**MOTION-ACTIVATED LIGHT SYSTEM**

**Submitted By**

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**MINI LAB PROJECT REPORT**

This Report Presented in Partial Fulfilment of the course **CSE224**: **Digital Logic Design LAB in the Computer Science and Engineering Department.**



**DAFFODIL INTERNATIONAL UNIVERSITY DHAKA,BANGLADESH.**

**December 1, 2024.**

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**COURSE & PROGRAM OUTCOME**

The following Course have course outcomes as following:

Table 1: Course Outcome Statements

|  |  |
| --- | --- |
| **CO’s** | **Statements** |
| CO1 | Recall theoretical knowledge of digital logic and concepts of Integrated circuit (IC) to design, construct, and test basic digital circuits and systems in a laboratory setting |
| CO2 | Apply appropriate laboratory equipment and tools to measure and verify the behaviour and performance of digital circuits and systems. |
| CO3 | Develop a system/prototype for real life application based on the knowledge gained from the course. |

Table 2: Mapping of CO, PO, Blooms, KP and CEP

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| CO | PO | Blooms | KP | CEP |
| CO1 | PO1 | C1, C2, P1, P2 | K1, K2, K3 | EP1 |
| CO2 | PO2 | C2, C3, P1, P2, A2 | K3, K4 | EP2 |
| CO3 | PO3 | C3, P1, P2, P3, A1, A2 | K5 | EP3 |

The mapping justification of this table is provided in section 4.3.1, 4.3.2 and 4.3.3.

**Table of Contents**

**Declaration**

**Course & Program Outcome**

[Introduction 6](#_Toc183997792)

[1.1 Introduction 6](#_Toc183997793)

[1.2 Motivation 6](#_Toc183997794)

[1.3 Objectives 7](#_Toc183997795)

[1.4 Feasibility Study 7](#_Toc183997796)

[1.5 Gap Analysis 8](#_Toc183997797)

[1.6 Project Outcome 8](#_Toc183997798)

[Proposed Methodology/Architecture](#_Toc183997799) 10

[2.1 Requirement Analysis & Design Specification](#_Toc183997800) 10

**[2.1.1 Overview](#_Toc183997801)**10

**[2.1.2 Proposed Methodology/ System Design](#_Toc183997802)**13

**[2.1.3 Circuit Diagram](#_Toc183997803)**14

[2.2 Overall Project Plan](#_Toc183997804) 15

[Implementation and Results](#_Toc183997805) 17

[3.1 Implementation](#_Toc183997806) 17

[3.2 Performance Analysis](#_Toc183997807) 19

[3.3 Results and Discussion](#_Toc183997808) 21

[Engineering Standards and Mapping](#_Toc183997809) 23

[4.1 Impact on Society, Environment and Sustainability](#_Toc183997810) 23

**[4.1.1 Impact on Life](#_Toc183997811)**23

**[4.1.2 Impact on Society & Environment](#_Toc183997812)**24

**[4.1.3 Ethical Aspects](#_Toc183997813)**25

**[4.1.4 Sustainability Plan](#_Toc183997814)**25

[4.2 Project Management and Team Work](#_Toc183997815) 26

[4.3 Complex Engineering Problem](#_Toc183997816) 27

**[4.3.1 Mapping of Program Outcome](#_Toc183997817)**27

**[4.3.2 Complex Problem Solving](#_Toc183997818)**29

[Conclusion](#_Toc183997819) 31

[5.1 Summary](#_Toc183997820) 31

[5.2 Limitation](#_Toc183997821) 31

[5.3 Future Work](#_Toc183997822) 32

[References](#_Toc183997823) 35

**Chapter 1**

# Introduction

This chapter provides an overview of the project, motivation of this project, main objectives of this project and project outcomes. We also analyse the feasibility and highlight the gap analysis.

## Introduction

Technology is getting interesting and bigger day by day then before. From waking up from the bed in the morning till we sleep, we are using technology. People have focused on saving energy and they are using automation in workplaces and homes too. Traditional lighting system are often controlled manually which wastes energy and is something inconvenient. Especially, when natural light is enough or no one is around or unoccupied periods e.t.c. Also, manual control can be hard in big or faraway areas.When everyone leaves, the lights will automatically shut off. This removes the need for constant manual adjustment and ensures that energy isn’t wasted when the lights are no longer necessary.

