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CNN and Adaboost fusion model for multiface recognition based automated verification system of students attendance

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ABSTRACT

In recent times, companies and institutions globally are increasingly adopting automated systems for recording employee attendance due to the inefficiency and error-prone nature of traditional methods. Face recognition is the fastest, most natural, and most accurate way to identify someone, despite its difficulty. Remote deployment and control of the technology using internet of things (IoT) protocols provides real-time attendance data worldwide. We use the Haar-cascade algorithm to detect and extract features and the adaptive boost algorithm confused with convolutional neural network (CNN) algorithm to recognize the face in our proposed smart attendance system. Per frame, the proposed system recognizes multiple faces. Face recognition in 18 conditions was designed into the proposed system to ensure its versatility. The system's graphical user interface (GUI) was made for average users. This work is more important because IoT technology records student attendance and sends data to authorities. We use Raspberry Pi 4 and camera module for our suggested system. Python and OpenCV libraries tested the multiple face image recognition proposal in 18 situations under four conditions. Single-face image recognition was compared to other methods. In most cases, the proposed method was 100% accurate and outperformed related methods.

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1. INTRODUCTION

Handling presence in different environments is becoming a tiresome undertaking in the rapidly changing environment of society. Classical ways of checking presence in classes [1] take a lot of effort, are highly susceptible to mistakes, and are ineffective. The internet of things (IoT) [2]–[7] powered facial identification [8]–[12] based automated registration system [13]–[17] is an upcoming technology-based approach that will transform the handling of attendance. Face recognizing based automated attendant system has many advantages. Classical registration systems are no longer necessary, which reduces documentation and boosts productivity. The system's computerized approach reduces crucial administration time and energy, enabling staff to concentrate on more important job duties. The contactless capability also guarantees a clean recording of attendance procedure, fostering a more secure and healthier atmosphere. The basic system for recording students' absence through a combination of the use of facial recognition technologies and the IoT begins with extracting images and taking a snapshot, then extracting the facial area from the rest of the image, extracting the distinctive features of the image, comparing the image to the database. If the photo is recognized, the student's attendance will be recorded, an email will be sent to Whom It May Concern, and the task will be

completed. The most widely used technique to detect the facial region is the histogram of oriented gradients (HOG) technique [18], and the landmark technique [19] is one of the techniques widely used to extract the distinctive features of each person's facial region. Finally, machine learning [20] and deep learning [21] techniques such as support vector machine (SVM) [22], K-nearest neighbour (KNN) [23], and convolutional neural network (CNN) [24] are used to recognize faces.

The main concern of this work is to develop and update the attendance recording systems for school and university students. The most important development aspects of the proposed system are the following: Recording the attendance of students by relying on the system of looking at the students' faces by identifying the students' faces one by one is something that may take a lot of time, and this may result in crowding in front of study sessions, and also perhaps a delay in entering the hall and attending the lecture from the beginning. Also, this matter may It would be annoying for the lecturer to have students enter one by one. Therefore, in this work, our interest is in designing a system capable of recording students' attendance after they enter the hall and sit in their seats, relying on recognizing the faces of all students at the same moment. Therefore, the proposed system for identifying faces in the previously mentioned manner was based on the combination of HOG and Haar-cascade techniques to identify students' faces and extract the most important features, in the stage of creating the database, and then using the adaptive boost algorithm in the stage of recognizing faces. Also, in order to confirm the efficiency of the proposed system of recording students' attendance in the manner previously mentioned, the proposed system had to be trained to work in difficult and different working conditions. The suggested system was created with the average user's simplicity of use in mind, allowing for graphical user interface (GUI)-based interaction. The significance of this effort is increased by connecting our established system to track students' attendance and transmitting all of their data to the relevant authorities using IoT technology. Using a Raspberry Pi 4 and a Raspberry Pi camera module, our suggested solution is put into practice.

