Sys Rev Pharm 2021;12(3):314-321
A multifaceted review journal in the field of pharmacy

ATTENDANCE SYSTEM USING RFID, IOT AND MACHINE LEARNING: A TWO-FACTOR VERIFICATION APPROACH

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ABSTRACT
The time and attendance systems help to monitor the employers and students working and attending time. Educational systems are struggling with the traditional system. It affects the pedagogical activities considerably. The traditional system is encountering many problems, and there is a need for a robust technological solution. This study focuses on building a two-factor prototype with RFID, IoT, and machine learning techniques. A microcontroller, GSM module, RFID tag, an RFID reader are used for first step verification. A camera with Multi-task Cascaded Convolutional Network (MTCNN) model is used for a second verification. When both are okay, students will get the attendance. If it fails, parents will get a notification about the student's attendance. When the prototype is developed as a complete system, the educational system will be getting higher advantages.

Keywords: ATTENDANCE SYSTEM USING RFID, IOT AND MACHINE LEARNING

INTRODUCTION

The attendance system is an essential part of each organization. The time and attendance systems help to monitor the employees and students working and attending time. Attendance and attendance reporting programs can help an employer monitor their employees' working hours, early departures, late arrival, and time taken on breaks. Attendance is a crucial part of any organization for several kinds of stuff.

The student's attendance is another significant factor used for several purposes. By using the student attendance, educational institutions decide the examinations, scholarships, memberships, and much more. However, universities and other education sectors still using the traditional paper-based system. The problems in the traditional system are time-consuming, higher cost, interruption of pedagogical activities, and insecurity—almost a teacher spending more than 30 minutes for getting and storing student's attendance. It is delaying and ruin the time of pedagogical activities.

Nevertheless, another issue found in the traditional system is, students will vanish from the classroom after getting their attendance. This disrespect to the teachers and must be avoided. Albeit the government has introduced several methods to tackle this issue, it is still a nightmare for the educational system. This issue must be approached in a new and sophisticated technological manner than a traditional way.

In contemporary, RFID, IoT, Industry 4.0 [1], [2], and machine learning techniques offer edge services in several sectors. Introducing these technologies will help tackle the attendance issues. Also, a two-factor attendance process is essential for avoiding many struggles. One tires system has many possibilities of having fraud activities and wrong throughputs. An effective and efficient system must contain higher security, low cost, and ease of use. In that respect, working with those technologies will be provided all aspects and eliminated all current issues.

This study aims to develop a two-factor prototype that will effectively and efficiently give a robust solution for current attendance issues.

LITERATURE REVIEW

1. RFID and IoT

I. General review

In contemporary, the contributions of RFIDs are highly impactable and Indispensable. In almost every sector, the RFID's flag is flying [3]–[4]. The RFID provides an efficient and effective solution for several issues. RFID and its application can easily handle Highly-paid attention problems categorized as clinical waste management issues [6], healthcare issues, attendance issues, and many others. Also, the Internet of things (IoT) delivers potent remedies to most contemporary issues. Many sectors use IoT applications in a different way to handle issues easily [7]–[10]. Many studies and authors have shown the bond of RFID and IoT in different areas, and it is throughputs. Furthermore, RFID and IoT are highly supported for education activities. Mostly e-learning [11] and blended learning activities are done using RFID and IoT technologies these days.

I. Systematic review

A.A. Olanipekun and O.K. Boyinbode [12] developed an RFID automatic attendance system for students. Students can use an RFID card for getting attendance. An RFID reader placed in the classroom is used for the RFID tag of each student. When students punch the tag in front of the reader, the student gets their attendance. There are many possibilities for fraud activities in this method. Others can use someone else's card for getting attendance. It is better to have a second verification method to avoid this issue.

H. K. Nguyen and M. T. Chew [13] proposed an attendance

system using RFID technology. This system's identified components are RFID tag, RFID reader, laptop, microcontroller, and WiFi module. When the students move the RFIF tag into the reader, the signal passes via WiFi to the laptop computer. Using the details of the RFID tag, students will get their attendance. This system also has higher possibilities of fraud activities.

Unnati Koppikar et al. [14] developed a similar web-based RFID attendance system for work sectors. This system consists of an RFID tag, RFID reader, microcontroller, and a web-based GUI. Suppose the employee or students wants to get their attendance, they need to place the RFID card to the reader. If the tag is valid with the employee information, then they will be got their attendance.

