Assiut University

Faculty of Computers & Information

Smart Classroom

PROJECT REPORT

GRADUATION PROJECT
ACADEMIC YEAR 2022-2023

Smart Classroom

Project Report

Project Team

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Table of Contents

Project Proposal

1 Project Abstract

Universities use a dramatically large amount of energy, and quite a lot of this is unnecessarily wasted. This means that education facilities are spending a lot of their allocated budget on energy, despite potentially not using all that they are paying for, and as budgets are becoming more and more limited, saving energy through minimizing running costs and power wastage in universities, is a method that can come in very useful.

Electricity saving can be achieved through the efficient use of energy, such as turning off lights, fans, air conditioning, and other electrical appliance when not in use. This project aims to prevent wasting Electricity in the classroom by implementing a tiny machine learning system that will detect and count the number of students entering and exiting the classroom using a sensor system and cameras, and Based on this information, the system will decide whether to turn on the electrical devices or not

The system will reduce the consumed energy, cost, and human resources by automating the process of lighting and ventilation.

2 Project Objectives

Reduce the energy consumed in classrooms by automating the process of lighting and ventilation. This system will save up to 20% more power. It will also reduce the cost and human resources wasted. Since universities use a dramatically large amount of energy, this system will improve the current systems and save more resources. The system will be running by July 2023. To achieve such goals, we propose the following objectives:

1. *Design data collection models for the sensor resources.*
2. *Design machine learning models to detect humans and their position.*
3. *Develop smart systems for classroom power control.*

3 Approaches and Methodology

- *Use sensors to detect any motion in the classroom.*
- *Gathering data with cameras*
- *Use a microcontroller/microprocessor to control the electrical devices.*
- *Pre-processing the collected data to remove any noise.*
- *Applying machine learning algorithms to detect humans and their position.*
- *Adjust the power consumption based on the position of the humans.*

4 Project Plan and Management

First Semester

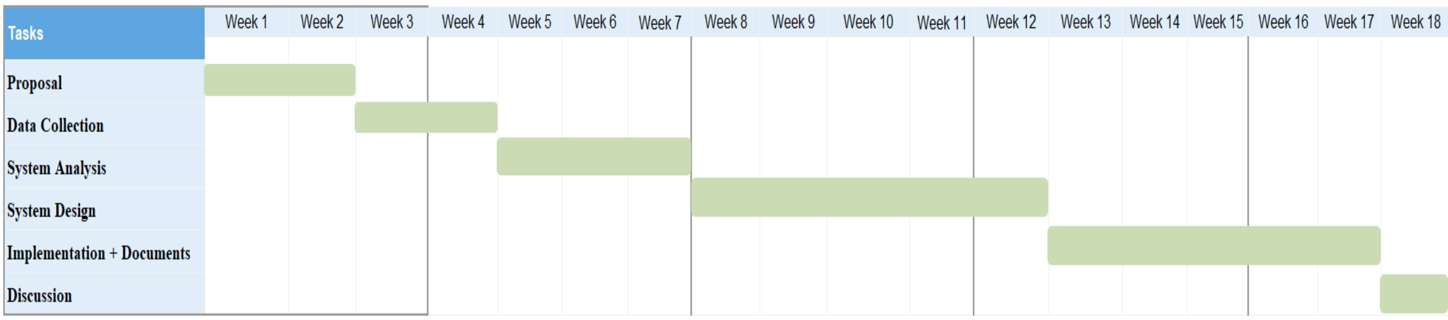

Figure 1. First semester timeline.

First semester tasks

Task	***Team Members***
Project Proposal	***All team members***
Data Collection	***Nourhan Mahmoud, Manar Mohamed***
System Analysis	***Mostafa Usama, Mohamed Nabil***
System Design	***Sondos Osama, Manar Mohamed, Nourhan Mahmoud***
Implementation + Documents	***Mostafa Usama, Mohamed Nabil, Mohamed Ramadan***
Discussion	***All team members***

Second Semester

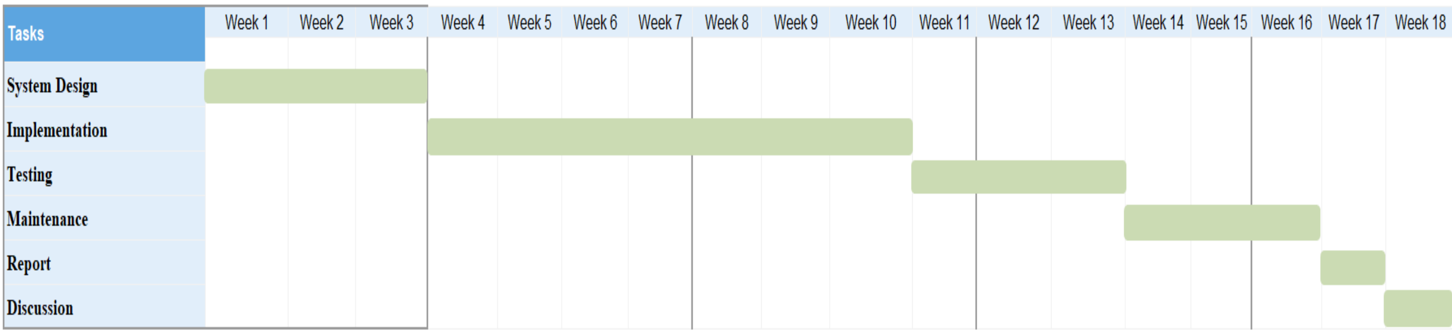

Figure 2. Second semester timeline.

Second semester tasks

Task	*Team Members*
System Design	*Sondos Osama, Manar Mohamed, Nourhan Mahmoud*
Implementation	*Mostafa Usama, Mohamed Nabil, Mohamed Ramadan*
Testing	*Nourhan Mahmoud, Sondos Osama*
Maintenance	*All team members*
Report	*All team members*
Discussion	*All team members*

System Analysis

1 Introduction

The following sections provides an overview the software requirements specifications for the smart classroom.

Purpose

The purpose of this SRS is to determine both functional and non-functional requirements of the system in the classroom which will control the lighting and ventilation .Also the document provides an overall description with UML analysis models.

Document Conventions

The document is prepared using Microsoft Word 2013 and has used the font type 'Times New Roman'.
The fixed font size that has been used to type this document is 14pt with 1.5 line spacing. It has used the bold property to set the headings of the document.

Intended Audience and Reading Suggestions

Intended reader groups for this software requirement specification are the Faculty Administration, the lecturer, the project team, and the supervisor

Through this document, the workload needed for development, validation and verification will ease. To be specific, this document is going to describe functionality, external interfaces, performance, attributes and the design constraints of the system which is going to be developed.