The results of evaluating the concept for multiple-face image recognition in eighteen scenarios under four distinct conditions were obtained using Python and OpenCV tools. The outcomes of testing several other related strategies were also compared with the results of testing the concept for single face image recognition. All of the results demonstrated the suggested system's superiority over related procedures as well as its ability to handle a variety of conditions, with the suggested method's accuracy typically reaching 100%. The results of testing the proposed system proved its high efficiency in implementing the various tasks of creating a database that contains names, codes, and photos of students, then registering attendance by identifying faces and linking these entities to the database, and finally, sending an email in the presence or absence of the student to the academic advisor or parents. Our research paper is organized as follows: in the next section we review an explanation and clarification of the proposed method, the third section deals with the review and analysis of the results, and the fourth section deals with a summary of the proposal and future work.

2. METHOD AND IMPLEMENTATION

The proposed technology aims to develop the implementation of multiface recognition tasks using the one-shot system within classrooms, then record student absences, and finally send each student's data to the academic supervisor and parents. The proposed method for automatically recording student attendance is based on the development of face recognition techniques. The proposed system for developing face recognition techniques depends on the use of Haar cascade algorithm [25] for faces detection, and then the fusion of both the CNN and the AdaBoost [26] classifiers, as shown in Figure 1. The steps and explanation of implementing the proposed method for face recognition will be discussed.

2.1. Images pre-processing

Our proposal is first treated using image enhancement and then feature scaling. Firstly, an improvement of the images contrasting was related by the use of histogram equalization technique. Secondly, in our situation, the feature scaling technique involved scaling our datasets into 128×128 dimensions using red, green and blue (RGB) formatted pictures. In addition to image resizing, we also normalized the gathered dataset as part of our feature scaling process. In addition, the CNN stops sooner when data is provided between [0, 1] than it does when data is provided between [0, 255]. This is done to lessen the impact of illumination disparities.

2.2. Faces detection

The proposed method for face detection was based on the use of the Haar cascades technique due to Haar cascades can work in real-time. The basis for the Haar cascades algorithm's operation is the detection of the frontal face and its distinguishing characteristics, such as the mouth, nose, and eyes. At the end of this stage, the facial area will be extracted as an entry point for the next stage.

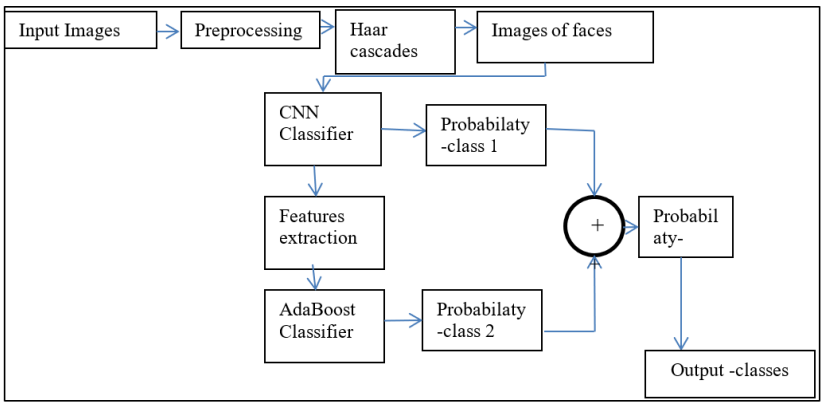

Figure 1. Blockdiagram of our suggested multiface detection and recognition

2.3. Architecture of our suggested CNN model

Our proposed approach as shown in Figure 2, which is intended to identify the facial features, consists of two convolutional layers, two Max-pooling layers, one dropout layer, and a fully connected layer, as illustrated in Figure 2. The two convolutional layers were constructed as; the first convolutional layer, which consisted of 32 filters with 3×3 pixel size the output of the first layer is received by the second convolutional layer, which has the same number of filters and filter sizes as the first layer. In order to account for non-linearity, the output of the convolution process is subjected to an activation function after the convolutional layers. As per our idea, the convent is activated by the rectified linear unit, (ReLU) activation function. The sub-sampling layer, which uses Maxpool and is 2×2 in size, comes after the activation function. The dropout layer, a regularization technique for neural networks in which certain neurons are assigned at random and not used during retraining, comes after the sub-sampling layer. Lastly, there are two dense layers with a "softmax" activation function that are fully interlaced and capable of differentiating between different apple classes. 64 kernels of spatial size 3×3 with stride size 1 and padding of 2 were utilized for both convolution layers. Max pool operation with kernel size 2×2, stride 2, and zero padding for both pooling layers.