This project aims to design and implement a motion-activated lighting system that can be use for automatically turn lights on and off based on occupancy detection. It will also include manual control options for flexibility. By automation the lighting process and optimizing energy usage. This project seeks to contribute to energy conservation and make life easier for users.

It combines energy saving, ease of use, and flexibility into one system. The idea is to design a solution that works for all types of spaces—whether it’s a home, classroom, office, or even a larger public space—helping users save energy while making lighting control simple and efficient.  
  
In short, this motion-activated lighting system isn’t just about saving time or energy. It’s an example of how smart technology can make life easier and contribute to a greener future. With the combination of smart sensors and manual features, this system could change how we interact with something as simple as a light switch, turning it into an intuitive and seamless part of everyday life.

## Motivation

This project is motivated by the concern for energy efficiency and make environment smarter and responsive. By using automatic lighting system, we can significantly reduce energy consumption and avoid wasting it. It also matches the technology of smart home where devices can be controlled from far away.

Another major reason behind this project is saving energy. It can cut back on unnecessary electricity use. This will save money. This system is going to solve the problem.

This system is meant to make life simple. Having a light that woks automatically can make life easier as it’s easy to use. Everyone will feel more comfortable.

In the end, this project is about designing a solution that can make life a little easier while also encouraging people to save energy and live more sustainably. With smart, intuitive features like motion sensors and manual controls, this system could make lighting accessible for everyone while also helping the planet.

## Objectives

**Design and Implementation:** Created a circuit using a micro-controller to control the light.The microcontroller is at the heart of this design, acting as the brain to manage all the system’s functions.

**Motion detection:**One of the key features was integrating a motion sensor into the system. This allows the system to detect when someone enters the room and automatically turn on the lights, making it efficient and convenient..

**Manual Control:** Provided a switch and a mic sensor to override the automatic operation.It means everyone can control it from their voice control .

**Energy Efficiency:** Optimized the system to use less energy. System will only use the amount of power it needed.

**User Friendly**:The system was built to be user friendly and to make life easier for the user. The idea was to create a simple, intuitive design that anyone could operate easily without any frustration.

These objectives combined to create a practical, easy-to-use, and energy-efficient lighting system. It’s meant to provide a simple solution to everyday problems while making energy use smarter and easier for anyone using the system.

## Feasibility Study

**Review:** Research has shown that motion-activated lighting systems can save a lot of energy while making life much more convenient for users. These systems are gaining attention because they respond automatically when someone enters or leaves a space, reducing the need for manual operation.

**Similar Project:** We found several similar projects, often control the lighting directly through smart home hubs. However, one thing that was missing is most of these system miss few features like manual control options also a way to count people leaving and entering. So, I felt like there’s still some place to be fixed or improve.

**Methodological Contribution:** This project will contribute to automated lighting system field by:

1.Implementing advanced motion detection algorithms to improve accuracy.

2.Offering flexible control options.

3.Using power saving features to reduce energy use.

4.Making the system user friendly to use

## Gap Analysis

Motion-activated lighting systems have become common, but they still face a few issues that limit their effectiveness. While they provide basic functionality, these problems can affect their performance and user experience. Here are some of the key gaps identified in current motion-activated lighting systems:  
  
Wrong Triggers: Many systems are too sensitive and turn on or off based on any kind of sound or movement, even if it isn’t a person entering or leaving the space. This leads to frequent false activations, which can be frustrating for users.  
  
Limited Flexible Control: Users often can’t control the lights in the way they want. Sometimes the system does not allow manual overrides or user preferences, leaving people with less freedom to operate their own environment.

Wasting energy: System doesn’t always use energy efficiently. It happens because the system doen’t accurately know when to save power or when too shut off. This is the reason which might increase electricity bill.

User Friendly Interface: Sometimes low response when someone enters a room. That what makes delays to the system and makes the system not trustworthy to the user.

These problems show that there’s still room to make motion-activated lighting systems better. By solving these issues, we can make these systems more accurate, efficient, and easier for people to use. This project aims to tackle these challenges by creating a system with improved motion detection, options for flexible control, energy-saving features, and a user-friendly interface that responds quickly and easily. The idea is to build a lighting system that works the way users expect it to—without unnecessary complications or wasted energy

## Project Outcome

Expected outcomes of this project include:

Working Model: This is a Motion Activate Light System that we built which actually works. It will turn the light when someone enters the room. It will also turn off the light when no one is around. It also have manual light control system.

Documentation: We will give clear and simple statement how the system was built. Also we will say how the system was built step by step. In other hand we can say about how the system was manufactured, built and tested.

