Designing Smart Attendance System Using Face Recognition and IoT Networking Concept

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Abstract: Students' attendance in universities or schools is crucial in assisting an effective learning process. Their active participation can enhance their skills and learning experience. Various methods were implemented to record their attendance. However, the old methods have become less practical due to the new advancements in technology. This approach utilizes the Internet of things (IoT) devices to minimize the overhead of implementation where Raspberry Pi with a camera is planted in the class. The detected faces were then forwarded to the processing server for recognition and analysis. The system includes a web interface, where data is smoothly transferred between IoT devices and the processing server, then stored in a database to facilitate the management process. The whole process is completely automated to minimize human error risk. The simulation results show that the proposed system design provides an efficient approach in detecting and recognizing student's faces.

Keywords: Attendance system, face detection, face recognition, neural network.

1. INTRODUCTION

The system of student attendance system is mainly a system that follows the student depending on its existing in university or school class[1]. Various leading organizations such as schools, industries and universities start engaging students and emphasize that their students are regularly committed to the attendance and absence rate becomes very important in their measures. Student's attendance is critical because a succeeded student is more likely are consistently attending their school class. It is a difficult task for the teacher to evaluate students' progress and skills if he is absent all the time or most of the time. Recently, Advances and improvement of technology have emerged itself to provide more efficient education process[2].. The techniques of Biometric-based are considered one of the key trends, which were emanated to be one of the promising choices for individual identification in the last few years. So, it replaced the process of authenticating people and access granting to both virtual and physical domains depending on passwords, smart cards, plastic cards, PINs, tokens, keys and so on, individual's physiological or behavioral characteristics are examined by these methods to determine and identify his identity [3]
Taking advantage of face recognition to recognize student's faces and network architecture to facilitate the flow of data between system components is a crucial task [4]. In higher education, taking students' attendance in the real-time is an inefficient, time-consuming process. Managing the process will be even harder in larger size classrooms. Moreover, the process needs special attention in case of prevention of cheating on attendance.

In this paper, a design an attendance system using face recognition with the Internet of things is propose and evaluated.

2. LITERATURE REVIEW

Various mechanism have been proposed to handle student's attendance using different approaches and technologies. In this section, a list of recently proposed approached are discussed. Sensors-enabled smart attendance systems using NFC and RFID technologies was proposed in [5] Web-based attendance system using NFC technology in Android smartphones. NFC and RFID attendance system is very great in recording attendance. NFC system is offering more conveniences and lower cost infrastructure in both operational and setup cost. Students have to interact with the system using their mobile phone which minimizes the automation process. Also, NFC technology can be hacked or manipulated, so false indication can result in manipulated attendance. RFID-enabled smart attendance management system, in Future information technology was proposed in [6] which has limited accessibility where each student must get its RFID card. Also, the automation requires user interaction and users can use each other identity devices to cheat the system, so the system may be insecure. Unlike other biometric and non-biometric means of attendance system where Correlation tracker from the dlib library is used to save track of the face from frame to another, A face recognition based attendance system for a classroom environment in [7] use Viola & Jones idea which provides lower efficiency in detecting face than recently proposed neural network solutions. College attendance management system with mobile phone detector proposed in [8] depended on Biometric fingerprint authentication system, which is an automated method of verifying a match between two human fingerprints for validating identity. However, a fingerprint-based approach is used where the client needs to interact with a user end peripheral. Besides, the system is not automotive. An android application proposed in [9] which helps keep student information, which can be accessed by the mobile via location identification and calculating distance. Although, it mainly depends on student mobile, not the student himself, so it can be cheated easily. Also, GPS sensors need to be activated at the client-side, otherwise, it will be considered absent. Attendance tracking using Wi-Fi proposed in [10] where Client marks their attendance when he is connected to WI-FI network through android Smart Phone, he also needs to provide their fingerprint. The system depends on remote figure print provided using specific WiFi network, a simple workaround can be used to provide different figure prints. also, other users can connect remotely to local users and provide their figure prints.

3. SMART ATTENDANCE SYSTEM MODULES AND DESIGN

Proposed smart attendance system includes three main modules: Face detections module, Face recognition module and Results Storing and Interfacing Module.