G. D. P. Maramis and P. T. D. Rompas [15] developed a database system for RFID automatic attendance system. The primary aim of this study was to develop a database to store the attendance of the employee—the RFID tag and reader are used for passing the signal to the computer. Developed software for the attendance system provides a portal for store employee attendance into the database.

A similar study is done by Ukoima Kelvin Nkalo et al. [16] with backup SMS for the attendance system. The microcontroller is the regulator of this system. The RFID reader and GSM module are connected with the microcontroller. When the students place the RFID tag in the reader, it investigates the validity. If the tag match with the student, the students get the attendance; meanwhile, a message will be sent to the students' phone. Using that message, students confirm the percentage of his/her attendance, and it will help attend the exams with adequate attendance.

As a supportive study to [16], Damini D et al. [17] developed an attendance system with parent SMS notification. Here the SMS will send to the parents about the students' absence instead of sending themselves.

2. Machine learning

I. General review

Artificial Intelligence and machine learning techniques are ruling the world these days. The applications of both are used in different sectors [18]–[21]. The image classification, face recognition. Object detection and pattern identifications are highlighted applications of both.

Many studies and authors state that a deep neural network is one of the best options for face recognition in contemporary. Also, it provides an improved solution in recognition than previous algorithms [22]–[27]. Another similar study detailed that the deep learning model could be improved by enhancing images and degraded samples [28].

The best image classification [29] and object detection [30] are achieved with CNN. Therefore, a CNN model is often used for classification problems [31]–[34]. Moreover, to improve the performance of runtime of the CNN model, Haoxiang Li et al. [35] introduced an ultramodern solution is called the CNN cascade. It increases the runtime performance of image detection considerably. It consists of 6 CNNs, "3 for binary classifications and remains for bounding box calibration".

I. Systematic review

Dr. Shrija Madhu et al. [36] developed an attendance system using a machine learning approach. Facial recognition is the primary aim of this system by Histogram of Oriented Gradients (HOG). When the camera captures the image, the machine learning model investigates the image. Once the model finds a face in the image, it will store it in a database and print it as a pdf. For this group, Viola and Jones method and AdaBoost classifier were used.

Tata Sutabri et al. [37] was carried out with a deep learning algorithm. This study focused on facial recognization and web-based applications. The conventional neural network (CNN) and k- nearest neighbor algorithms are used to detect and classify the faces. When it identifies the faces, the attendance will store in the database of the web-based application.

Domingo Mery et al. [38] proposed a student attendance system using a machine learning technique. The system works based on the eigen-faces face recognition approach. Students' face images will be stored in the database initially. The proposed approach monitors the faces and behaviors of the students. Once the face match with the database, it gives attendance automatically. The LBP and SVM method is used to identify the student's entry to the classroom.

Akshara Jadhav et al. [39] accomplished a similar study for an automatic attendance system with face recognition. Viola-jones algorithms play a significant role in the face detection of this study. Cascade and PCA algorithm used for feature selection and SVM used for classification along with viola-jones algorithm. When the student enters the classroom, the camera applies those algorithms and compares them with the database. If both are matches, the students get their attendance.

Amey Shirke et al. [40] proposed an algorithm for the student attendance system using a machine learning approach. This study utilizes the Sparse Fingerprint Classification Algorithm for recognizing the face of the students. The dataset of the student train and test with the algorithm model. When students enter the classroom, it will identify based on the training. Furthermore, as a conclusion, the authors suggested that frauds will be caught very quickly when this algorithm applies in crowded places.

AZM Ehtesham Chowdhury et al. [41] developed an automatic attendance system based on a machine learning approach. A camera model captures the students' faces after 15 minutes of the class and before 15 minutes. The FaceNet model was applied to this study. When the FaceNet identified face has validity, and if it is already recognized, the class's attendance increases by 1. If the face is new, it will be stored in the database, and the attendance count will be increased by 1. This system is dynamic, and as a result, they got 100% accuracy using this approach.

Marko Arsenovic et al. [42] proposed a CNN model for an automatic attendance system. Based on the camera image, the model identifies the landmarks and image position of the face. SVM classifier delivers the employee identity, and it will store in the database. Dataset is trained and test with a CNN model based on the employee numbers. This system produced 95.02% of accuracy in real-time.