User Feedback: After completing the system, we will ask user to try the system and user will give opinions about how well the system works and if it’s easy to use.And also if there are needed of any kind of changes that will make the system more user friendly.

Commercial Use:If everything works well, this technology could be shared with companies or manufacturers. This means it could be used in smart homes, offices, or other places where it would be helpful.   
  
The main goal is to create something simple, practical, and easy for everyday use..

**Chapter 2**

# Proposed Methodology/Architecture

In this chapter we discussed about the requirements, circuit diagram and overall project plan for implementing the project:

## 2.1 Requirement Analysis & Design Specification

### **2.1.1 Overview**

This project aims to automate lighting systems using motion detection and mic detecting clap sound to save energy and make life more convenient. The system uses two IR sensors and ground sensors to detect motion ,also a Mic system. When motion is detected or finds clap sound , lights are automatically turned on and the system shows updates on an LCD screen. It can be used in smart homes, offices, or public spaces to save energy.The purpose of this project is to make people's life easy and also conserve energy by monitoring it ,this project will surely help to reduce electric consumption also in near future there are upgrade possiblitie in the system as this system was made for efficient use it will certainly help to cut down wastage of electricity also save lot of money it also can help to improve load shedding and conserve more electricity.

**Requirement Analysis & Design Specification :**

**Components list:**

**1.IR Sensor :** An IR (Infrared) sensor detects heat or motion, a mic module captures sound or audio input. Combined, these modules can be used in various applications like robotics, drones, and interactive systems.

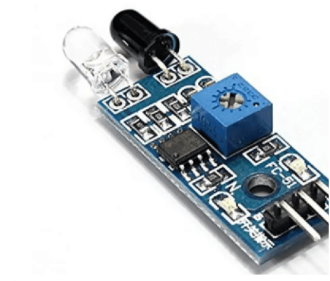


Fig : IR sensor

**2.Ground module:**A ground module typically refers to sensors used for measuring elevation or terrain.Combined, these modules can be used in various applications like robotics, drones, and interactive systems

Fig : Ground module

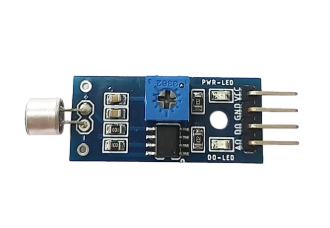
**3.Mic module :**A mic module captures sound or audio input.It can be used in lot of different ways its main purpose is to collect any type of sound and convert into digital signal from analog signal.

Fig :Mic Module

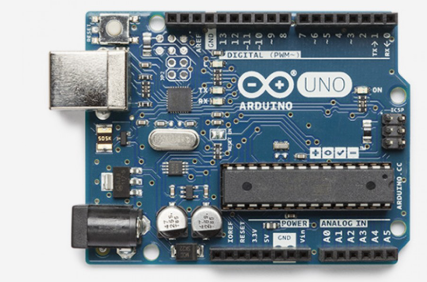
**4.Arduino uno :** Arduino Uno is an open-source microcontroller board based on the ATmega328P. It has 14 digital input/output pins, 6 analog inputs, and a USB connection for programming. It's widely used in electronics projects for prototyping and learning, offering flexibility and ease of use with various sensors, actuators, and shields.

Fig: Arduino Uno

**5..LED :** An LED light is a type of lighting that uses light-emitting diodes to produce light. It is energy-efficient, durable, and used in various applications like home lighting, streetlights, and screens.

Fig:LED

**6.LCD Display:**An LCD (Liquid Crystal Display) is a screen technology that uses liquid crystals to control light and display images. It requires a backlight and is commonly found in TVs, computer monitors, smartphones, and other electronic devices 

Fig :LCD Display

The system is made up of several key components:

1. **Input Sensors (IR , Ground, MIC):**

○ Two IR sensors and ground sensors detect motion within their range.

○ When they sense movement, they send a "HIGH" signal to the Arduino.

○ A mic system that listens to clap sounds.

2. **Processing Unit (Arduino Uno):**

○ The Arduino acts as the brain of the system. It processes signals from the sensors.

○ Based on the signals, it decides whether to turn the lights on or off.

○ It also updates the LCD screen with messages like "Motion Detected" or "Lights ON or Off "

and ”Count Objects(mainly persons)”.

**3.Output-devices:  
LEDs:** Represent the lights in this project. They turn on or off based on the motion and mic

system.

