

Smart Classroom Automation and Attendance Control System Using Raspberry Pi

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Abstract— This project focuses on the design and implementation of a Smart Classroom Automation and Attendance Monitoring System that integrates Internet of Things (IoT) and Artificial Intelligence (AI) technologies using a Raspberry Pi. The main goal is to promote energy conservation and modernize classroom management. The Raspberry Pi serves as the central processing unit. Environmental automation is achieved using a DHT11 sensor to monitor temperature and humidity, automatically adjusting fan speed via Pulse Width Modulation (PWM), and an LDR (Light Dependent Resistor) sensor to detect ambient light, automatically switching ON/OFF the classroom lights. The system also includes an intelligent attendance monitoring system utilizing facial recognition technology. A Pi Camera Module captures real-time facial images, which are processed using OpenCV and the face recognition Python library. Upon successful recognition, the student's details are automatically recorded in a local or cloud-based database. This integration provides a fully automated, real-time monitoring solution that is accurate, scalable, and cost-effective.

Index Terms— Smart Classroom Automation, Attendance Monitoring System, Raspberry Pi, IoT (Internet of Things), AI (Artificial Intelligence), Facial Recognition Technology, Energy Conservation, DHT11 sensor, LDR sensor, OpenCV, Pulse Width Modulation (PWM), Pi Camera Module.

I. INTRODUCTION

The sources discuss systems leveraging automation and technology to streamline routine tasks, particularly within organizational or educational settings. 1. Smart Attendance Tracking Using Raspberry Pi and Native Mobile Application (Source 1): The core motivation is the progression of technology towards process automation to simplify jobs and lives. Regular attendance monitoring and

human resource tracking are described as time-consuming, monotonous, and challenging duties in any company or organization. The goal is to provide a feasible “Smart Attendance Tracker” using a facial recognition approach that operates on ‘Small form factor’ hardware (Raspberry Pi) for optimum efficiency. The system aims to be an automated, easy-to-integrate solution requiring minimum maintenance. 2. Smart Classroom Automating System (Source 2): This paper highlights the rapid development of the Internet of Things (IoT) and the need to improve teaching efficiency. Smart classroom automation systems are seen as significant advances that improve the learning experience and make educational operations more efficient. Traditional classrooms rely on manual processes, which are time-consuming. The objective is to develop smart, responsive classroom settings that automatically manage and monitor lighting, HVAC, security, and other environmental considerations using Raspberry Pi and Node-RED. 3. Classroom Automation by Using Raspberry Pi (Source 3): This system addresses the thriving attraction of automation using IoT. The project includes controlling appliances and entertainment systems via the internet and Google Assistant voice mechanism. The primary focus is the automation of attendance, traditionally a time-wasting task when done manually. The system proposes detecting and recognizing faces in real-time, aiming to be a low-cost, mobile, and reliable module that replaces conventional methods of taking attendance.[3][4]

II. RELATED WORKS

Several studies have focused on automating classroom attendance using Raspberry Pi and face recognition techniques. These systems typically use a camera module with OpenCV-based algorithms such as Haar

Cascade and LBPH to detect and recognize student faces, thereby reducing manual effort and proxy attendance. While these methods are cost-effective and suitable for real-time applications, their performance is affected by lighting conditions and facial occlusions.

In parallel, IoT-based smart classroom automation systems have been developed to control lights, fans, and other electrical appliances using presence sensors and microcontrollers. Some researchers have proposed hybrid systems that integrate attendance monitoring with classroom automation to improve energy efficiency. However, many existing works treat attendance and automation as separate modules, highlighting the need for an integrated, low-cost solution using Raspberry Pi for both attendance control and smart classroom management.[6]

III. MEHODOLOGY

The proposed Smart Classroom Automation and Attendance Control System is designed to automate student attendance and classroom electrical control using a Raspberry Pi as the main processing unit. The system integrates image processing, System Architecture

The Raspberry Pi acts as the central controller of the system. It is interfaced with a camera module, PIR motion sensor, and [5] relay modules to perform attendance monitoring and classroom automation.

1. Face Detection and Attendance Process

A camera module connected to the Raspberry Pi captures real-time images or video frames of students present in the classroom. These frames are processed using the OpenCV library. Initially, face detection is performed using algorithms such as Haar Cascade Classifier.

Once faces are detected, the system performs face recognition by comparing the detected faces with a pre-trained [2] dataset of student images stored in the Raspberry Pi. Each student is enrolled beforehand by capturing multiple facials.