Kritika Shrivastava et al. [43] proposed an improved solution for an automatic attendance system with a machine learning technique. A Haar-cascade classifier does the face recognition for detect faces. Also, a Linear Binary Pattern Histogram machine learning algorithm was applied for the identification of the face. The proposed system provides a state-of-the-art solution by gender classification. When the students enter the classroom camera capture the picture, this will pass to the live database with Raspberry pi. The live database detected the face by Haar-cascade classifier and compared it with the attendance database. A Linear

Discrimination Analysis is used for gender classification, and a Local Binary Pattern Histogram uses for face recognition. When both are identified, students get their attendance.

Another similar attendance system is created by Harish M et al. [44] for getting automatic attendance. The primary goal of this attendance system is to replace the existing time-consuming system. The Facenet model is used to recognize the face, and HOG is used to detect the face. A lecturer uses his/her smartphone to capture the images of the students. It later sends to google drive with REST API. A specific program needs to be developed to monitor google drive and run the model to predict face. When the program detects the faces, it will give the specific students the attendance and share it with a google spreadsheet.

Omar Abdul Rhman Salim et al. [45] studied a face recognition attendance system with a machine learning technique. A Raspberry plays a crucial role in this system. A camera connected with the Raspberry keeps capturing the images of the students. If the image is matched with the trained dataset in the database, then the door will open, and the student can attend the class. The Local Binary Patterns algorithm does face recognition. Once it okay, then the attendance of the student is stored in the MySQL database. Attendance and door opening happens at the same moment.

Visar Shehu and Agni Dika [46] dealt with computer vision algorithms for the attendance system. The system has divided into three phases. Initially, the image of the students has captured using a camera. Image Capturing happens with the help of an in-built module in the learning management system. The next step is dealing with face detection. The HAAR classifier is used for face detection, which is an OpenCV library. The eventual step of the attendance system is face recognition. For this, they have used a server-based module programmed in Python is called “Pyfaces”. When the system detects and recognize the face, it will be compared with database trained dataset and student will get the attendance.

METHODOLOGY

This study focused on creating a conceptual framework for an automatic student attendance system with two-factor verification. The verification process is the combination of RFID based IoT technology and the machine learning algorithm. Also, this attendance system will be notified to the parents of the students in case of absence. An Arduino microcontroller is the regulator of the system. The major components of this system are RFID tag, RFID reader, GSM module, and camera module. A Multi-task Cascaded Convolutional Network (MTCNN) model is used for the face detection of the students. This model is used with the camera module for the second verification process. Each student needs to have an RFID tag with their ID cards. Whenever students enter the classroom, they need to place their RFID tag in the RFID reader. Once it read the tag, the camera takes a picture of the students and verifies the face with an RFID tag. If both okay, students can attend the lecture. When the students fail to attend the class, the GSM module sends the notifications to the responsible person.

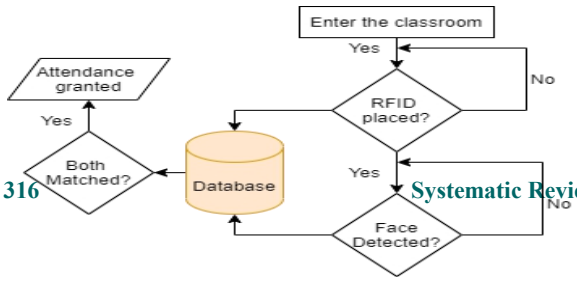


Figure 1: Flowchart for the two-factor attendance system

Figure 1 shows the exact method of how a two-factor attendance system works. When the faces and RFID tags match with the database students, get the attendance. The specific desktop application is used to insert the student attendance.

System components and functions

IoT components

1. RFID Tag:

RFID (Radio Frequency Identification) tags can be used to track items. An RFID tag can exchange information with an RFID reader through radio waves. All RFID tags have an antenna and Integrated circuits (IC). The antenna is used for receiving radio frequency waves, and ICs are used for processed and stored [4].

2. RFID reader

RFID readers are devices that gather information from RFID tags that track individuals. RFID uses radio waves to transmit data from tag to reader [4].

3. GSM module

It is used to send the message to the parents of a student’s absence [7].

4. Camera module

It is used to capture the image of the students when entering the classroom.