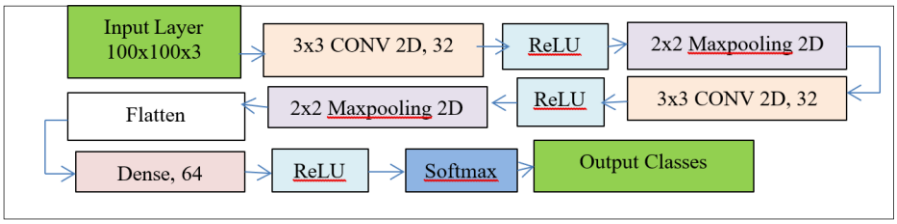

Figure 2. Our CNN architecture of the planned multiface recognition

2.4. AdaBoost classifier

One of the solutions available for face recognition is usually the AdaBoost classifier, which has certain benefits in terms of accuracy and speed of detection. AdaBoost classifier is a one way for increasing the accuracy of face recognition systems, which is an ensemble machine learning method. AdaBoost classifier involves training a number of weak classifiers and then merging them to produce a strong classifier.

2.5. CNN-AdaBoost

CNN is thought to be the most potent and successful identification of features method. As a result, by combining CNN with AdaBoost, one may fully utilize CNN's significant benefits for feature extraction while also enhancing AdaBoost's identification accuracy. CNN-AdaBoost's architectural design is displayed in Figure 3.

2.6. Software implementation

In this section, the software implementation of the proposed system is explained. the suggested smart attendance-based face recognition and IoTs technologies system includes two phases: the first phase is established in case of new registration, and the second phase is established in case already registration.

Therefore, in the case of new registration, the administrator, through the GUI window, enters the student's name and identification number to be registered. After the student's data (name-identification number) has been placed, by clicking on take a picture, the camera will open for a period ranging between 10 to 15 seconds, and it will take more than 50 snapshots of the student's face during this period. After the camera is automatically closed, the administrator presses save profile. From here, the student's information is stored, as follows: his or her name, identification number, and several snapshots of his or her face in the database. After the student information has been entered and the administrator presses on save profile, a new window will appear in which the administrator must enter the password to save the file so that no files are recorded without the knowledge of the administrator. This is to display the number of registered students in order for the administrator to make sure that the student registration process has been completed. When all students are registered, the system now is ready to take attendance. Each time the administrators want to take attendance they must click on "take attendance" and the program will automatically open the camera and start recognizing the registered students, then after that, the administrator makes sure that everyone is within the frame of the snapshot and presses the exit button, which is Q. After the administrator finished taking attendance and exited the camera, the program records the data automatically and displays the names. Student's data is registered in an Excel file. Finally, when clicking the Email button, this file is sent to the administrator's email after it has been added. When everything is done, the administrator presses the exit button to close the program and complete the process.