3.1 Face Detection Module

This module mainly depends on IoT devices and networking to detect student faces across multiple student classes. Student's faces are detected and captured using the Raspberry Pi 4 chip which is connected to a portable camera.as in figure1

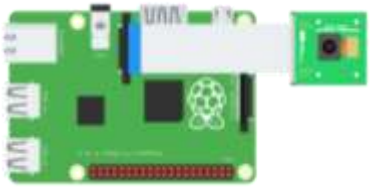

Figure 1 Face detection module

After that, the Raspbian which is the operating system of the Raspberry Pi is configured to transfer captured data to the face recognition module and remove it from the storage of the Raspberry Pi chip to save storage and make the solution more scalable. The main component of this module is the Raspberry Pi 4 chip. The main reason for selecting this chip is due to its capabilities in processing and storage when it is compared with other IoT devices.

To implement a reliable face detection algorithm for the system, deep learning has been utilized to achieve a high level of face detection accuracy. Python has been used as the primary language for developing the required algorithm. OpenCV is one of the widely spread and most reliable face detection and recognition library. In this model, we utilize Deep Neural Network module with Caffe models (Y. Jia et al., 2014) multimedia researchers and practitioners utilize Caffe as an efficient and reliable framework for latest algorithms of deep learning and reference models collection. Caffe framework is a BSD licensed library which is programmed by C++ and support bindings for both MATLAB and Python. This binding is used to train and deploy general-purpose convolutional neural networks and other efficient commodity architectures deep models. To use OpenCV Deep Neural Network module with Caffe models you will need two main components using two files:

1. Model architecture which is defined by pretext file
2. The weights for the actual layers which is included in the Caffe model file

The system is designed to follow the video stream captured by the Raspberry Pi camera when a face is detected with an accuracy range more than 90% these pictures are stored at the storage of Raspberry Pi storage temporarily.

3.2 Face Recognition Module

After the face is detected and captured as images, a script is scheduled to transfer these images to the processing server where face recognition module is implemented. Face recognition module include three main phases: Face training, Face recognition and results storing. The training phase includes introducing previous images to the system, to train and recognize new detected images. The training process includes two iterative steps:

a. Accept the first image as input
b. Extract a classification label as output for that input message

Dlib [11] is used for the facial network where real-valued feature vector is generated. The output feature vector is 128-d that is used to quantify the face. Triplets are used in network training. “Triplet training step” is an implemented deep metric learning for facial recognition. The neural network of the recognition-training algorithm generates a 128-d vector for each of the three face images. For the two face images of the same person, then the neural network weights are tweaked to make the vector closer via distance metric.

Face Recognition Phase

When files are received from the Raspberry Pi to the processing server, it then stored in the un-recognized image folder, a scheduled task is executed periodically (every 10 minutes) to check new images and run the face recognition algorithm.

Face recognition algorithm mainly depends on ResNet-34 approach proposed in (He, Zhang, Ren, & Sun, 2016) Residual network are abbreviated as ResNet where residual learning is an efficient deep convolutional neural network. Human-level image classification was achieved by this kind of classification. Various level features and classifiers are extracted by deep networks by using the end-to-end multi-layer approach. The stacked layers number of can enhanced the features levels [12]. The face recognition module receives images that contain faces, which is detected in the first phase. After that, the facial landmarks are computed to enable the task of preprocessing and aligning the face. In this task, two main subtasks are implemented:

i. The faces geometric structure is identified.

ii. The canonical alignment of the face is obtained depending on rotation, scale, and translation.

Face alignment has been implemented to increase face recognition accuracy in processing pipelines. After applying face alignment and cropping, the input face is passed through our deep neural network. The deep learning model of FaceNet

computes a 128-d embedding that evaluates the face itself. The face embedding is computed by the network using the training process itself, including the following steps:

i. The input data to the network during the training phase

ii. The triplet loss function

The 128-d measurements are calculated by the neural network for each face, and then weights network are tweaked using the triplet loss function, where the 128-d measurements of the anchor and positive image lie closer together and at the same time, pushing the measurements for the negative image father away. In this approach, the network will be able to learn to recognize faces and return highly robust and distinguishing measurements and classification the images by k-nearest neighbor's algorithm that enhance the accuracy of face recognition.

Results Storing and Interfacing

After received images of detected faces are being processed by the face recognition phase, results are handled by results storing module. Faces are categorized based on what is learned during the learning phase. Where each set of training images (group from 5 to 8 images per person) for a single person has an id for that person. So, we face recognition is completed and face is correctly recognized the person id is delivered to the results storing. MySql Database is used to store student's information and attendance system processing results. This database includes all the system data including administrator details, student's details and smart attendance system details.

3. EXPERIMENTAL RESULTS

The results of the samples images used for face recognition is described in this section. The first image shown in Figure 2, demonstrated accurate face recognition for the three faces detected in this image. This image is categorized as a simple image where it includes three separated faces and all faces are included in the training images. The system was able to detect and recognize all images successfully.