When a match is found, the student's attendance is automatically marked in a local database along with the date and time. Duplicate entries for the same session are avoided by applying validation checks.

2. Classroom Occupancy Detection

To determine classroom occupancy, the system uses face detection results and a PIR motion sensor. If human presence is detected, the classroom is considered occupied.[1] The PIR sensor provides additional reliability by detecting motion, especially in cases where face recognition may fail due to lighting issues or camera obstruction.

3. Classroom Automation Using Relays

Based on occupancy status, classroom electrical appliances such as lights and fans are automatically controlled. Relay modules are connected between the Raspberry Pi and the electrical devices. When the classroom is occupied,[8] the Raspberry Pi sends control signals to the relays to switch ON the appliances.

4. Data Storage and Management

Attendance data is stored locally in the Raspberry Pi in the form of CSV files or a database. The stored data can be accessed by authorized personnel for review, report generation, or export.

5. System Operation and Workflow

The system operates in real time during classroom hours. The camera continuously monitors the classroom, attendance is marked automatically, and appliance control is handled dynamically based on occupancy.

6. Advantages of the Proposed Methodology

The proposed methodology provides a low-cost, energy-efficient, and user-friendly solution. It minimizes human intervention, improves attendance accuracy, and contributes to energy conservation. Due to its modular design,[9] the system can be further extended with cloud storage, mobile applications, or advanced AI models in future implementations.

IV. OJECTIVES

The primary objective of this project is to design and implement a Smart Classroom Automation and Attendance Monitoring System that leverages the power of Raspberry Pi, IoT (Internet of Things), and AI thereby enhancing classroom efficiency, accuracy, and energy conservation. Specific Objectives:

- To monitor and regulate temperature and humidity using DHT11 sensor: The DHT11 sensor will continuously measure temperature and humidity in the classroom. The Raspberry Pi will analyze the data and, through PWM (Pulse Width Modulation), adjust the fan speed accordingly. When the temperature rises beyond a set threshold, the fan will automatically turn ON or increase speed; when it drops.
- To detect ambient light intensity using LDR sensor: An LDR (Light Dependent Resistor) sensor will be employed to sense the light level in the classroom. The Raspberry Pi [4] will use the sensor's data to determine whether to switch ON or OFF the classroom light.
- To implement an AI-based attendance monitoring system using face recognition: One of the key objectives is to design a facial recognition module using OpenCV and the face_recognition Python library. A Pi Camera connected to the Raspberry Pi will capture images of students entering the classroom.
- To ensure energy conservation and sustainability: The system emphasizes smart energy management by ensuring that electrical devices operate only when needed
- To enable real-time monitoring and decision-making: [5] The Raspberry Pi serves as the brain of the system, collecting data from sensors and processing it in real time.

V. LITERATURE REVIEW

1. "An IoT-Based Energy Conservation Smart Classroom System" – TechScience Press (2019) This study presented an IoT-based smart classroom framework designed for efficient energy utilization through intelligent control of electrical appliances.
2. S. Diddeniya et al. (2020) – "IoT Based Energy Efficient Smart Classroom," Journal of Multidisciplinary Engineering Science Studies (JMESS) In this research, the authors designed an IoT-enabled classroom automation system using microcontrollers, sensors, and wireless communication modules. The setup used temperature and light sensors to control fans and lights automatically.

3. R. Gupta and T. Kumar (2021) – "Smart Classroom Automation System Using Raspberry Pi," International Journal of Innovative Research in Science and Technology (IJIRST) This paper proposed a classroom automation model using Raspberry Pi as the central controller. The system used DHT11 and LDR sensors for environmental monitoring and relay modules for controlling fans and lights

4. A. Sharma and R. Mehta (2021) – "Automated Attendance System Using Facial Recognition," International Journal of Computer Applications This research focused on automating attendance using facial recognition technology implemented with Python and OpenCV. The system captured student images and compared them with a pre-trained dataset using feature extraction algorithms.

5. KM Al-Obaidi et al. (2022) – "A Review of Using IoT for Energy Efficient Buildings," MDPI Energies Journal [8] This review paper analyzed multiple IoT applications aimed at improving energy efficiency in buildings, including educational spaces. It discussed how sensor-based automation can control appliances like fans, lights, and air conditioning systems based on occupancy and environmental data.

6. P. Roy and S. Nair (2022) – "IoT and AI-Based Smart Classroom Environment," IEEE Conference on Smart Systems The authors proposed a combined IoT and AI model for smart classrooms that monitored environmental parameters [2] and provided personalized learning analytics. The system used a Raspberry Pi controller connected to temperature, humidity, and light sensors for environmental control.