Machine learning components and functions

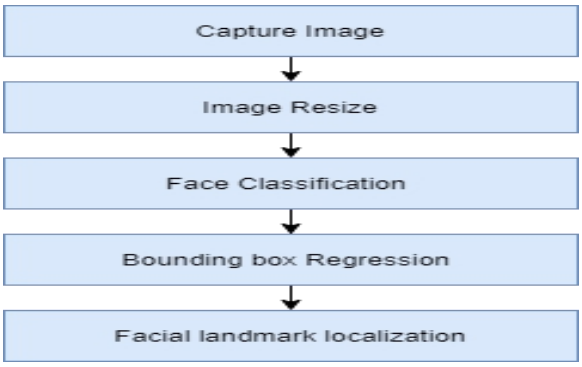


Figure 2: MTCNN face detection process

Face identification and detection is the primary task of this study, which is used as a second verification of this proposed system. The Multi-task Cascaded Convolutional Networks (MTCNN) is used for both face detection and face alignment. In recognizing facial features, the model has three convolutional networks that enable the model to recognize faces and landmarks such as eyes, nose, and mouth.

Face Classification:

When the image is resized, the trained model starts to classify the face. It is a binary classification problem that uses cross-entropy loss

Bounding box regression:

Bounding box regression is a popular technique for real-time object detection. Regressors typically predict either feature vectors or fixed anchor boxes to adjacent bounding boxes of a pre-defined target object classes.

Facial landmark localization:

It is the process of detecting and locating facial points.

When the all process is done, It will identify five landmarks: left eye, right eye, nose, left mouth corner, and right mouth corner.

RESULT AND DISCUSSION

1. IoT and RFID verification – first verification of attendance system

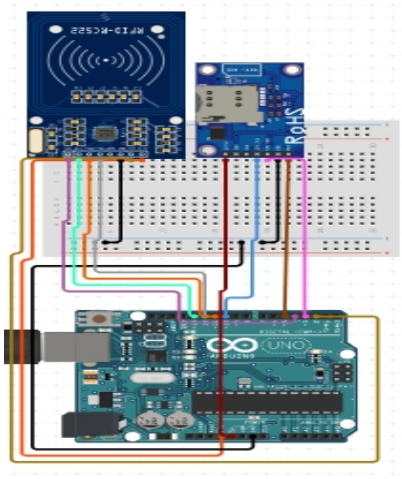


Figure 3: The attendance setup with microcontroller

Figure 3 shows the microcontroller with an RFID reader and GSM module.

```
void setup()
{
    Serial.begin(9600);
    while (!Serial) ;
    Serial.println("start");

    //initialize RFID module
    rfid.init();
    menuOption = menu();

}

void loop()
{

    if(menuOption == '1') {
    // RFID Card Reader - RC522 - T
    //Read RFID tag if present
    String rfidtag = rfid.readTag();
    //print the tag to serial monit
    rfid.printTag(rfidtag);
```

```
// Include Libraries
#include "Arduino.h"
#include "RFID.h"

// Pin Definitions
#define RFID_PIN_RST  2
#define RFID_PIN_SDA  4
#define SIM800L_SOFTWARESERIAL_PIN_TX 10
#define SIM800L_SOFTWARESERIAL_PIN_RX 3


// Global variables and defines

// object initialization
RFID rfid(RFID_PIN_SDA,RFID_PIN_RST);

// define vars for testing menu
const int timeout = 10000;
char menuOption = 0;
long time0;
```

Figure 4: Sample code for the setup

Figure 4 shows the sample code for the microcontroller and other setups.

Figure 5: RFID tag verification

Figure 5 shows the first verification of the automatic attendance system. The RFID tag is verified, and an authorized message is obtained for the second verification process. Once the card is verified, the student needs to verify the face as second verification for getting the attendance.

2. Face verification – second step verification of the attendance system

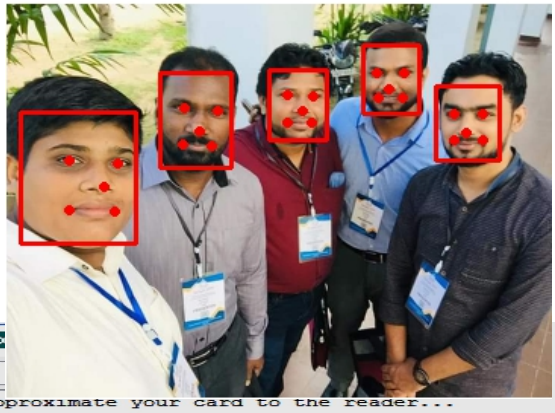
Figure 6: Sample picture for test purpose