Product Scope

This project aims to prevent wasting electricity in the classroom by implementing a tiny machine learning system that will detect and count the number of students entering and exiting the classroom. Also the system will reduce the consumed energy, cost, and human resources by automating the process of lighting and ventilation.

2 Overall Description

Product Perspective

The smart classroom system is a new self-contained product which will be produced by the project team in order to overcome the problem of wasting energy, this classroom system manages the electrical devices in the classroom by collecting data from sensors and cameras, then processing this data, taking action, and finally sending orders to the lighting system, air conditioning, and more, the final outcome of this project will increase the efficiency of the current systems and will reduce energy wasted.

Figure 3. Major system components.

Product Functions

The system will help make the classroom more energy efficient with some functions such as:

1. Calculate the total number of people in the classroom.
2. Count the number of people in a specific section of the classroom
3. Control the lighting in a specific space based on the number of people in that space and turn it off when not in use.
4. Control air conditioners in a specific place based on the temperature and the number of people present in that place, and shut them down when not in use.

Operating Environment

Hardware:

1. Heat sensors
2. Camera
3. Raspberry Pi microprocessor

Software:

1. Microsoft SQL Server Management Studio Express 2010.
2. Raspbian Operating system.

Design and Implementation Constraints

1. All electrical connections must be in place and all appliances working efficiently.
2. The system will be suitable for regular classrooms and not for huge halls or open spaces

User Documentation

There will be a simple user manual written in an understandable way to operate the system, and there will be a hard copy that will be delivered with the system.

Assumptions and Dependencies

Assuming that there is a machine vision model for counting people in the classroom, this algorithm can be used in the system after modification, or this model will be generated from scratch.

3 External Interface Requirements

Hardware Interfaces

- *A camera will be used to take photos of the students in the classroom to determine their position, the camera should be placed in an appropriate location to take pictures of the classroom with a good angle.*
- *Various sensors will also be used to determine the temperature of the classroom, these sensors will be placed all around the classroom to accurately calculate the temperature.*
- *The GPIO pins in the raspberry PI will be used to connect the electrical devices with the microprocessor and control them based on collected information from the camera and the sensors.*

Software Interfaces

The Python programming language version 3.10 will be used to develop the software, Google Colab platform will be used for developing the system, OpenCV or Tensorflow libraries will be used for detecting students in the classroom, Proteus software will be used to simulate how the system will work.

4 System Features

Feature 1: Control Lighting

- ***Description and Priority:***
  Control the lighting in the classroom (High Priority).

- ***Stimulus***
  A student sits on a place with no lights on.

- ***Response Sequence***
  The lights are turned on this position.

Feature 2: Control Ventilation

- ***Description and Priority***
  Control the ventilation in the classroom (High Priority).

- ***Stimulus***
  The temperature in the classroom is high.

- ***Response Sequence***
  The fans/air conditioning are turned on.

Feature 3: Counting Students

- ***Description and Priority***
  Counting the number of students (High Priority).

- ***Stimulus***
  A student enters or leaves the classroom.

- ***Response Sequence***
  The number of the students will change.

5 Other Non-functional Requirements

Performance Requirements

- *The accuracy of the detection model should not be less than 95%.*
- *The response of the system should not exceed 3 seconds,*
- *The system would not slow down under high workloads.*

Safety Requirements

- *In case of failure, the system will switch to safe mood and the user will be able to control the electrical devices manually*

Security Requirements

- *Only developers can make modifications to the RPI*

Software Quality Attributes

- ***Availability**: the system will be working during all working hours of the university.*
- ***Maintainability**: maintain sessions would not take more than 2 hours*
- ***Environmental**: RPI will be protected by a cooling system to prevent any damage caused by the weather.*

6 Other Requirements

Appendix A: Glossary

RPI	*raspberry PI*
ML	*Machine Learning*
GPIO	*General purpose input output*
UML	*Unified Modeling Language*

Appendix B: Analysis Models

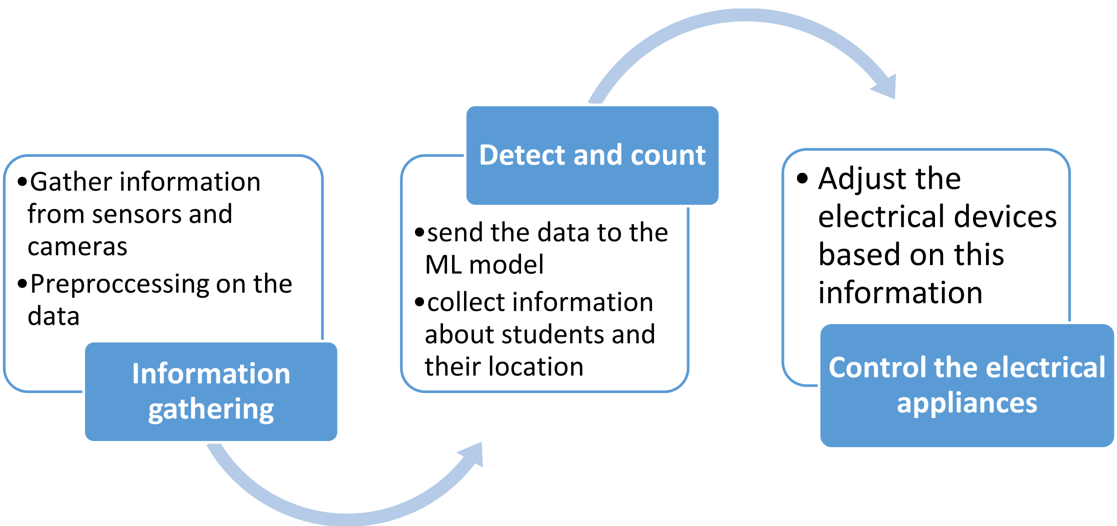

Figure 4.

Software Design

1 INTRODUCTION

Purpose

This software design document describes the architecture and system design of the smart classroom. It also contains the high level requirements for the project. The technical specifications for this project have been drafted following several meetings between the development team and the supervisor of the project. This project will implement a smart classroom system to control electrical devices.

Scope

This project aims to prevent wasting electricity in the classroom by implementing a tiny machine learning system that will detect and count the number of students entering and exiting the classroom. Also, the system will reduce the consumed energy, cost, and human resources by automating the process of lighting and ventilation.

Overview

Universities use a dramatically large amount of energy, and quite a lot of this is unnecessarily wasted. This means that education facilities are spending a lot of their allocated budget on energy, despite potentially not using all that they are paying for, and as budgets are becoming more and more limited, saving energy through minimizing running costs and power wastage in universities, is a method that can come in very useful. Electricity saving can be achieved through the efficient use of energy, such as turning off lights, fans, air conditioning, and other electrical appliance when not in use. This project aims to prevent wasting Electricity in the classroom. The system will reduce the consumed energy, cost, and human resources by automating the process of lighting and ventilation.