**LCD Display:** Shows real-time messages about the system's status.

4. **Power Supply:**

The system is powered by either a USB type c connection or an external power source.

5. **Control Logic:**

The logic is programmed into the Arduino:

■ If motion is detected, the lights turn on, and the LCD displays "Motion Detected: Lights ON and counts the objects" .

■ If the mic system finds clap sound it will turn ON or OFF in current status.

■ If motion is detected by someone leaving, the lights turn off, and the LCD shows "Lights OFF and count the objects that are leaving ."

#### **2.1.2 Proposed Methodology/System Design**

**Flow chart :**

|  |
| --- |
| Start (Turning on the system) |

|  |
| --- |
| Person entering in the room |

|  |
| --- |
| Count person show in the Display also show Lights “ON” |

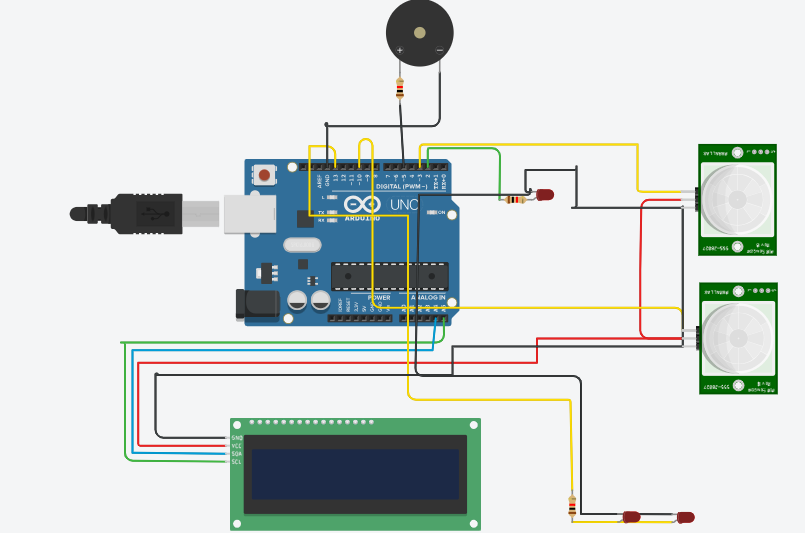
|  |
| --- |
| If person want to stay in the room they will clap to turn ON or OFF the system |

|  |
| --- |
| If person left the room it will count if it found there is no one left then Lights will be turn of and show on Display |

|  |
| --- |
| END (system will turn OFF) |

So from the flow chart we can easily understand what going on overall in the project from its Starts to End .The main purpose of the flowchart to show the basic principle way the project will run which would be very easy to understand for anyone who wants to know how this project is working also it will help them to investigate the project properly and much easier way and in the next phase will draw a circuit Diagram So in the next page we can see the main circuit Diagram of this project.

**2.1.3 Circuit Diagram**

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The interface is simple:

A 16x2 LCD screen displays messages like:

○ "System is ON and shows Count = 0" when starting.

○ "Motion Detected: Lights ON" when motion is detected.

○ “Mic system (if track clap ) then “ Light ON or OFF” according to the status.

○ "Motion Detects some objects leaving shows “ Lights OFF and count " .

### 

### **2.2 Overall Project Plan**

The project is divided into four phases:

1. **Component Assembly:** Connect the IR sensors, Ground and Mic module, lLEDs, and LCD to the Arduino following the circuit diagram.check if its working properly or not ,if not try to find out the problem with optimal solution.

2.**Coding:** Write and test the Arduino program for motion detection and light control also add sound

capture code using C language try to optimize the code for better performance and compare

with the previous code for best output make it simpler for everyone to understand what’s

going on under the whole project how a software working with the hardware and how is it

reacting to the outside reality.

3.**Testing:** Test different situations like motion being detected or not, to ensure it works well also make

some sound to see when lights are on or off how they react to clap sound if its not working

properly then try to find out if there is problem in hardware if hardware seems ok then will try to

find problem with in the coding and try different approach to solve the problem if its work then

the project is ok to run if its not then try to find out the problem with same step and test it again

and again until it is properly working.

4. **Deployment:**Connect the system to a real lighting setup and use it practically.we can use it in real life we need create a box looking like a room where there will be door which will hold Ir sensor and the ground sensor will be attach so that when a person or object enter or leaving the room will be capture and therefore it will count and show it to the display for information also there will be Mic so that if any person in the room try stay or sleep they could just clap and the system will turn the light on or off according to the situation and update on the Display this how the project will be showcase and display its a model base but with little help it could work on the real life .

