Lighting System Based on the Human Presence for Daily Applications

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Abstract**—** The scope of this project is to use embedded systems to automate light switching and light adjustment based on human presence. Therefore, this system can be implemented in any closed place to control the light status and intensity. This system will detect the human presence in a closed workplace by counting the number of humans inside the place. The counting process will be applied by using two distance sensors in each door. The triggering of the two sensors will specify if the human is going in or going out. After detecting human presence, the light intensity will be adjusted according to the light intensity in the place. Light intensity will be adjusted automatically either using a variable resistor and stepper motor or using fixed voltage lines with different values of resistance for each one, which will give different light intensities to each line. Furthermore, this system is able to be controlled manually through an Android app.

Keywords**—** *Lighting System, Human Presence, Daily Applications*

I. Introduction

Even though there are many projects that have been implemented using PIR sensors to detect the human presence, this method fails when a human is at rest, such as reading, watching TV, listening to a lecturer, and so on. Manual switching might be an uncomfortable task for some people when they come in or out, especially in active workplaces such as offices, classes, halls, etc. The main problems that this project will solve are the manual switching of the light and also adjusting the light intensity manually. Also, PIR sensors are not efficient sensors to be used to detect human presence because they do not detect humans at rest. The scope of this project is to use embedded systems to automate light switching and light adjustment based on human presence. Therefore, this system can be implemented in any closed place to control the light status and intensity. This system will detect the human presence in a closed workplace by counting the number of humans inside the place. The counting process will be applied by using two distance sensors in each door. The triggering of the two sensors will specify if the human is going in or going out. After detecting human presence, the light intensity will be adjusted according to the light intensity in the place. Light intensity will be adjusted automatically either using a variable resistor and stepper motor or using fixed voltage lines with different values of resistance for each one, which will give different light intensities to each line. Also, this system is able to be controlled manually through an Android app. This app can control the light condition using buttons or through voice commands, and it can control other stuff such as air conditioners and so on. A Galaxy Tab or any tablet will be held on the wall in the workplace as a control panel, and it will use Bluetooth connectivity to communicate with the microcontroller. In addition, there is a smoke detector that will be programmed to detect any fire smoke, and then the app will send an SMS to the place owner and Bomba. A temperature sensor is also used to measure the temperature and display it on the app. Automatic lighting in the trains will reduce costs because the lighting system will be turned off when no one is present.

II. Related Work

Lighting control systems have been the focus of extensive research in recent years. Table 1 compares these studies based on their key strategies and objectives.

Table 1. Related research on smart lighting control system development

	Main Purposes				Techniques and Method		
Research	Energy Saving	User Preference	Sensing Devices	scheduling	Dimming (Brightness level)	Mobile Application	Daylight Factor
Hajjad, Mohammed et al. [1]	1	1	1	0	1	1	0
Acosta, Ignacio et al. [2]	1	0	1	0	1	0	1
Cheng, Yusi et al. [3]	1	1	1	0	1	1	1
Sun, Baoshi et al. [4]	1	1	1	1	1	1	0
Deepaisarn, Somrudee et al. [5]	1	0	1	0	1	0	1
Islam, Saidul et al. [6,7]	1	0	1	0	1	0	0

Research on lighting control systems has mostly focused on reducing energy consumption, with significant findings [5]. According to a study of lighting control technology [3,5], campus and office settings can save 36% to 50% on electricity. The goal of this scenario was to determine the effect of using sensing devices during the day on the system. The two scenarios required examining the desk's toggling state and sensing devices to better understand how the intelligent lighting system behaves in typical settings and how it affects power consumption under different conditions. The proposed concept has the potential to save energy and improve office comfort [4].

A. Occupancy Sensors for Smart Lighting Control

Occupancy sensing has been extensively researched, and numerous sensing approaches have been suggested, including passive infrared (PIR) sensors [8,9] and microwave Doppler sensors [2]. PIR sensors have been widely used in the field of occupancy detection because they are fast and cost-effective [8]. A PIR sensor can detect radiation at a wavelength of around 10 microns, the peak wavelength of heat energy released by humans [10]. Its output is either zero or one, indicating whether the state is vacant or occupied. Although a PIR sensor has an accuracy rate of 98.4%, it frequently causes false-negative detection errors when occupants move significantly [11]. Additionally, it fails to recognize persons in hot conditions.