VI. PROJECT DESCRIPTION

The Smart Classroom Automation and Attendance Control System Using Raspberry Pi are an intelligent embedded system designed to enhance the efficiency of classroom management by integrating automated attendance recording with smart control of classroom electrical appliances. Traditional classroom systems rely heavily on manual attendance and [1] manual operation of lights and fans, which are time-consuming, prone to errors, and result in unnecessary energy wastage.

This project addresses these issues by providing a fully automated, contactless, and energy-efficient solution.

- Automated Attendance Control

The attendance control module uses computer vision and face recognition technology to identify students present in the classroom. During lecture hours, the camera continuously captures images or video frames of the classroom environment. These frames are processed using the OpenCV library, where face detection is first carried out using algorithms such as Haar [9] Cascade classifiers to locate human faces in the image.

After detection, the system performs face recognition by comparing the detected faces with a pre-trained dataset of student images stored locally on the Raspberry Pi. Each student is enrolled in advance by capturing multiple facial images under different lighting conditions and angles to improve recognition accuracy.

- Smart Classroom Automation

In addition to attendance management, the system implements smart classroom automation to reduce power consumption. Classroom occupancy is determined using face detection results and a PIR motion sensor, which detects human movement. The combination of vision-based and sensor-based detection [10] improves system reliability, especially in scenarios where lighting conditions are poor or the camera view is partially obstructed. Based on the occupancy status, the Raspberry Pi controls classroom electrical appliances such as lights and fans using relay modules.

- Data Storage and Management

Attendance data is stored locally on the Raspberry Pi in the form of CSV files or a lightweight database. The stored data can be accessed by authorized faculty members for viewing, reporting, or exporting to other systems. This digital storage method improves data accessibility,[6] reduces paperwork, and simplifies attendance analysis over time.

- System Workflow and Operation

The system operates in real time during classroom hours. The camera monitors student presence, attendance is marked automatically, and appliance

control is adjusted dynamically based on occupancy. All modules work together in a synchronized manner to ensure smooth operation. The system requires minimal human intervention once deployed.

- Scalability and Future Enhancement

The proposed system is modular and scalable. It can be extended with cloud-based storage, mobile or web applications for attendance monitoring, and advanced deep learning models for improved recognition accuracy.[7] Additional sensors such as temperature and light sensors can also be integrated for more intelligent environmental control.

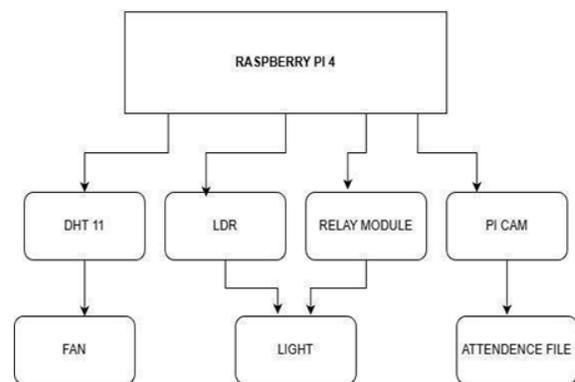


Fig 1: Block diagram

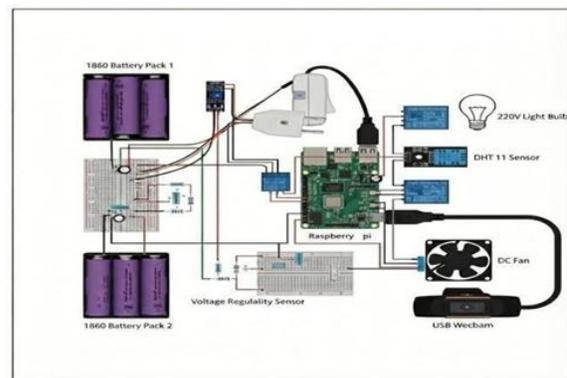


Fig 2: Circuit Diagram

VII. DRAWBACKS/LIMITATIONS

- Face recognition accuracy depends on lighting conditions. Poor illumination, shadows, or backlighting in classrooms can reduce detection and recognition performance.
- Occlusion and pose variation (masks, spectacles, head rotation, or partially covered faces) may lead to missed or incorrect attendance entries.