**Time-line:**

● **Week 1:** Try to find requirements and gather components.

● **Week 2:** Build the circuit and try to find errors and implement code.

● **Week 3:** Test and fix any issues (code related and circuit related).

● **Week 4:** Run the system and finalize the report.

**Tools and Technologies:**

**Hardware:** Arduino Uno, Mic module ,Two IR and Ground sensors, 2 LEDs, LCD screen, resistors, and wires.

**Software:** Arduino IDE for writing and testing the code.

**Operation of the project :**

● Try to find objects(mainly human) and detect motion without errors.

● Save energy by turning lights off when it can’t find any person in the room.

● The display shows information and messages on the LCD.

**Chapter 3**

# Implementation and Results

This section explains how we connected the sensors, LEDs, and LCD to the Arduino, providing clear instructions to make the setup simple and functional.

**3.1 Implementation**

**1. Initialize required libraries, variables, and pins:**

* PIR sensors for outside and room-side
* Clap module, button, LED, and Lights
* LCD with I2C address
* Counter for people in the room and status flags

**2. Setup:**

* Start Serial communication
* Set PIR sensor pins as input
* Set the clap module pin and button pin as input
* Set LED and Light pins as output
* Initialize LCD, display "Initializing", and update the display

**3. Main Loop**:

Read the states of:

* Outside PIR sensor
* Room-side PIR sensor
* Clap module
* Button

**4. Entry Detection :**

* If room-side motion is detected and count > 0
* Turn on indicator LED
* Start a timer
* While timer is within 500ms:
* Check outside PIR sensor for exit
* If exit detected
* Decrement counter update display
* Turn Off the indicator LED
* Break

**5. Exit detection:**

* Turn on indicator LED
* Start a timer
* While timer is within 500ms
* Check outside PIR sensor for exit
* If exit detected
* Decrement counter, update display
* Turn off the indicator LED
* Break

**6. Light Control:**

If count > 0 and a manual flag is false:

* Turn on lights
* Set flags for automatic mode

If count == 0 and the automatic mode flag is false:

* Turn off Lights

If clap detected Or a button is pressed:

If lights are off:

* Turn on lights
* Display “Manually on” with a person count
* Update flags for manual mode

Else:

* Turn off lights
* Display “Manually off” with a person count
* Update flags for manual mode

**7.Function:** Update Display

* Clear LCD
* Display “Person count” with current counter value

**3.2 Performance Analysis :**

**1. Functional Performance :**

Entry and Exit Detection:

Strengths:

* The system effectively tracks people entering and exiting the room using PIR sensors.
* A timer ensures false detections are minimized by requiring consistent readings within a 500ms window

Weaknesses:

* Limited Detection Time Window: The 500ms window may miss valid movements or detect unintended entries/exits if the movement occurs slowly or too quickly.
* Max Capacity Constraint: The count variable has a hardcoded limit (count < 5), limiting its application to larger spaces.

Manual Override (Clap and Button):

* Clap module and button provide manual control of the lights, allowing flexibility in operation.
* Ensures lights can be controlled even without motion detection.
* Clap detection may result in false positives due to unintended sound interference.
* The system requires explicit toggling via manual methods, which may not be user-friendly in some cases.

**2. Computational Efficiency :**

Code Efficiency:

* The code uses flags and short delay intervals to avoid redundant operations (e.g., re-checking the same sensor repeatedly).
* A single loop() function handles all tasks without excessive branching or computational overhead.

Potential Bottlenecks:

* Polling Approach: Continuous sensor polling could lead to inefficiency in environments with many sensors or additional functionalities.
* Fixed Timer Logic: Using millis() for timing is lightweight but may be unsuitable for longer or asynchronous tasks.

**3.Scalability :**

* Room Capacity: The system supports a maximum of five people (count < 5). Extending the room capacity requires modifications to the logic or sensor placements**.**
* Sensor Dependence: The reliance on only two PIR sensors limits coverage. Expanding the area would require additional sensors and logic to integrate them.

**4. Accuracy :**

* Sensor Sensitivity: PIR sensors can produce false positives due to environmental factors

( heat sources or movement outside the intended detection zone).

* Light Control Logic: The system might incorrectly toggle lights due to overlapping manual and automatic conditions.