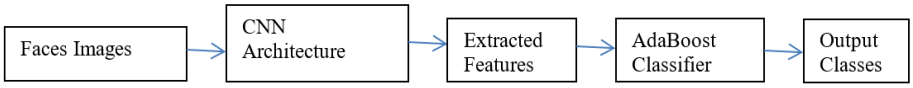

Figure 3. CNN-AdaBoost's architectural design

2.7. Hardware implementation

As shown in Figure 4, the communication takes place between the GUI, the Respberry Pi, and the camera twice, the first phase is established in case of new registration, and the second phase is established in case of already registration. Therefore, after entering the student data, the Respberry Pi takes a command to turn on the camera. The Respberry Pi connects to both the camera and the GUI. The user interacts through the GUI first, to enter the student's data into the system, so the Respberry Pi takes a request to turn on the camera by pressing the "take a picture" button, the camera will open for a period ranging between 10 to 15 seconds, and it will take more than 50 snapshots of the student's face during this period. The Respberry Pi prompts a request to save the student's data by pressing the button so that the data is stored in the Respberry Pi's memory. The Respberry Pi takes a request to take the student's absence by pressing the take attendance button, and the program will automatically open the camera and start recognizing the registered students. Then the Respberry Pi receives a request to close the camera by pressing the Q button, and the camera closes. Finally, the Respberry Pi receives a request to message the absence of students by pressing the email button.

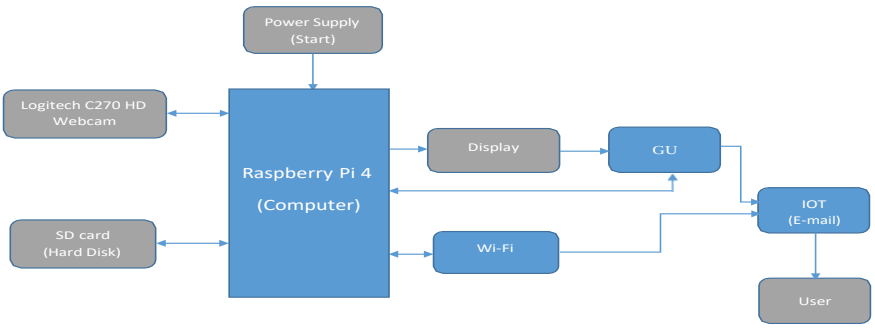

Figure 4. block diagram of the suggested system

3. RESULTS AND DISCUSSION

3.1. Training results

The proposed technology was trained using 70% from database of images on which our database consists of eight folders for eight studintes. Each folder contains 187 images for each one, distributed among

eighteen situations for four conditions as shown in Tables 1 to 4, so that the total number of images that were used in the training work are 70% from 1,496 images with background. The results show the great advantage of the proposed system, as it achieved 100% accuracy in 16 out of 18 situations. While, it achieved 99.8% for the condition of accessories, and finally, it achieved 97.6% accuracy for the lighting condition.

3.2. Testing results

The proposed technology was tested using 30% from 1,496 database of images of eight folders for eight studintes. Each folder contains 187 images for each one, distributed among eighteen situations for four conditions as shown in Table 5. The table shows the results of the overall test losses and accuracy of our proposed method. The obtained results demonstrate the superiority of the planned model in recognizing the student's faces, as the accuracy ranges from 97.44% to 98.85%. The results show the great advantage of the proposed system, as it achieved 100% accuracy in 16 out of 18 situations. While, it achieved 99.8% for the condition of accessories, and, it achieved 80% accuracy for the lighting condition.

Table 1. The obtained results of the training accuracy of multiple-face recognition of the proposed system over images with background for conditions of accessories

Condition name	Dataset 1 Two faces	Dataset 2 Three faces	Dataset 3 Four faces	Dataset 4 Five faces	Dataset 5 Six faces	Dataset 6 Seven faces	Dataset 7 Eight faces	Dataset 8 Nine faces	Overall of recognition accuracy
Eyeglasses	100%	100%	100%	100%	100%	100%	100%	100%	100%
Light sunglasses	100%	100%	100%	99.75%	99.20%	98.40%	97.80%	97%	99.40%
With mask	100%	100%	100%	100%	100%	100%	100%	100%	100%
With hat	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 2. The obtained results of the training accuracy of multiple-face recognition of the proposed system over images with background for conditions of intensity of illumination