2 SYSTEM OVERVIEW

The system will control the electrical devices by dividing the classroom into a group of sections, then count the number of students on each section using a detection algorithm called DSFD, and with this information, the system will decide whether to turn on the electrical devices or not.

- **Algorithm Description**

DSFD architecture is a Face Detection Algorithm mainly based on the SSD (Single Shoot Multi Box Detector) key different feature maps at various depth that are transformed in six "enhanced" feature maps by a module called (Feature Enhance Module).
The algorithm has three stages:

-Feature Extraction: Which contains a stack of convolutional networks that generate feature maps and encode the useful information about the image.

-Detection Head: It is also a stack of convolutional networks to generates box predictions and class confidence.

-Non-Maximal Suppression (NMS): Used to remove the repeated detections in order to get better performance.

- **Pseudocode**

1. Initialize the camera, sensors and Raspberry PI.
2. Take a frame (image) from main camera.
3. Check the temperature from the heat sensor
4. Send input images to DSFD detection () to construct the number of student faces in classroom.
5. Count Function () takes the constructed images and count the number of student faces in each section.
6. Control Electrical device function () lights a specific section based on the number of students in that section or turn it off when not in use.
7. Return full control of electrical devices.

3 SYSTEM ARCHITECTURE

Architectural Design

- The camera will take pictures of the classroom and the sensors will measure the temperature and send this information through the GPIO pins to the Raspberry PI.

- The Raspberry PI will receive this information and count students number in each section and then sends a signal to the electrical devices in the classroom through the GPIO pins.
- the electrical devices will be turned off or on based on the sent signal.

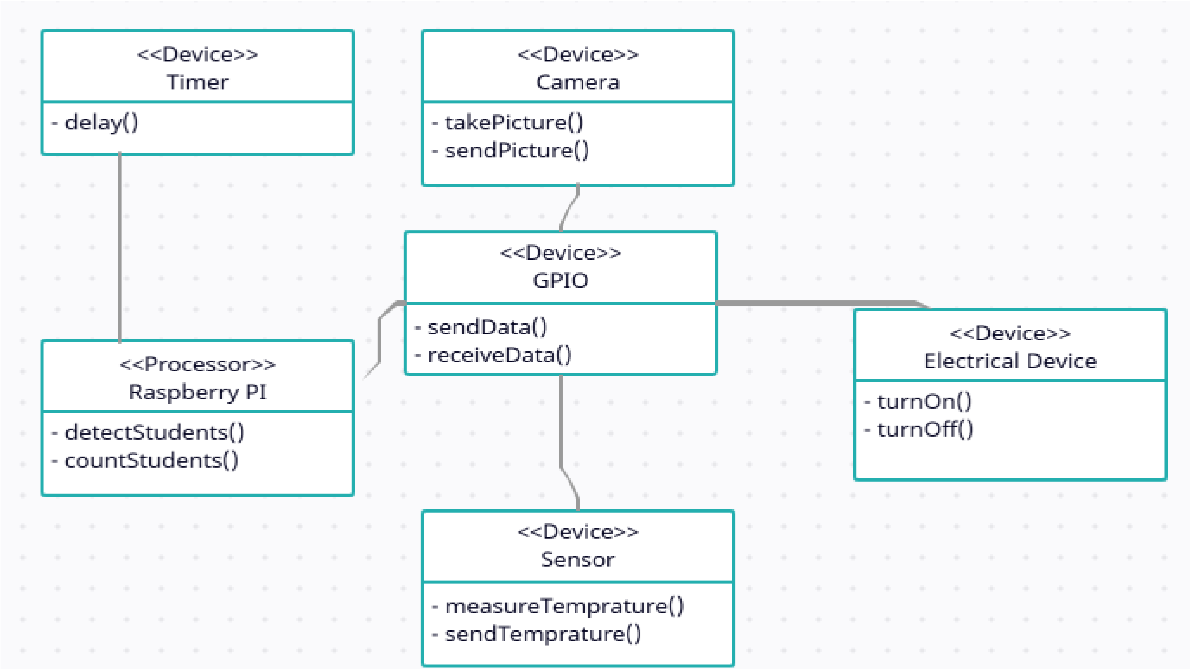

Figure 5. Deployment diagram.

Decomposition Description

System functions:

- Capture pictures.
- Read temperature.
- Calculate student count.
- Calculate student location.
- Determine in which section is the student.
- Check count, location and temperature
- Turn on/off Electrical devices

Structural decomposition diagram:

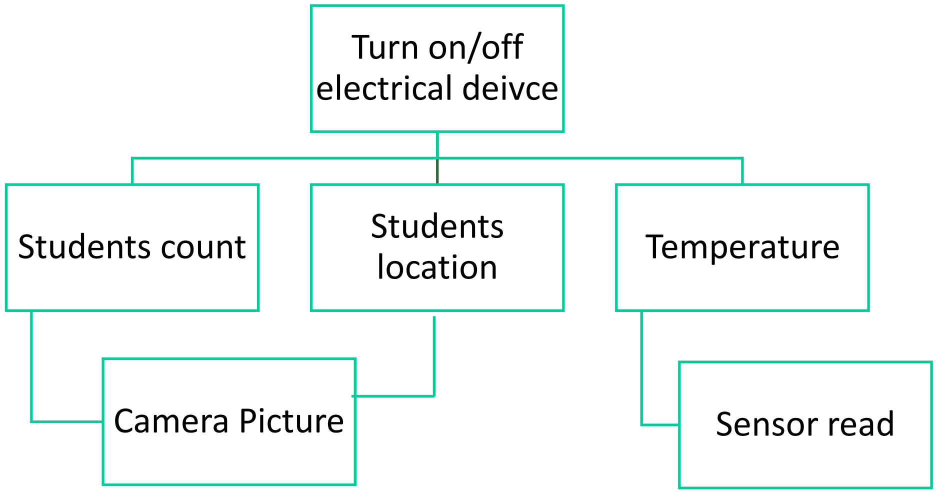

Figure 6. This diagram shows the functionality of the system as a whole and the steps needed to reach this functionality.