B. Lighting Control

A lighting system's control design might be distributed or centralized [12]. In a centralized control system, sensor inputs are routed to a central controller, where a control law determines the dimming level for the appropriate luminaire and sends it to it. In comparison, with a distributed control system, each sensing module has a controller and communicates with neighbors to determine the dimming levels [8, 12, 13]. In wireless networks, when compared to centralized-control networks, a dispersed control system uses more bandwidth and has a greater cost due to bigger amounts of processing and storage in a sensing module.
To calculate luminaire dimming levels, two control methods are used: open-loop and closed-loop. The open-loop technique analyzes incoming daylight and notifies a controller to proportionally lower the luminaire based on the daylight contribution [14]. The closed-loop approach regulates the luminaire dimming level so that the combined contribution of natural and artificial light maintains the desired lighting level. Proportional integral (PI) and proportional integral differential (PID) are two widely used closed-loop approaches [12]. In comparison to the closed-loop approach, the open-loop method's performance is impacted by the absence of feedback.

III. MYTHOLOGY

An automatic lighting system based on human presence using a low-cost and effective way by using two ultrasonic sensors fixed on the door jamb with a 10 cm distance between them, as shown in Fig. 1.

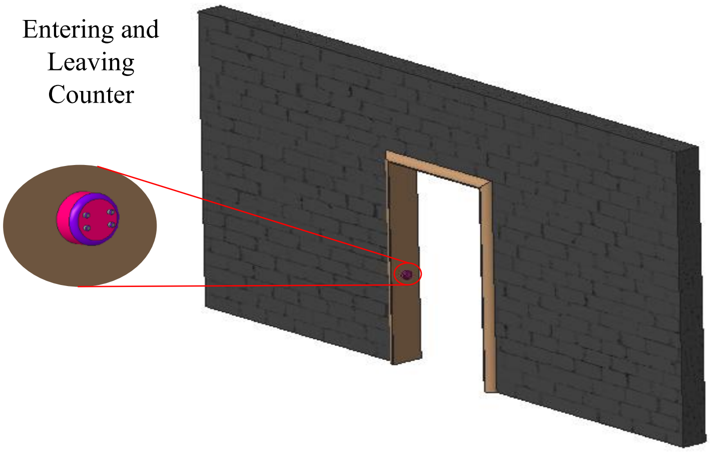

Figure 1. Concept Development of the system

These two sensors would be able to detect if the person is entering or leaving the place by utilizing the triggering sequence of the sensors. If the first sensor triggered first and then the second one triggered, that means there is someone entering the place, or if the second sensor triggered first and then the first sensor triggered, that means there is someone leaving the place. Therefore, we can count the number of humans inside the place and set a condition that will turn ON the light if the number of humans is greater than zero. Otherwise, it would be OFF. The application's main page shows a top-view diagram of the room's distribution along with details on its current functionality, including the total power consumed, the number of people in the room, and the total consumption of each LED lightbulb, as shown in Fig. 2. All of these details are simultaneously fed into a database that the user cannot access.