Figure 2 Face recognition output

The result of the face detection approach is demonstrated in Table 1, as shown earlier images are categorized into 4 levels based on the number of persons in a single image. As demonstrated the used face detection approach achieves high face detection accuracy where all faces are detected successfully. The image with a missed face which is noised by an external factor and the face was not complete. The complexity of image is described in term of number of persons, image clearance, number of interfered or similar person faces

Table 1 Results of face detection

Samples Group	Number of Persons	Image Complex Number	Detected faces	Un-detected faces	Accuracy of face detection
Research laboratory	3	2	3	0	100%
Classroom	4	1	4	0	100%
Meeting room	10	1	9	1	90%
workshop	12	1	12	0	100%

The other part is the results of face recognition as shown in Table 2 the detected phases in the first phase. The result shows a high accuracy of recognizing detected phases of the known group of faces. As shown all detected faces of known persons are recognized successful. However, the miss-detected face in the detection phase results in face recognition failure and thus decrease the

accuracy of face recognition of the third level image

Table 2 Face recognition results

Samples Group	Number of Persons	Image Complex Number	Number of Known persons	Recognized persons Numbers	Unrecognized Known Persons Numbers	Accuracy of face recognition
Research laboratory	3	2	3	3	0	100%
Classroom	4	1	3	3	1	100%
Meeting room	10	1	7	6	4	85%
Work shop	12	1	6	6	6	100%

To demonstrate the efficiency of the proposed approach, it is compared against other widely used approaches for following student absence. As shown in Table2, the systems are compared in term of various critical features. The proposed approach achieves the best results for these features where the proposed approach can be used to take student attendance as the main function. However, the student attendance information is stored in the database and can be used later. The proposed approach is cheating tolerant where the system mainly depends on the student's face and cannot be manipulated, the whole process registration is completed automatically without student intervention. Also, propose approach provide reporting and handle groups of students as bulk. It also depends on the network to exchange and process data. Finally, it can be tested against dataset for efficiency investigation. In the Table 3 of attendance systems first the phone applications and second the special attendance systems of computers. We selected two phone applications used for registering student attendance in university and two attendance systems recently proposed on a computer and comparison were classified based on ease of use and accuracy of detecting faces and preventing fraud in Students' attendance, as well as student registration automatically, however the results shows that our proposed design has outperformed other systems on computers on the other hand. Our attendance system also outperforms applications because it automatically records students ’attendance and prevents cheating.

The on the other hand, depending on the QR code for attendance can be easily breached. Student can use their colleague’s phones or hacked QR to register attendance without being there in real. Face recognition approach provides a more reliable and efficient mechanism for student attendance where it mainly depends on a factor which cannot be used by others.

Depending on student's face can prevent any cheats attempts of students and minimize the burden on students. Students do not need to install the mobile application and bring their mobile to register their attendance.

The proposed solution also makes the deployment process more flexible where attendance can be monitored in different places to follow the student’s attendances for specific classes or all classes. The lightweight IoT devices used in the proposed approach make it more cost-effective and more reliable approach.

Table 3 comparison with recent approaches

Features	Attendance System				
	Smart attendance system	**Time sheet**	**Biometric**	**Proximity card reader**	**Manual recording**
Take student Attendance	Yes	Yes	Yes	Yes	Yes
Reuse Student Attendance Information	Yes	No	No	Yes	Yes
Prevent Cheating Issue	Yes	No	Yes	No	No
No Fault Tolerance	Yes	No	Yes	Yes	No
Automatically registration	Yes	No	Yes	No	No
Reporting	Yes	Yes	Yes	Yes	No
Grouping	Yes	No	No	No	No
Network Environments	Yes	No	Yes	No	No
Dataset	Yes	No	Yes	Yes	No

4. CONCLUSION

In this thesis, the design and the implementation of smart attendance system were proposed mainly depends on IoT devices and face recognition approaches in real-time. IoT is an emerging technology, which provides flexible and widely deployed standards, has been used to facilitate the instalment and functionality of the attendance system. Raspberry Pi 4 has been used as a powerful IoT device which has many features such as processing, RAM, storage and various supported modules including the camera. Images were transferred to a processing server to minimize the face recognition overhead from the raspberry to the processing image. This resulted in better performance and flexible design. The result of the face recognition it then registered to a database to maintain records for all actions of the system.to facilitate the management process of the smart student system a PHP-based website has been implemented where users can log in to the system and follow student's attendance and apply filtering rules to smoothly collect information. This website mainly read data from the database that periodically updated by the processing server.

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