Dataflow Diagram:

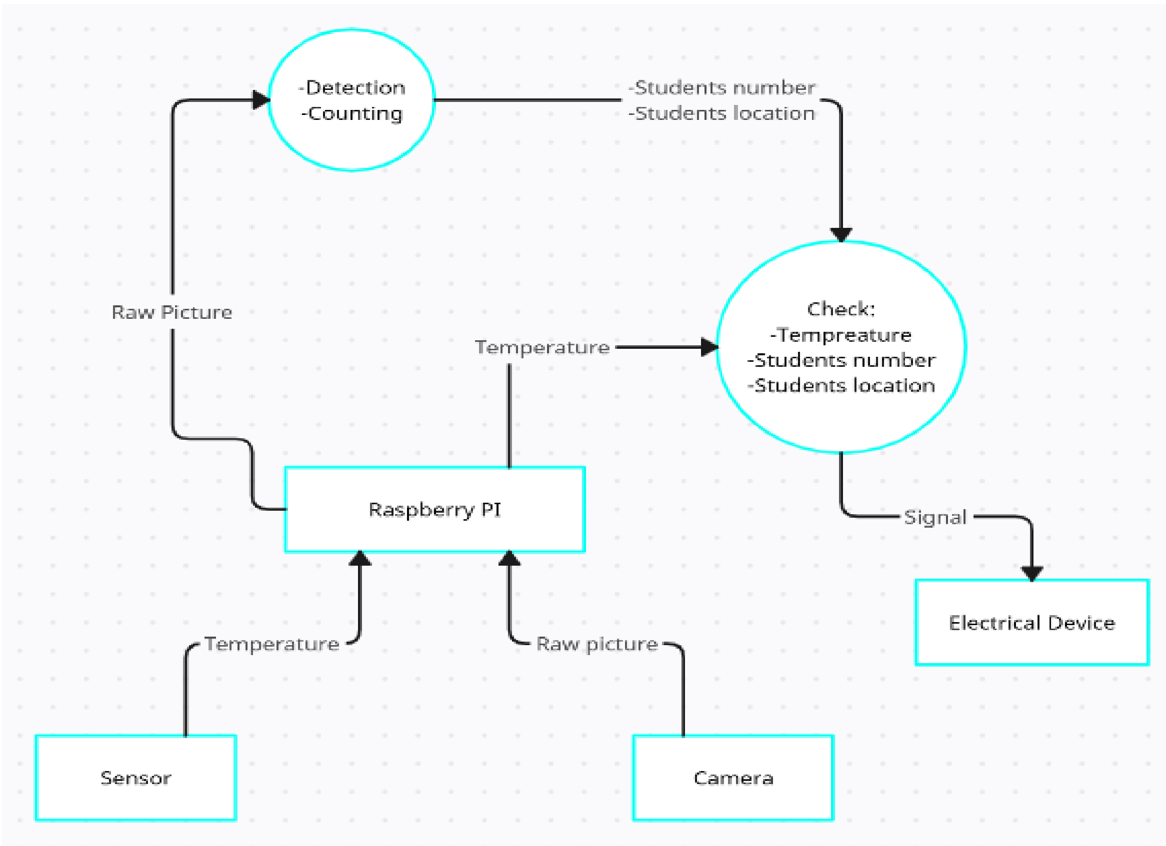

Figure. 7 This diagram shows the workflow of the system and how all the individual components communicate with each other to achieve the whole systems' functionality.

Design Rationale

This architecture has several valuable applications. You can use it to show which software elements are deployed by which hardware elements, illustrate the runtime processing for hardware and provide a view of the hardware system's topology. Which fits our overall system that contains both hardware and software.

4- DATA DESIGN

Data Description

The camera sends picture data and the sensors send temperature data to the Raspberry PI and then it stores this information for processing. The Raspberry PI checks the temperature and apply the DSFD detection algorithm to detect the students and count them, and finally, the Raspberry PI sends a voltage signal to the electrical devices.

Data Dictionary

Data	Type	Description
Classroom picture	Image	A picture captured by the camera
Temperature	Electrical signal and later converted to digital signal	The current temperature of the classroom read by the sensors
Raspberry PI signal	Electrical signal	A signal that decides if the electrical device is turned on or off

Function	Parameter	Data returned
Capture picture	None	Classroom picture (Image)
Sensor read	None	Temperature (Electrical signal)
Calculate students count	Classroom picture	Number of students in each section (List of integers)
Calculate students location	Classroom picture	Location of students (Coordinates)
Determine the section	Location of students	The section (Section index)
Check data	Students count, and temperature	Flag (Bool)
Turn on/off electrical device	Electrical signal from the Raspberry PI	None

5 COMPONENT DESIGN

- **Sensors:** Measures the temperature of its environment and converts the input data into electronic data to record then send this data to Raspberry PI

- **Cameras:** Iteratively collect images and send these images to Raspberry PI

- **Raspberry PI:** The photos taken from the cameras and temperature read from sensors are analyzed and passed through the system to count the number of students, find out their locations, perform some operations, then decide whether to turn on the devices or not and send the command taken to the electrical devices.

- **Electrical Devices:** Through commands sent to the devices, the devices are turned on or off

6 REQUIREMENTS MATRIX

Req. Number	Req. Name	Req. Description	Req. Place	Design
1	*Count people*	*Count total number of people in specific area in the classroom.*	*2.2 Product Functions*	*Not Started*
2	*Control the lighting in a specific area.*	*Turn on the light based on the number of people in that area, and turn off when it's not in use.*	*2.2 Product Functions*	*Not Started*
3	*Control fans and air conditioners in a specific area.*	*Turn on air conditioners based on the temperature and number of people in that area, and turn off when they are not in use.*	*2.2 Product Functions*	*Not Started*

Implementation

1 INTRODUCTION

This project aims to reduce energy wastage in universities, specifically in classrooms, by automating the lighting and ventilation processes. The smart classroom system, which is self-contained and equipped with sensors and cameras, collects data about the classroom environment to determine the optimal settings for the lighting and ventilation systems. The system then automatically adjusts these settings to conserve energy, lower costs, and improve the classroom's comfort. Its most beneficial feature is its ability to save energy by adjusting the lighting and ventilation settings according to the number of people present in the classroom. This ensures that energy is not wasted when the classroom is vacant or has fewer occupants than usual. For instance, if the classroom is empty, the system will turn off the lights and ventilation, thereby conserving energy and reducing expenses. If there are a few people in the classroom, the system will adjust the settings to create a comfortable environment. Additionally, if the classroom is full, the system will increase the lighting and ventilation settings to ensure that everyone is comfortable.

Purpose

The purpose of this implementation plan is to outline the steps that will be taken to implement the Smart Classroom System. The system will use a combination of hardware and software to reduce energy consumption in classrooms.