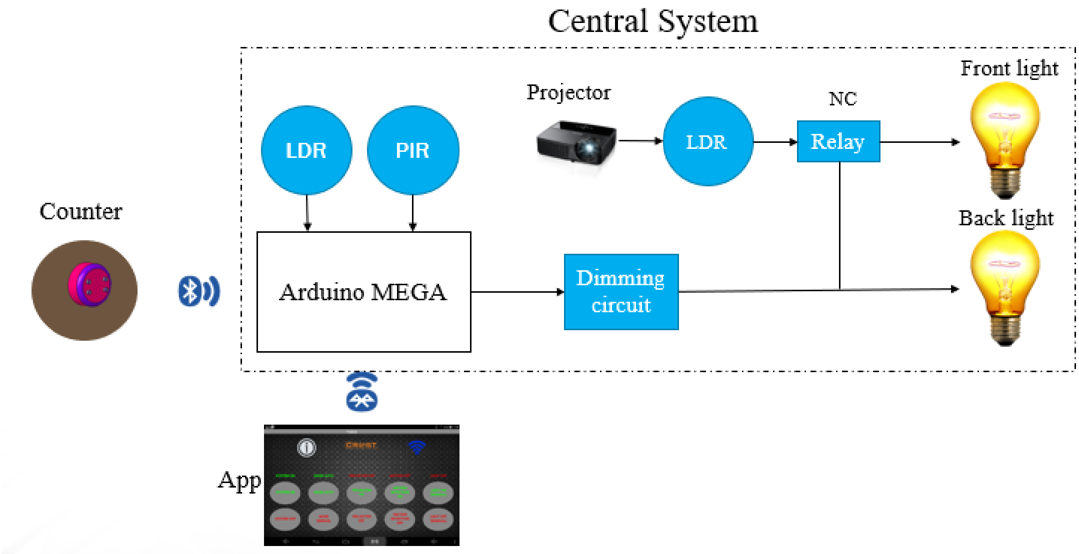

Figure 2: Illustrates the overall architecture of the central control system

The light intensity would be adjusted automatically to the suitable intensity by using LDR sensors if the previous condition is TRUE. A user would have the option to set the system to be automatic or manually controlled. If it was chosen to be manually controlled, the user would be able to interface with the system using an Android tablet, which would be hung on the wall using an Android app connected by Bluetooth to the PIC microcontroller as shown in Fig. 3. A user could interface with the controller using buttons or direct voice commands. In classes. We normally switch OFF the front lights when we turn ON the projector. The projector status will be indicated using an LDR sensor fixed on the board that will receive the show projection of the projector. Light intensity would be adjusted to three levels—high, medium, and low—by using three AC lines with different resistance, as shown in Fig. 4.

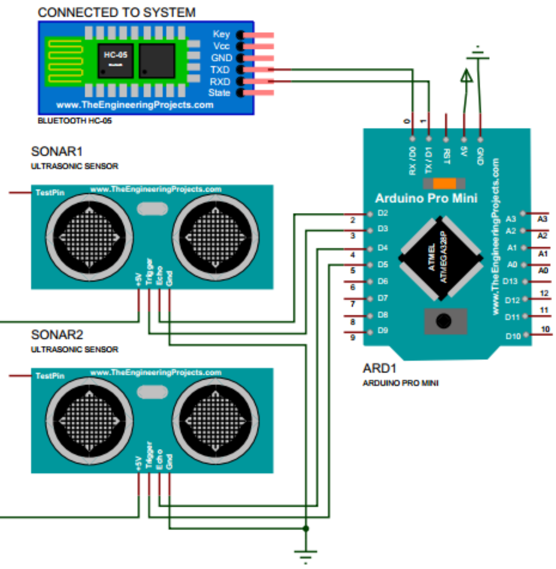

Figure 3: Entering and Leaving Counter

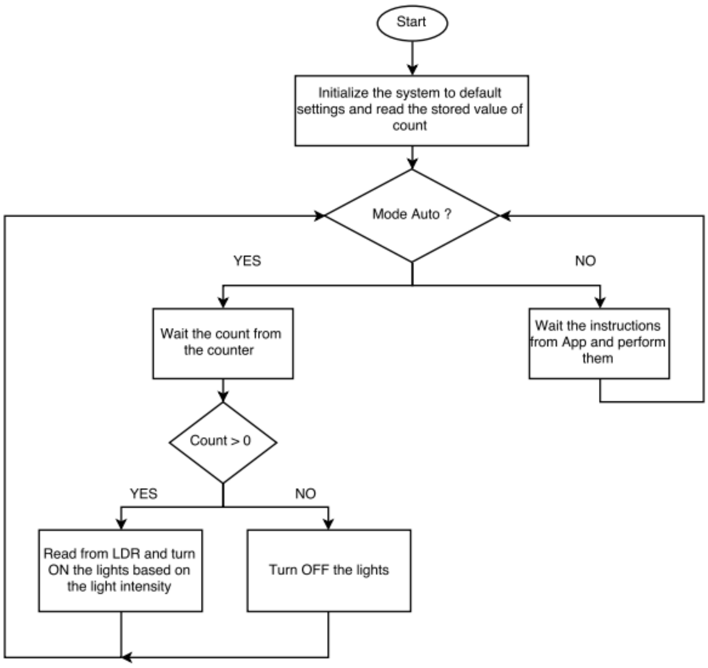

Figure 4: Flowchart of the system's logic

The flowchart illustrates the operational logic of an automated lighting system that is based on human presence as showing Fig.5.