Figure 6 shows the sample picture that we are going to use for getting second verification.

```
face = cv2.resize(face, (80, 80), interpolation = cv2.INTER_AREA)
cv2_imshow(face)
```

Figure 7: Image resize and isolated face

Figure 7 shows the image resizes and the classification of each faces.



```
Approximate your card to the reader...

UID tag : BD 31 15 2B
Message : Authorized acess
```

Figure 8: Bounding box regression
Figure 9: Facial landmark localization

Figure 8 and figure 9 shows the bounding box regression and facial landmark localization. When the model classifies the face, it will identify the five landmarks as in figure 9.

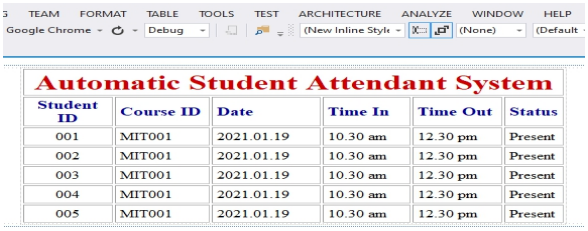


Figure 10: Desktop application of student attendance

Once both verifications are obtained without error, the student's attendance will be stored in the specific desktop application. Figure 10 shows the developed desktop application for store the student's attendance.

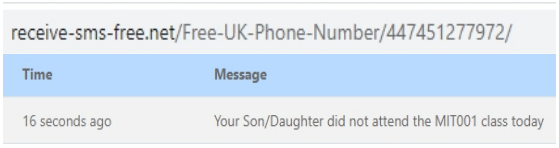


Figure 11: Attendance failure SMS to the parents

When the students failed to attend the class, the system will send a message to the corresponding parents. It was done using a virtual phone number, as in figure 11.

Comparison of the previous studies

Table 1: RFID Attendance systems

Study	Functionality	Major Idea
[47]	Attendance data maintenance	RFID Attendance system
[48]	Attendance track	RFID and fingerprint verification
[49]	Attendance Monitoring	Face recognition attendance monitoring
[50]	Attendance data maintenance	RFID and GSM based attendance system
[51]	Attendance data maintenance	RFID and Web-based system

Table 1 shows the previous studies of RFID attendance systems. There are several ideas, and implementation has been done since 2010. Which indirectly indicated that most sectors hate the traditional attendance systems.

Table 2 Face detetction approches

Study	Approach	Input
[52]	Deep learning	Image
[53]	HOG	Image
[54]	MKD-SRC	Video
[55]	Eigen-faces	Image
[56]	Fisher-faces	Video
[57]	Microsoft API	Image
[58]	Deep learning	Image
[59]	Deep learning	Image
[60]	Eigen-faces	Image

Table 2 shows the different approaches to face detections. Deep learning techniques are used highly from this table. Also, mostly image is used as an input than video.

Table 3: Classifier algorithms

Algorithm	Objective(s)	Method	Study
Viola-jones	Face detection [61], Object Detection	Computing Integral image	[62], [63]–[67], [68]–[71]
		Adaboost	
		Cascading Classifiers	
Eigenface	Face detection	Principal Component Analysis	[72]–[75]
Neural network	Face Detection	Self-learning based on training	[76], [77]
Feature-based approach	Face Detection	Identify the unique features of eyes, mouth, nose	[78]–[80]
Holistic based approach	Face detection	Statistical approach	[81]
		artificial intelligent approach	
Hybrid based approach	Face detection	Component Analysis and Linear Discriminant Analysis	[82]
		Generalized Two-Dimensional Fisher's Linear Discriminant	[83]
Convolutional Neural Network	Face detection, Object detection, Pattern detection	Optimized neurons based on training	[35], [84], [85]

CONCLUSION

This study mainly focused on the two-step verification of the automatic attendance system. Many previous studies failed to follow the second step verification in the RIFD attendance system. The RFID and machine learning techniques are delivering excellent services in different sectors. The RFID side microcontroller plays a primary role, while images play a crucial role in the machine learning approach. Throughout the study, a prototype was proposed and developed. When the prototype is built as a complete system, the attendance issue will vanish without any suspects. Usually, any system must build with higher security, reliability, faster performance, and cost-effectiveness. In that respect, the developed prototype is obeying each of the characteristics and working without any glitches.

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