The implementation plan will outline the following steps:

- *Hardware and software development.*
- *Testing and deployment.*
- *Scalability testing and deployment.*

The Smart Classroom System is an innovative solution that can aid universities in reducing energy consumption and cutting costs. The system's automated features, including light and air conditioning control based on the number of occupants and room temperature, will help optimize energy usage. Additionally, the system has the ability to count the number of people in a specific section of the classroom, which can be used to regulate lighting in that area.

System Overview

The smart classroom system is a new product that manages electrical devices in the classroom by collecting and processing data from sensors and cameras to control the lighting, air conditioning, and more. The system aims to increase efficiency and reduce energy waste.

As previously mentioned, this system works to reduce energy consumption through various processes. This will be achieved through some of its features, such as automatic operation. The system will automatically turn on and off at the scheduled start and end times of lectures each week, without requiring human intervention.

Organization of the system which is as follows.

• A camera will be used to take photos of the students in the classroom to determine their position, the camera should be placed in an appropriate location to take pictures of the classroom with a good angle.

• Various sensors will also be used to determine the temperature of the classroom, these sensors will be placed all around the classroom to accurately calculate the temperature.

• The GPIO pins in the RPI will be used to connect the electrical devices with the microprocessor and control them based on collected information from the camera and the sensors.

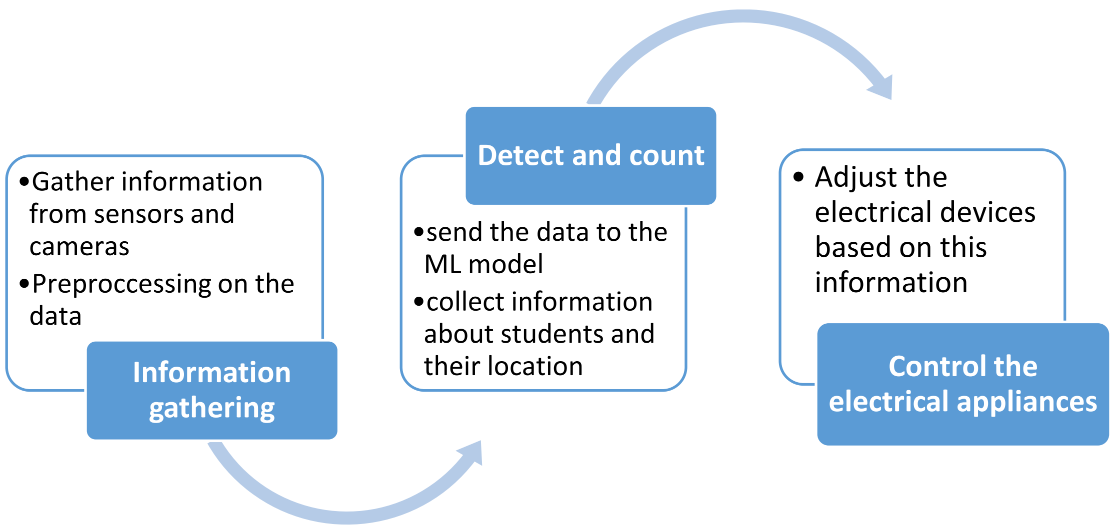

Figure. 8 This diagram shows the workflow of the system and how all the individual components communicate with each other to achieve the whole systems' functionality.

System Description

1. Study schedule based on it, the system will operate automatically at the start of each lecture and stop at its end, achieving the desired goal of the system, which is to conserve energy.

2. Count the number of people in a specific section of the classroom.

3. Control the lighting in a specific space based on the number of people in that space and turn it off when not in use.

4. Control air conditioners in a specific place based on the temperature and the number of people present in that place and shut them down when not in use.

System Organization

The system contains many components, whether hardware or software, and each component plays an active role in the system's operation with high accuracy. These components include measuring temperature and humidity, capturing images to determine the number of students, and components that include information about the study schedule to operate the system automatically.

Hardware:

1. Heat sensors

2. Camera

3. RPI microprocessor

Software:

1. *SQLite Database Browser*
2. *Raspbian Operating system*

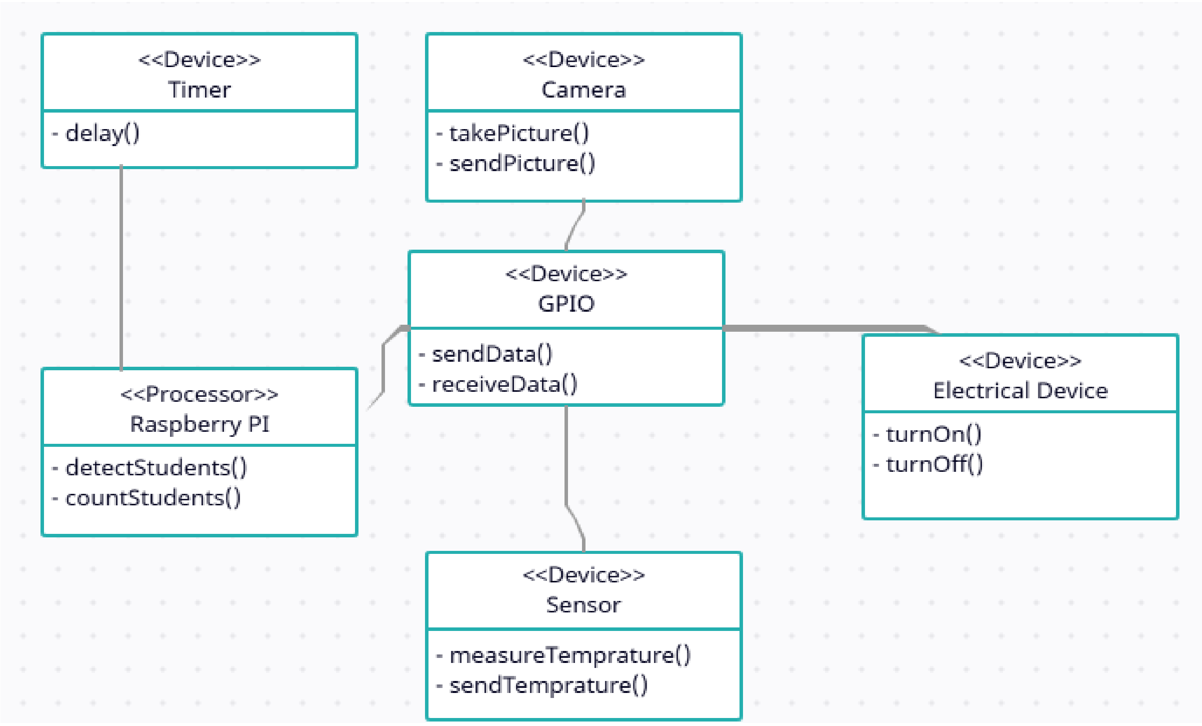

Figure. 9 Deployment Diagram.

Project References

This section provides a bibliography of key project references and deliverables that have been produced before this point in the project development.

Glossary

RPI	*raspberry PI*
ML	*Machine Learning*
GPIO	*General purpose input output*

2 MANAGEMENT OVERVIEW

The major tasks involved in the implementation of the Smart Classroom System are:

• Hardware and software development: This involves designing and building the hardware components of the system, as well as developing the software that will control the system.

• Testing and deployment: Once the hardware and software have been developed, they need to be tested to ensure that they are working properly. The system will then be deployed in a classroom setting to test its effectiveness in reducing energy consumption.

• Scalability testing and deployment: Once the system has been tested in a single classroom, it needs to be tested to ensure that it can be scaled up to work in multiple classrooms. The system will then be deployed in multiple classrooms to test its effectiveness in reducing energy consumption across an entire university.

Description of Implementation

The Smart Classroom System will be implemented in the following phases:

1. Hardware and software development: The first phase will involve the development of the hardware and software components of the system. This will include the design and construction of the camera, sensors, and Raspberry Pi microprocessor. The software for the system will be developed using Microsoft SQL Server Management Studio Express 2010 and Raspbian Operating system.

2. Testing and deployment: The second phase will involve testing the system and deploying it in a pilot classroom. This will allow the system to be tested in a real-world environment and any bugs or issues to be identified and addressed.

3. Scalability testing and deployment: The third phase will involve testing the system for scalability and deploying it in multiple classrooms. This will allow the system to be tested in a larger environment and ensure that it can be scaled to meet the needs of the university.

The system will be deployed in a phased approach, starting with a few classrooms and then expanding to more classrooms as the system is proven to be effective. The system will be monitored and evaluated on an ongoing basis to ensure that it is meeting the project goals.

The following are some of the key considerations for the implementation of the Smart Classroom System:

• The system will need to be installed in a central location in the classroom, such as on the ceiling or wall.

• The camera will need to be positioned in a way that it can capture a clear view of the entire classroom.

• The sensors will need to be placed in strategic locations around the classroom to accurately measure the temperature.

• The Raspberry Pi microprocessor will need to be connected to the electrical devices in the classroom.

• The software for the system will need to be installed on the Raspberry Pi microprocessor.

Points of Contact

In this section, identify the System Proponent, the name of the responsible organization(s), and titles and telephone numbers of the staff who serve as points of contact for the system implementation. These points of contact could include the Project Manager. Program Manager, Security Manager. Database Administrator, Configuration Management Manager, or other managers with responsibilities relating to the system implementation. The site implementation representative for each field installation or implementation site should also he included, if appropriate. List all managers and staff with whom the implementation must be coordinated.

Major Tasks

Task	What the task will accomplish	Resources required	Key person(s)
Providing overall planning and coordination for the implementation	Ensure that all aspects of the implementation are well-planned and coordinated	Project manager, system engineer, electrical engineer	All tasks are completed on time and within budget.
Providing appropriate training for personnel	Ensure that all personnel who will be using the system are properly trained	Training manager, system engineer	All personnel are able to use the system effectively.
Ensuring that all manuals applicable to the implementation effort are available when needed	Ensure that all manuals and documentation are available to personnel who need them	Documentation manager, system engineer	All manuals and documentation are available when needed.
Providing all needed technical assistance	Ensure that all personnel who need technical assistance can get it	Technical support engineer, system engineer	All personnel who need technical assistance can get it in a timely manner.
Scheduling any special computer processing required for the	Ensure that all special computer processing is scheduled and	System engineer, IT manager	All special computer processing is completed on time and within budget.

implementation	*completed on time*		
Performing site surveys before implementation	*Ensure that the site is ready for implementation*	*Project manager, electrical engineer*	*The site is ready for implementation and all necessary changes have been made.*
Ensuring that all prerequisites have been fulfilled before the implementation date	*Ensure that all prerequisites for implementation have been met*	*Project manager, system engineer*	*All prerequisites have been met and the implementation can proceed on schedule.*
Providing personnel for the implementation team	*Ensure that there are enough personnel available to complete the implementation on time*	*Project manager, system engineer*	*There are enough personnel available to complete the implementation on time.*
Acquiring special hardware or software	*Ensure that all necessary hardware and software is acquired and installed*	*Project manager, system engineer*	*All necessary hardware and software is acquired and installed.*
Performing data conversion before loading data into the system	*Ensure that all data is converted into a format that can be used by the system*	*Data conversion specialist, system engineer*	*All data is converted into a format that can be used by the system*
Preparing site facilities for implementation	*Ensure that the site is ready for the installation of the system*	*Project manager, electrical engineer*	*The site is ready for the installation of the system and all necessary changes have been made.*

Implementation Schedule

Task	*Beginning Date*	*End Date*
Providing overall planning and coordination for the implementation	*2023-02-01*	*2023-02-15*
Providing appropriate training for personnel	*2023-02-16*	*2023-03-01*
Ensuring that all manuals applicable to the implementation effort are available when needed	*2023-03-02*	*2023-03-15*
Providing all needed technical assistance	*2023-03-16*	*2023-04-01*
Scheduling any special computer processing required for the implementation	*2023-04-02*	*2023-04-15*
Performing site surveys before implementation	*2023-04-16*	*2023-05-01*

Ensuring that all prerequisites have been fulfilled before the implementation date	*2023-05-02*	*2023-05-15*
Providing personnel for the implementation team	*2023-05-16*	*2023-06-01*
Acquiring special hardware or software	*2023-06-02*	*2023-06-15*
Performing data conversion before loading data into the system	*2023-06-16*	*2023-06-23*
Preparing site facilities for implementation	*242023-06-24*	*2023-07-02*

3 IMPLEMENTATION SUPPORT

The Smart Classroom System requires a variety of software, materials, equipment, facilities, and personnel to be implemented. The specific requirements may vary depending on the specific needs of the university.

- *Software: SQLite Database Browser and Raspbian Operating system*
- *Hardware: Heat sensors, Camera, RPI microprocessor, Laptop and Screwdriver*
- *Materials: Wiring, Cables and Power supply*
- *Facilities: Classroom and Electrical outlets*

Hardware, Software, Facilities, and Materials

- *Software: The system will require the following software:*

  1. *SQLite Database Browser*
  2. *Raspbian Operating system*

- *Hardware: The system will require the following hardware:*

  1. *Heat sensors*
  2. *Camera*
  3. *RPI microprocessor*

4. Laptop

5. Screwdriver

- *Materials: The system will require the following materials:*

1. Wiring

2. Cables

3. Power supply

- *Facilities: The system will require the following facilities:*

1. Classroom

2. Electrical outlets

Hardware

- *Heat sensors: These sensors are used to measure the temperature of the classroom.*
- *Camera: This is used to count the number of people in the classroom.*
- *RPI microprocessor: This is the brains of the system. It collects data from the sensors, processes it, and sends commands to the electrical devices.*
- *Laptop: This is used to configure and manage the system.*
- *Screwdriver: This is used to install the hardware components of the system.*
- *Wiring and Cables: This is used to connect the hardware components of the system.*
- *Power supply: This is used to power the system.*
- *Classroom: This is where the system will be installed and used.*
- *Electrical outlets: This is where the system will be plugged in.*

Software

• SQLite Database Browser: This software is used to view and manage the database that stores the data collected by the system.

• Raspbian Operating system: This is the operating system that runs on the RPI microprocessor.

Facilities

• Classroom for assembling and testing hardware components: This Classroom should be large enough to accommodate the assembly and testing of the hardware components of the system. It should also be well-lit and have access to power, this will be done for

4 hours per day, 5 days per week, for 2 weeks.

• Desk space for software installers: This desk space should be in a central location and should be large enough to accommodate the installation of the software components of the system. It should also have access to a computer with internet access, this will be done for 2 hours per day, 5 days per week, for 2 weeks.

• Classroom space for training the implementation staff: This classroom space should be large enough to accommodate the training of the implementation staff. It should also have access to a projector and a whiteboard, this will be done for 8 hours per day, 5 days per week, for 1 week.

Material

• Magnetic tapes: These tapes are used to store the data collected by the system. They are a reliable and cost-effective way to store large amounts of data.

• Disk packs: These disks are also used to store the data collected by the system. They are more expensive than magnetic tapes, but they offer faster access to data.

• Other materials: The system may also require other materials, such as cables, connectors, and mounting hardware. The specific materials required will vary depending on the specific configuration of the system.

Personnel

This section describes personnel requirements and any known or proposed staffing requirements, if appropriate. Also describe the training, if any, to be provided for the implementation staff.

Personnel Requirements and Staffing

In this section, describe the number of personnel, length of time needed, types of skills, and skill levels for the staff required during the implementation period. If particular staff members have been selected or proposed for the implementation, identify them and their roles in the implementation.

Training of Implementation Staff

This section addresses the training, if any, necessary to prepare staff for implementing and maintaining the system; it does not address user training, which is the subject of the Training Plan. Describe the type and amount of training required for each of the following areas, if appropriate, for the system:

- *System hardware/software installation*
- *System support*
- *System maintenance and modification*

Present a training curriculum listing the courses that will be provided, a course sequence. and a proposed schedule. If appropriate, identify which courses particular types of staff should attend by job position description.

If training will be provided by one or more commercial vendors, identify them, the course name(s), and a brief description of the course content.

If the training will be provided by State staff, provide the course name(s) and an outline of the content of each course. Identify the resources, support materials, and proposed instructors required to teach the course(s).

Performance Monitoring

This section describes the performance monitoring tool and techniques and how it will be used to help decide if the implementation is successful.

Configuration Management Interface

This section describes the interactions required with the Configuration Management (CM) representative on CM-related issues, such as when software listings will be distributed, and how to confirm that libraries have been moved from the development to the production environment.

4 IMPLEMENTATION REQUIREMENTS BY SITE

This section describes specific implementation requirements and procedures. If these requirements and procedures differ by site, repeat these subsections for each site; if they are the same for each site, or if there is only one implementation site, use these subsections only once. The "X" in the subsection number should be replaced with a sequenced number beginning with I. Each subsection with the same value of "X" is associated with the same implementation site. If a complete set of subsections will be associated with each implementation site, then "X" is assigned a new value for each site.

Site Name or identification for Site X

This section provides the name of the specific site or sites to be discussed in the subsequent sections.

Site Requirements

This section defines the requirements that must he met for the orderly implementation of the system and describes the hardware, software, and site-specific facilities requirements for this area.

Any site requirements that do not fall into the following three categories and were not described in Section 3, Implementation Support, may be described in this section, or other subsections may be added following Facilities Requirements below:

- *Hardware Requirements - Describe the site-specific hardware requirements necessary to support the implementation (such as. LAN hardware for a client/server database designed to run on a LAN).*
- *Software Requirements - Describe any software required to implement the system (such as, software specifically designed for automating the installation process).*
- *Data Requirements - Describe specific data preparation requirements and data that must be available for the system implementation. An example would be the assignment of individual IDs associated with data preparation.*
- *Facilities Requirements - Describe the site-specific physical facilities and accommodations required during the system implementation period. Some examples of this type of information are provided in Section 3.*

Site implementation Details

This section addresses the specifics of the implementation for this site. Include a description of the implementation team, schedule, procedures, and database and data updates. This section should also provide information on the following:

- *Team--If an implementation team is required, describe its composition and the tasks to be performed at this site by each team member.*
- *Schedule--Provide a schedule of activities, including planning and preparation, to be accomplished during implementation at this site. Describe the required tasks in chronological order with the beginning and end dates of each task. If appropriate, charts and graphics may be used to present the schedule.*
- *Procedures--Provide a sequence of detailed procedures required to accomplish the specific hardware and software implementation at this site. If necessary, other documents may be referenced. If appropriate, include a step-by-step sequence of the detailed procedures. A checklist of the installation events may he provided to record the results of the process.*

If the site operations startup is an important factor in the implementation, then address startup procedures in some detail. If the system will replace an already operating system, then address the startup and cutover processes in detail. If there is *a period of parallel operations with an existing system, address the startup procedures that include technical and operations support during the parallel cycle and the consistency of data within the databases of the two systems.*

- *Database--Describe the database environment where the software system and the database(s), if any, will be installed. Include a description of the different types of database and library environments (such as, production, test, and training databases).*
- *Include the host computer database operating procedures, database file and library naming conventions, database system generation parameters, and any other information needed to effectively establish the system database environment.*
- *Include database administration procedures for testing changes, if any, to the database management system before the system implementation.*
- *Data Update--If data update procedures are described in another document, such as the operations manual or conversion plan, that document may be referenced here. The following are examples of information to be included:*
    - *Control inputs*
    - *Operating instructions*
    - *Database data sources and inputs*
    - *Output reports*
    - *Restart and recovery procedures*

Back-Off Plan

This section specifies when to make the go/no go decision and the factors to be included in making the decision. The plan then goes on to provide a detailed list of steps and actions required to restore the site to the original, pre-conversion condition.

Post-Implementation Verification

This section describes the process for reviewing the implementation and deciding if it was successful. It describes how an action item list will be created to rectify any noted discrepancies. It also references the Back-Off Plan for instructions on how to back-out the installation, if, as a result of the post-implementation verification, a no-go decision is made.