- Scalability issues in large classrooms. When many students are present, processing multiple faces simultaneously on Raspberry Pi may increase latency.
- Limited processing power of Raspberry Pi restricts the use of advanced deep learning models, which could otherwise improve recognition accuracy.
- Initial dataset creation is time-consuming, as multiple facial [3] images of each student must be captured under different conditions.
- Privacy and data security concerns arise due to the storage of facial data, requiring proper consent, access control, and encryption mechanisms.
- Dependence on camera positioning and quality. Improper camera angle or low-resolution cameras can affect system performance.
- False triggers in automation may occur if motion is detected temporarily (e.g., by non-student movement), leading to unnecessary switching of appliances.
- Maintenance requirements such as updating student datasets and recalibrating sensors are necessary for long-term accuracy.
- Limited fault tolerance. Failure of a camera, sensor, or power supply can disrupt both attendance recording and classroom automation.

VIII. RESULTS

The Smart Classroom Automation and Attendance Control System was successfully designed, implemented, and tested in a real classroom environment. The system effectively demonstrated automated attendance recording and intelligent control of classroom electrical appliances using Raspberry Pi.

Attendance System Performance

The face recognition-based attendance module was tested with enrolled students under normal classroom lighting conditions. The system was able to detect and recognize multiple faces in real time and mark attendance automatically.

However, the overall performance was satisfactory for small to medium-sized classrooms.

Classroom Automation Results

The classroom automation module successfully controlled lights and fans based on occupancy

detection. When students entered the classroom and motion or face presence was detected, the system automatically switched ON the connected appliances. This automated control [10] helped reduce unnecessary power consumption during idle periods such as breaks or after lecture hours.

Data Storage and Monitoring

Attendance data was stored locally in digital format and was easily accessible for review and export. The digital records eliminated the need for manual attendance registers and improved data management efficiency.

Overall System Evaluation

The integrated system performed both attendance monitoring and classroom automation simultaneously without interference between modules. The results confirm that the proposed system provides a low-cost, contactless, and energy-efficient solution for smart classroom management.

Standard	Name	Date	Time	Slot
1	Name	Date	Time	Slot
2	Swastik	2025-12-09	14:48:56	14:30-15:30

Fig 3: Student database

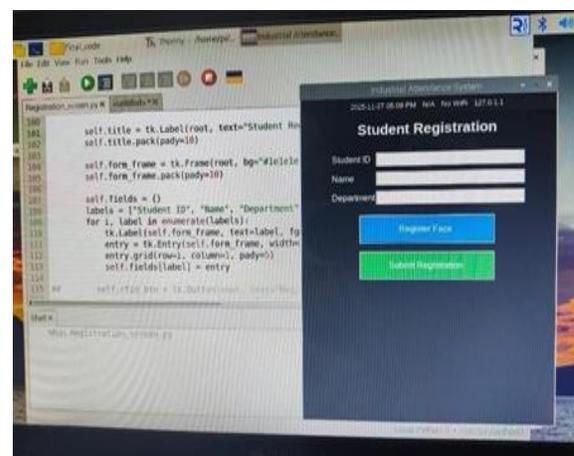


Fig 4: Student data entering



Fig 5: Project Model

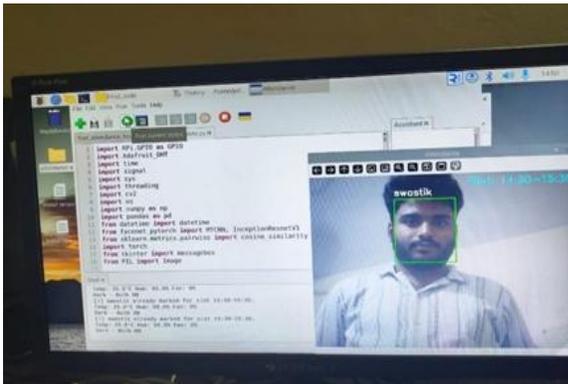


Fig 6: Student face capture

IX. CONCLUSION

The Smart Classroom Automation and Attendance Monitoring System using Raspberry Pi successfully demonstrates how IoT and Artificial Intelligence (AI) technologies can be integrated to enhance the efficiency and intelligence of modern educational environments. The project achieved its core objectives of automating classroom appliances such as lights and fans based on real-time environmental conditions and implementing a face recognition-based attendance monitoring system to replace traditional manual methods. Through the integration of DHT11 and LDR sensors, the system ensured real-time monitoring and control of temperature, humidity, and lighting conditions. The fan and light automation worked efficiently, reducing unnecessary power consumption and promoting energy-efficient classroom management. The use of facial recognition technology, powered by the Pi Camera and OpenCV, provided an accurate and contactless attendance system, minimizing human error and saving valuable instructional time.

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