Condition name	Dataset 1 Two faces	Dataset 2 Three faces	Dataset 3 Four faces	Dataset 4 Five faces	Dataset 5 Six faces	Dataset 6 Seven faces	Dataset 7 Eight faces	Dataset 8 Nine faces	Overall of recognition accuracy
Very High	100%	100%	100%	100%	100%	100%	100%	100%	100%
High	100%	100%	100%	100%	100%	100%	100%	100%	100%
Medium	100%	100%	100%	100%	100%	100%	100%	100%	100%
Low	100%	100%	100%	100%	100%	100%	100%	100%	100%
Very low	89%	89%	89%	88%	88%	88%	87%	87%	88%

Table 3. The obtained results of the training accuracy of multiple-face recognition of the proposed system over images with background for conditions of position degree

Condition name	Dataset 1 Two faces	Dataset 2 Three faces	Dataset 3 Four faces	Dataset 4 Five faces	Dataset 5 Six faces	Dataset 6 Seven faces	Dataset 7 Eight faces	Dataset 8 Nine faces	Overall of recognition accuracy
Right side:0 -45º	100%	100%	100%	100%	100%	100%	100%	100%	100%
Left side: 0- 45º	100%	100%	100%	100%	100%	100%	100%	100%	100%
Up: 0-45º	100%	100%	100%	100%	100%	100%	100%	100%	100%
Down: 0-45	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 4. The obtained results of the training accuracy of multi -face recognition of the proposed system conditions over images with background with conditions of facial expressions

Condition name	Dataset 1 Two faces	Dataset 2 Three faces	Dataset 3 Four faces	Dataset 4 Five faces	Dataset 5 Six faces	Dataset 6 Seven faces	Dataset 7 Eight faces	Dataset 8 Nine faces	Overall of recognition accuracy
Normal	100%	100%	100%	100%	100%	100%	100%	100%	100%
Smily	100%	100%	100%	100%	100%	100%	100%	100%	100%
Focased	100%	100%	100%	100%	100%	100%	100%	100%	100%
Sad	100%	100%	100%	100%	100%	100%	100%	100%	100%
Talking	100%	100%	100%	100%	100%	100%	100%	100%	100%

3.3. Compression between the final test results of the suggested model and the related models

Table 6 shows the obtained results of the accuracy testing of single-face recognition within the proposed system. The testing involved 150 images with background and 150 images without background, compared to different face recognition algorithms in normal conditions. The results show a significant advantage of the proposed system compared to the results of other techniques, where it reached 100% in recognizing faces in both cases (with and without a background).

Table 5. The obtained results of the overall losses and testing accuracy of multi -face recognition of the proposed system conditions over images with background

Condition name	Overall test losses	Overall of test accuracy
Condition 1	1.15%	98.85%
Condition 2	1.86%	98.32%
Condition 3	2.56%	97.44%
Condition 4	1.18%	98.82%

Table 6. Compression between the final test results of the suggested model and the related models

Model	Recognition accuracy of dataset 1 with background	Recognition accuracy of dataset 2 without background	Overall of recognition accuracy
CNN	79.35%	89.66%	84.40%
XGBoost	87.27%	93.42%	90.34%
CNN-XGBoost	88.20%	94%	92%
SVM	78.24%	87.42%	83%
KNN	86.78%	92.46%	86%
Proposed model	98%	98%	98%

4. CONCLUSION

In this work, software and hardware were used to create an automated verification system for school and university students' attendance. The proposed system was built on the use of HOG and Haar-cascade algorithms to detect student faces and then extract different features, as well as AdaBoost technique combined with to detect and recognize multiple faces at the same time. The proposed system's hardware implementation is based on the Respberry pi4 and Python with OpenCV libraries. The proposal focuses on using IoTs to send student data to those who need it. The proposed system was trained and tested in 15 different environments and conditions. The results of testing the proposed system on over 1,500 images demonstrate its high accuracy and efficiency, with most cases reaching 100%. Future directions for this work include training the proposed system to operate with high efficiency in more difficult conditions than the current ones. Also, train the system to recognize different facial expressions, record them, and send them to whoever they may concern.

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