Start: The system begins its operation.

1. **Initialize Human Presence:** The system initializes a counter for human presence (HP) to zero.
2. **Check for Entering Person:** The system checks if the ultrasonic sensors have detected a human entering the room.
   - **Yes:** If a person is detected entering, the Human Presence (HP) counter is incremented by one (HP=HP+1). The process then moves to the next step.
   - **No:** The system proceeds to the next step without changing the counter.
3. **Check for Leaving Person:** The system then checks if the ultrasonic sensors have detected a human leaving the room.
   - **Yes:** If a person is detected leaving, the Human Presence (HP) counter is decremented by one (HP=HP−1). The process then moves to the next step.
   - **No:** The system proceeds to the next step without changing the counter.
4. **Check Auto Mode:** The system checks if the "Automatic Mode" is turned on.
   - **No:** If the automatic mode is off, the system receives instructions to monitor the light from the Android app via a Bluetooth connection. After receiving instructions, the process cycles back to the start.
   - **Yes:** If the automatic mode is on, the system checks if the Human Presence counter is greater than zero (HP>0).
5. **Evaluate Human Presence:**
   - **No:** If the human presence counter is not greater than zero (HP≤0), all lights are turned off ("Light OFF (ALL)"). The process then cycles back to the beginning.
   - **Yes:** If human presence is detected (HP>0), the system proceeds to the next step.
6. **Turn On and Adjust Lights:** The system turns on the lights and adjusts their intensity based on the measurements from the LDR (light sensors).
7. **Check Projector Status:** The system checks if the projector is on.
   - **Yes:** If the projector is on, the "Front light" is turned off ("Light OFF (Front light)"). The process then cycles back to the beginning.
   - **No:** If the projector is not on, the process cycles back to the beginning without any further action on the front light.