Testing

Test Plan Identifier:

Smart Classroom System_1.0

1 Introduction

1- This test plan for Smart Classroom system testing supports the following objectives:

1. To define the tools to be used throughout the testing process.

2. To communicate to the responsible parties the items to be tested, set expectations around the schedule, and define environmental needs.

3. To define how the tests will be conducted.

2 Test Items

The systems to be tested include the model used to detect people in the classroom, the interface that registers the admin, adds doctors, and schedules class times, and the Raspberry Pi to act based on the data received from the model. The systems should be tested on both Windows and Raspberry Pi OS.

3 Features to be Tested.

As an admin, log into the system as an admin.

- *As an admin, add doctors.*
- *As an admin, delete doctors.*
- *As an admin, choose the way to control the system, either manually or automatically.*
- *As a user, add their own schedule.*
- *As a user, control the system either manually or automatically.*

4 Features Not to Be Tested:

All the features are going to be tested.

5 Approach

Tests will be conducted per the documented test cases stored in Test Lodge. The test manager will create test runs for each tester. The tester will execute the tests in Test Lodge and mark each case as Pass / Fail / Skip. The tester should leave notes on actual results and any other relevant details when possible.

When tests are marked as Fail, bug reports will automatically be created in the issue tracker integrated with Test Lodge.

Once complete, the test manager should review the test run reports in Test Lodge and report back to the team accordingly.

6 Item Pass/Fail Criteria

All core functionality of the systems should function as expected and outlined in the individual test cases. There must be no critical defects found and an end user must be able to handle with the system successfully and can use the system to detect the people in the classroom. 95% of all test cases should pass and no failed cases should be crucial to the end-user's ability to use the system.

7 Suspension Criteria and Resumption Requirements

Testing should be paused immediately if either system experiences login issues or the model failure to detect the people.

8 Test Deliverables

Test Plan: Outlines testing approach, team roles, criteria for test completion, and schedule.

Test Design Specifications: Details head detection model's function to detect people and communicate with Raspberry Pi.

Test Case Specifications: Includes tests for varying numbers of people, communication between head detection model and Raspberry Pi, and device control.

Test Procedure Specifications: Outlines procedures for tests, equipment, steps, and expected results.

Test Item Transmittal Reports: Documents tested items, including head detection model, Raspberry Pi, and controlled devices.

Test Logs: Documents test details, results, issues, and date/time.

Test Incident Reports: Documents issues encountered during testing and steps taken to resolve them.

Test Summary Reports: Provides a summary of test results, issues, and overall success.

Test Input and Output Data:

Input data: The input data includes data used to train and test head detection model, such as images of classroom environments with varying numbers of people.

Output data: The output data includes the number of people detected in the class and the status of the devices controlled by the Raspberry Pi.

9 Testing Tasks

The following tasks need to be accomplished to carry out the testing activity:

Develop a test plan.

Create test cases.

Produce functional specifications.

Ensure that the testing environment is set up and ready for use.

Execute the tests.

Prepare a detailed summary report of the testing results.

10 Environmental Needs

To prepare the testing environment, it's necessary to input some test data, including user and administrator information like names and passwords. Additionally, we must ensure that all the hardware components, such as the Raspberry Pi, camera, sensors, and wires, are properly connected to the system and powered on.

11 Responsibilities

The role of the Test Manager involves facilitating the testing project, providing necessary training when required, solving any potential risks to the team, and providing for the environmental needs.

The role of the Tester is to provide the test items, execute test cases, and to be committed to the expected completion date and required level of quality.

12 Staffing and Training Needs

Testing should be done by three testers. All testers should know the working mechanism of the system and have basic knowledge of writing test cases and reporting bugs.

13 Schedule

Testing will take place 2 weeks prior to the launch date.

First week should include creating test plan, creating test cases, and setting up the testing environment.

The second week should include executing test cases, reporting bugs, and writing a report of the testing results.

14 Risks and Contingencies

If the pre-testing requirements are not completed within 1 week, it could delay bug fixes and final testing.

If the testers don’t have a basic understanding of the system, testing could be delayed or not conducted properly.

15 Approvals

Both the test manager and the team leader must agree on a testing plan and completion of the testing project and decide when it is ready to progress to the next step.

Conclusion and Future Work

As part of our future work, we plan to implement the project in the real-world context of multiple universities. Our focus will be on promoting the project and seeking investment opportunities to support its growth and sustainability. By doing so, we aim to increase its visibility and impact, and ensure its long-term success.

Appendixes

Appendix A: Glossary

RPI	*raspberry PI*
ML	*Machine Learning*
GPIO	*General purpose input output*
UML	*Unified Modeling Language*

Appendix B: Analysis Models

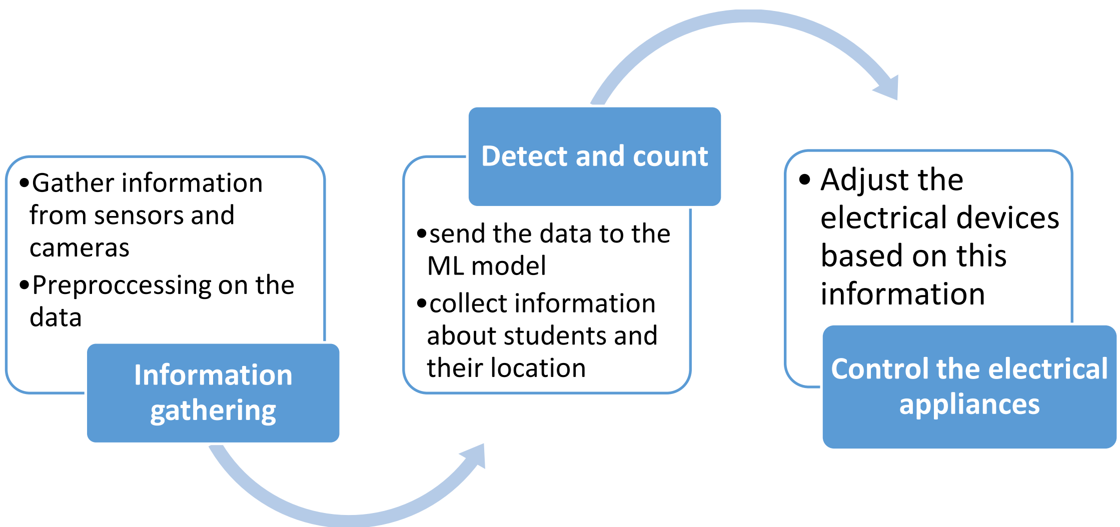

Figure 10. state-transition diagram

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