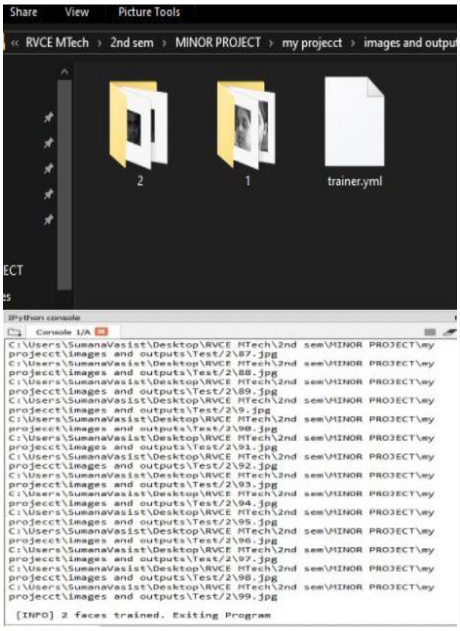

Fig.8. Outputs of face training stored in trainer.yml file and outputs trained in Python (Spyder).

Final part is recognizing and updating of attendance. The recognizer recognizes the face in the new image and maps it to the corresponding *Face_ID*, which can be either USN or name as shown in Fig. 10. The algorithm also detects multiple faces in the line of sight (LoS) as shown in Fig. 9. The image of a classroom is captured, and classified with haar cascade as well as trainer.yml. The accuracy of recognition is displayed on the boundary of the image in percentages as shown in figure 9.

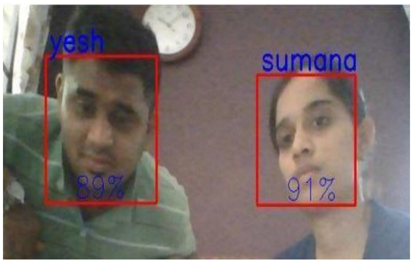

Fig. 9. Face Recognized Image with Confidence level = 89% & 91% respectively

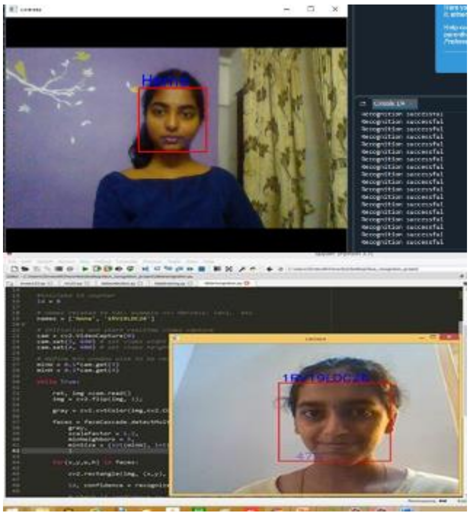

Fig.10. Face Recognized Image with Confidence level=77% & 47% for single face. FACE_ID is and name in above figure and the below one as USN

The algorithm is developed using python programming. Once the images are recognized, we map the recognized faces onto an excel sheet which represents the attendance sheet. The teacher is prompted to enter the subject name which is then used

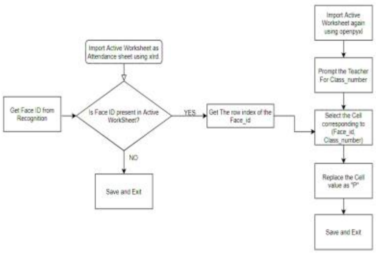

Fig. 11. Mapping of attendance in an excel sheet, Flow-chart

to import the attendance sheet of the entered subject. From this information, the face id index is obtained from the sheet. The lecturer is then prompted to enter the class number. Once the class number is obtained the attendance is marked present to the respective face id as "P".

The flowchart for the algorithm is represented in Fig. 11.

RESULTS & OBSERVATIONS

ANN:				
	1	2	3	4
ROLL NUMBER				
1RV19LDC001	P	P	P	A
1RV19LDC002	P	P	P	A
1RV19LDC003	P	A	P	A
1RV19LDC004	A	P	P	A
1RV19LDC005	P	P	P	A
1RV19LDC006	A	P	P	A
1RV19LDC007	P	A	P	A
1RV19LDC008	P	P	P	A
1RV19LDC009	P	P	P	A
1RV19LDC010	P	P	P	A
1RV19LDC011	A	A	P	A
1RV19LDC012	P	P	P	A
1RV19LDC013	A	P	P	A

Fig.12. Mapping of attendance in an excel sheet.

The outcome of the experiment will be the changes made with respect to attendance against each student field. The students who are present will be marked Present and the rest are marked absent by default. The outcome is as shown in Fig. 12 marking the attendance in an excel sheet.

V. CONCLUSION & FUTURE WORK

In this project we designed and developed A2MS using Python and MS Excel. The method involved in the experiment is CNN and HCC. The proposed system can be used to mark attendance of the students more efficiently and without the hindrance to the teacher who has to stop the class in the middle to take the attendance. Accuracy of the developed algorithm is found to be good and it can be used to recognize the faces more efficiently. Confidence of the classifier is the correctness of the detection and recognition of a face in an image. It is basically represented in percentages. The confidence of detection in our algorithm is in between 83% and 98% depending on lighting, training and the matching of prerequisites. Accuracy of the classifier is the number of times the recognition is done correctly over the total number of attempts made. The accuracy of the system is found to be 93%. Total of 30 attempts were made and it was found that 28 attempts were correct.

Face recognition in a critical environment using different algorithms can be studied for better results. The algorithm can be improvised by new features which can be used to manipulate the attendance, like calculation of percentage of attendance of students and providing the eligibility can be included. Battery powered system can be made. Hardware Implementation is also considered as future scope where the basic action of the device is to work hand in hand with the proposed software such that we get to implement the proposed system. Components such as Camera, Storage, Processing unit (Computer) can be used.

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