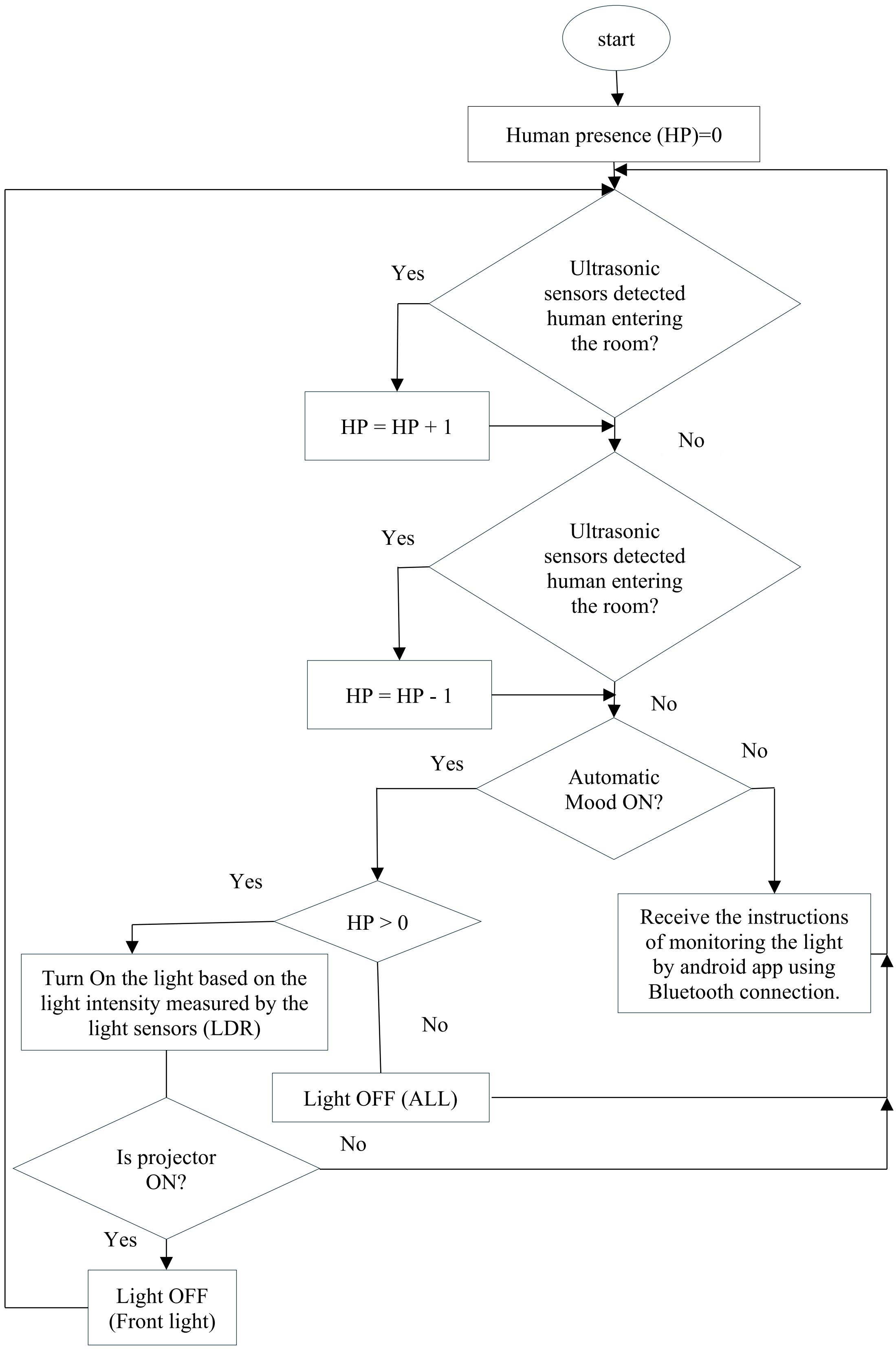

Figure 5: Illustrates the operational logic of an automated lighting system that is based on human presence.

This circuit diagram is a schematic of the central control system, showing how different components are connected to an Arduino Mega 2560, which is the main microcontroller, acting as the brain of the system. It receives inputs from all the sensors and modules, processes the data, and then sends signals to control the lighting and other devices. The LDR1

(Light Dependent Resistor) sensor measures the ambient light intensity in the room. The Arduino uses this information to automatically adjust the brightness of the lights. The PIR1 (Passive Infrared Sensor) sensor is used for detecting motion or human presence. While the text mentions that the main presence detection method uses ultrasonic sensors, the circuit diagram includes a PIR sensor, possibly for integration to detect unexpected errors. Bluetooth Modules (HC-05): There are two Bluetooth modules shown. CONNECTED TO APP module allows the system to communicate wirelessly with an Android app. Users can manually control the lights, and the app can display system information.

CONNECTED TO COUNTER

module connects to the separate counting system, which uses ultrasonic sensors at the door to track the number of people entering or leaving. The projector using the LDR sensor (not explicitly labeled LDR1 in the diagram but mentioned in the text as a separate sensor) detects if the projector is on. When the projector is running, the system turns off the "FRONT LAMP" to improve visibility. Relay (RL1) A relay is an electrically operated switch. The circuit uses it to control the "BACK LAMP" and the "FRONT LAMP." The Arduino sends a signal to the relay to turn the lights ON or OFF. Dimming Circuit: The diagram shows a "dimming circuit" controlled by the Arduino. This circuit likely uses components like a variable resistor or triac to adjust the light intensity of the lamps, which the text describes as being adjusted to three levels: high, medium, and low. The power supply circuit is powered by a 220V 50Hz AC source, which is rectified and regulated to provide the necessary DC voltage for the electronic components.

In essence, the circuit shows a complete system for an automated lighting solution. The Arduino gathers data on human presence (from the counter via Bluetooth), light intensity (from the LDR), and projector status. It then makes decisions to switch lights ON/OFF and adjust their brightness, which can be overridden by a user through a mobile app as shown in Fig. 6.

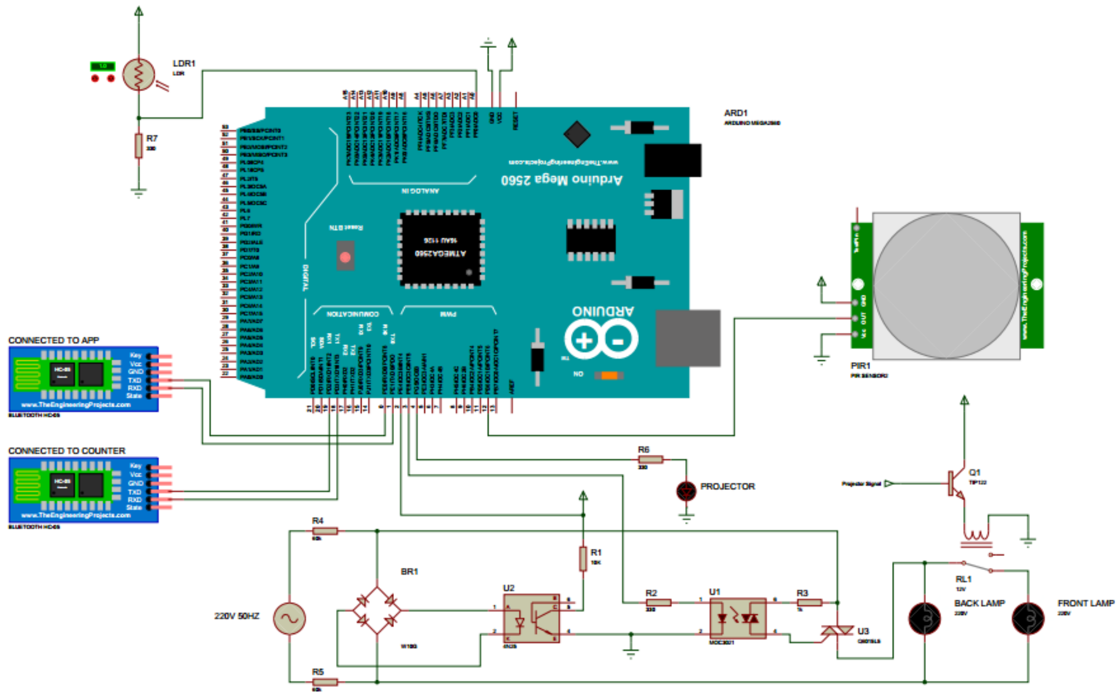

Figure 6: Circuit diagram of the central system

IV. Results and Discussion

The system has two situations for the smart lighting system. In the first situation, which is when people are present, the smart lighting is ON. This happens by using two ultrasonic sensors at the door that both sense the presence of a human at the same time. As you can see in Fig. 1. In the second situation of the hall system at night, which is usually from after midnight until sunrise. In this case, the hall lighting will turn OFF if there are no people.

movement. The state of lighting depends on the ultrasonic sensors that were placed at the door of the hall.

In summary, this project has succeeded in developing a system for monitoring hall lighting and saving electrical consumption. Our project implemented a smart lighting monitoring system to overcome the shortcomings of traditional street lighting systems. It also aims to reduce monthly electricity consumption and detect potential problems with individual hall lights. One of the problems that was solved was the erratic behavior of hall lights when there were no people around. The safety of pedestrians entering the hall is the most important topic that has been presented. Our investigation also focused on finding solutions to problems associated with random and intermittent manual watering of plants.

V. Conclusion

This system delivers high performance in real-world applications, offering a robust solution for automated control. The issue of system freezing has been effectively resolved by integrating a robust counter mechanism that ensures continuous, reliable operation. The primary benefit is significant energy reduction, achieved by automatically controlling and adjusting light intensity based on occupancy. Furthermore, the system is designed for scalability and ease of installation, allowing control of multiple rooms simply by adding more counter units. The system's reliable operation is guaranteed by an accurate people-counting function, which is intelligently integrated with a Passive Infrared (PIR) sensor to detect discrepancies and ensure high performance while simultaneously identifying and alerting operators to any unexpected errors.

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