**5. Usability :**

* LCD Display: Displays useful real-time information about the system’s state (e.g., person count).
* Indicator LEDs: Provides visual feedback for system activity.

**6. Reliability and Fault Tolerance :**

* The system does not handle:
* Sensor Failures: There is no fallback if one or more sensors fail.
* Power Interruptions: No mechanism to persist data such as the current count after a power reset.
* Debouncing for Button/Clap: Limited handling of noise or unintended triggers in manual control.

1. **Potential Improvements :**

Sensor Logic Enhancements:

* Introduce debouncing or filtering to reduce noise in clap/button detection.
* Use additional sensors or enhance the logic to account for varying speeds of entry/exit.

Scalability:

* Allow dynamic adjustment of the maximum capacity to support different room sizes.

Energy Efficiency:

* Add a timeout feature for lights if no motion or manual control is detected for a set duration.

Reliability:

* Include a backup mechanism to persist the count variable using EEPROM or an SD card to prevent data loss after a reset.

Usability Enhancements:

* Add wireless connectivity (e Wi-Fi or Bluetooth) for remote monitoring and control.
* Replace clap detection with a more reliable sound or gesture-based control mechanism.

**3.3 Result and Discussion :**

**Result :**

The project successfully demonstrates an automated room occupancy and lighting control system. The system uses motion sensors to detect the entry and exit of people and adjusts the lights accordingly. The results can be summarized as follows**:**

**1.Occupancy Tracking:**

* The system accurately counts the number of people entering and exiting the room within the designed constraints.
* Lights are turned on when at least one person is present in the room and turned off when the room is empty.

**2.Manual Override:**

* The clap module and button provide reliable manual control for turning lights on or off, offering flexibility in case of unusual scenarios or sensor inaccuracies.

**3. LCD Integration:**

* The LCD display effectively communicates real-time updates to the user, such as the number of occupants and the state of the lights (manual or automatic)

**4. Energy Efficiency:**

* The system ensures that lights remain off when the room is unoccupied, contributing to energy savings

**Discussion :**

**Strengths:**

* Automation: The system automates the process of light control based on occupancy, reducing manual effort and increasing convenience.
* Energy Savings: Lights are only turned on when needed, conserving energy and lowering utility costs.
* User-Friendly Design: The addition of an LCD display and manual control features improves usability.
* Scalability Potential: The design can be modified to include more sensors for larger rooms or more complex environments.

**Limitations:**

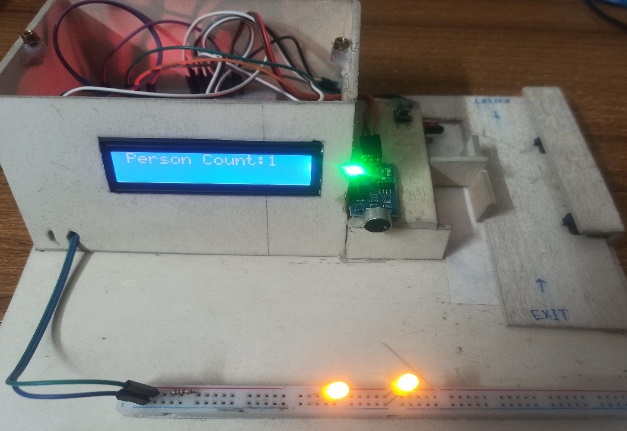
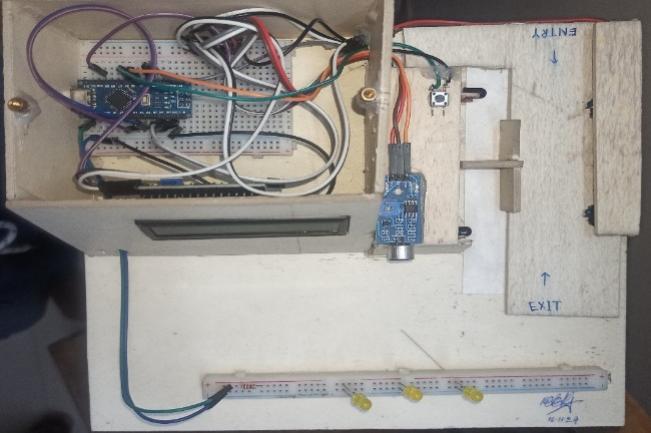
* Accuracy Issues: False positives can occur due to environmental factors affecting the PIR sensors ( heat sources, stray movements).
* