PROJECT REQUIREMENTS SPECIFICATION

Smart Classroom Solutions

UE18CS390A – Project Phase – 1

Submitted by:

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January - May 2021

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1. Introduction

According to the GSM Association, the **number of IoT devices** is expected to grow to 25.1 billion by **2025**. This robust growth is expected to be driven by the increased industry focus on deploying a connected ecosystem and the standardization of 3GPP cellular IoT technologies.

loT will have a strong development in many segments, but the fastest will be in the areas of consumer, industry and public services. Of all the components of these development areas, most advanced projects are focused on human comfort in a smart home, the security and electricity savings in a smart building or street-smart lighting or smart parking in the domain of public services. All these, and more others can also be applied in a university campus.

1.1. Project Scope

Lots of people in our country are without electricity and modern lighting. This problem is more severe in rural areas or in cities. The rural electrification varies widely from country to country. Our country India frequently suffers from unreliable and intermittent electricity supply. In some places, people get electricity only few hours of the day only. Without adequate electricity, it becomes challenging for adult towards concentrating on their professional work or study. Rural communities of course need a reliable and sustainable solution for lighting towards providing a brighter future. The country has made significant progress towards the augmentation of its power infrastructure.

Moreover, poor quality of power supply and frequent power cuts and shortages impose a heavy burden on India's fast-growing trade and industry.

So current scenario insists towards highly efficient and effective usage of any form of power in educational institutions like Colleges and universities where we use power for our teaching in classroom or labs. It is common practice that most of us leave the classrooms or labs with Air conditioner, Fan and lighting on even if no students or Faculty members present. In some cases, we see only few students sitting in one corner of the classroom or lab and entire fan, light and aircon going. All these amounts to unnecessary wastage of power contributing to country energy resource.

In present academic system, regular class attendance of students' plays a significant role in performance assessment and quality monitoring. The conventional methods practised in most of the institutions are by calling names or signing on papers, which is highly time-consuming and insecure. Our project presents the automatic attendance management system for convenience as well as data reliability.

The current scope of our project is limited to implementation of our methods in our university campus. Further, we would like to expand to other educational institutions.

2. Literature Survey or Existing System

If the Internet has been one of the most important human creations, the Internet of Things (IoT) will change everything, activities and objects from simple to the most complex, and why not, even us humans. Besides areas as business, transportation, energy, medicine, agriculture and others, the Internet of Things also have a major implication in education. A university campus may represent the ideal place for the creation of a smart environment.[1]

The concept of smart environment is defined like a small world where sensor-enabled and networked devices work continuously and collaboratively to make its inhabitants' lives more comfortable.

Type of Sensors that Can Be Used in a Smart University

Sensors and technologies can be identified depending on their usefulness in a university campus; then they can be used and after that split in the following categories:

- EN (environment): noise, humidity, temperature, light.
- SC (security): motion detection, window / door open / closed, video, fingerprint.
- SF (Safety): smoke / gas, fire, water, radiation.
- UT (utilitarian): NFC tags, electrical voltage.

- IN (information): Barcode. OR tags. RFID card.

Fig 1.
Categories of sensors and technologies used in a smart university [1]

Attendance information has always been an important part of university management. However, some opportunistic students may consign others to punch their timecards, which hampers the authenticity of attendance and effectiveness of record keeping. The existing manual system is time consuming and prone to by passing. Hence, it is necessary to develop an innovative anti-cheating system for attendance.[2]

Attendance plays a pivotal role in determining academic performance of children and youth in schools and colleges. The regularity of attendance shows that the students are less likely to engage in delinquent or destructive behaviour. Chronic absence increases the risk of school failure and early dropout. Manual maintenance of attendance is inefficient due to the following reasons:

- It takes away a lot of lecture hours.
- Prone to proxies or impersonations.

For better accuracy of face-log generation, this paper has employed face tracking technique. All we did was first detect the face using Viola & Jones idea as described in [2] and then, we used the correlation tracker from the dlib library to keep track of the face from frame to frame.

Developed in 2001 by Paul Viola and Michael Jones, the Viola-Jones algorithm is an object-recognition framework that allows the detection of image features in real-time. Viola-Jones outlines a box and searches for a face within the box.

There is room for improvement since these systems sometimes fail to recognize every face student present in the classroom. It also poses a lag of a few seconds as the system needs to detect a face. The algorithm used also gives best results in the frontal view of the face and might fail in other cases.

Radio-Frequency IDentification (RFID) offers new solutions to solve such problems because of its strong anti-interference capability and non-intrusiveness. In this paper, we present a smart attendance system that extracts distinguishable phase characteristics of individuals to enable recognition of various targets. [3]

However, this too can be easily by passed as the RFID tags are easy to transport and hence reliability becomes a matter of concern.

Another concern most of colleges and universities face is the fact that they still use the traditional lighting system where we have a switch to control the lighting. Most of us i.e., students and faculty members are habituated towards leaving the classroom without switching the lights and fans, which leads to unnecessary consumption of energy for organization and paying huge amount of bill from their budget.

The system developed will control lighting in particular area of classroom based on the presence of human using relay control compared to the one placed in ceiling which would switch on or off based on presence of human in room irrespective of position.[4]

This paper uses PIR sensors and an Arduino UNO to implement as automatic system of lights and fans. However, due to the low computational power of an UNO, the cost incurred as a result of the number of microcontrollers required is high.

In addition, mobile application given to the user's towards switching appliances on or off via Bluetooth too. In future, we can also look towards not only switching the appliances on or off but also dimming the light intensity, controlling fan speed, Air conditioner based on time of the day.[4]

3. Product Perspective

We have observed that even if the classrooms have been hugely automated in most of the institutions, there are quite a few loopholes in the previously existing solutions which can be optimized to make the systems full proof. One of those problems is attendance systems. For a long time, attendance has always been taken manually. This has caused multiple discrepancies and has wasted useful class time. We have observed that even if it is automated, there are several flaws. In addition to this, classroom equipment like fans etc. have occasionally been left on thereby wasting considerable energy.

3.1. Product Features

- Automated Attendance System:

  A full proof attendance system using a fingerprint scanner attached to a mic system carried by the teacher such that there are minimum loopholes for the students to exploit.
- Electricity Optimization:

  Estimating and reducing the average energy footprint of a classroom by using motion sensors to detect if there are students in a certain section of the classroom where the fans/lights are running and using temperature, humidity sensors for optimizing the classroom temperatures thereby aiming at providing a perfect environment to study.
- Cloud-based Dashboard:

  Designing a cloud-based dashboard containing a detailed analysis based on the attendance information.

3.2. User Classes and Characteristics

- Students:

  The students take the fingerprint scanner from the teacher for every class, mark their attendance and pass it around as their attendance gets marked automatically for that particular class.
- Teachers:

  The teachers carry the fingerprint scanner attached to the mic system they usually take to class. Their attendance is marked once the mic is switched on and then they would pass the fingerprint scanner throughout the class for the students to mark their attendance.

- System Admin:

  The system admin monitors the attendance of the students and basically looks after the entire working of the attendance as well as the energy optimization system.

3.3. Operating Environment

- Hardware available in campus: Relays, Wiring, Fans, Tube lights.
- Hardware required for the project: UART Capacitive Fingerprint Sensor, Digital Temperature Controller Thermostat, Tolako 5v Relay Module, PIR Motion Detector Sensor Module HC-SR501, Microcontroller: Raspberry Pico, Transmitter and Receiver.
- Software Components: Wireless Connectivity (Wi-Fi Module), Server: Agile, Django/ IoT Platform like ThingSpeak.

3.4. General Constraints, Assumptions and Dependencies

- Availability of Raspberry Pico:
  Raspberry Pico is very new to the market and needs to be tested whether it satisfies all the requirements for the project. As per the documentation, it does seem to satisfy them. As a backup, we would still have Raspberry Pi ready, but the cost would be more if we use Raspberry Pi instead of Raspberry Pico.
- Server systems in the Institutions:
  Our project also highly depends upon how the server system exists at a particular institution. If there is no existing server, it would be very easy to implement. If there exists a server, then we have to check how exactly we will be able to implement our project on it.
- Existing Wiring in Institutions:
  It depends which wiring system exists at the institution because our project would work on almost every existing wiring system unless it's very old.

3.5. Risks

- We assume that the server at the institutions is very easily compatible to our project.
- We also assume that existing wiring and relay system in institutions is not very old such that we cannot even implement our project on those systems.

4. Functional Requirements

Attendance Management System:

The singular component of smart attendance management system involves analyzing and taking fingerprint scans of student and validating the same over a cloud database.

- Validity Tests Involved:
  - Every student of every classroom will have their individual fingerprints scanned and registered in the class's database.
  - Upon commencement of classes, a scan of every student who are present is taken and validated in the database, thereby marking them present.

- Error handling and recovery:
  - Upon encountering an error, the student may request the teacher after through identification to manually mark the said student as present.
  - The database will employ its own error identification and correction techniques.

- Sequence of Operations
  - Student scans fingerprint
  - Scanner relays finger-print identification data wirelessly to microcontroller.
  - Microcontroller checks online database and verifies attendance.
  - Database logs in time and date as well.

Classroom Energy Management:

- Validity Tests Involved:
  - The power system of the classroom's compatibility with relays must be ensured for a smooth functioning of power cutoff.
  - Bidirectional switch connections must be accounted for.
  - The temperature of the room is checked, and the speed of the fans is adjusted accordingly.
  - The temperature can be manually overridden.

- In the event of the classroom being empty, power must be cut off to all equipment.

- Error Handling and Recovery
  - In the event of an error, circuit breakers are to break the circuit to prevent equipment failure.

- Sequence of Operations
  - Temperature is kept in constant check by the microcontroller.
  - As and when the temperature rises/falls, the fan speed is modulated.
  - When the occupants of the classroom leaves, the power to the lights are cut off.

5. External Interface Requirements

5.1. User Interfaces

- Dashboard for the teachers to view attendance.
- Interface for the teachers for manually provide attendance if the sensor fails.
- Controls for the teachers to perform analysis on the intake of students on a per subject basis.
- Controls for the system admin to oversee the registration and authentication of each student.

5.2. Hardware Requirements

- UART Capacitive Fingerprint Sensor
- Absolute Native Electronics W1209 50~100 digital temperature controller thermostat
- Tolako 5v Relay Module
- PIR Motion Detector Sensor Module HC-SR501
- Microcontroller: Raspberry Pico/ Raspberry Pi
- Transmitter and Receiver for 1km range.

5.3. Software Requirements

Wireless Connectivity	1	Wi-Fi Module Specifications: • Model Number: ESP8266 • Colour: Black • Form Factor: All-in-One • Item Weight: 60.0 grams
Server	1	• ThingSpeak: Home License • Number of messages: 33 million/year per unit (~90,000/day per unit) • Message update interval limit: Every second • Number of channels: 10 per unit

5.4. Communication Interfaces

- Wi-Fi: Connectivity of each of the microcontrollers on every floor will be ensured through Wi-Fi.
- Bluetooth: Connectivity of the fingerprint scammer to the microcontroller will be ensured through Bluetooth.

6. Non-Functional Requirements

6.1. Performance Requirement:

Our product is designed to be extremely versatile, and it doesn't have any specific conditions to work under and no external factors are going to affect the performance of the product. The fingerprint scanner is also extremely reliable as it will still be able to take a reading regardless of external factors. As for the smart classroom system, the sensors are easily available and are very effective for the use that we are putting them to and are not that easily affected by external factors.

6.2. Safety Requirements:

Our project uses a 5V relay which allows a relatively low voltage to easily control higher power circuits. A relay accomplishes this by using the 5V outputted from a microprocessor pin to energize the electromagnet which in turn closes an internal, physical switch to turn on or off a higher power circuit.

6.3. Security Requirements:

Security is not an issue with our product as the device will always be in the possession of the teacher and all the microcontrollers for the electricity saving model will be in the possession of the floor admin.

The data collected will be stored safely on a server which is only accessible by the system admin.

Appendix A: Definitions, Acronyms and Abbreviations

- ThingSpeak: Open-source IoT application and API to store and retrieve data from things using the HTTP and MQTT protocol over the Internet or via LAN.
- Capacitive Fingerprint Scanner: uses capacitance to gauge the depth of the finder and collect the fingerprint.
- Relay: A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals.
- Thermostat: A thermostat is a regulating device component which senses the temperature of a physical system and performs actions so that the system's temperature is maintained near a desired setpoint.
- Microcontroller: A microcontroller is a small computer on a single metal-oxide-semiconductor integrated circuit chip.

Appendix B: References

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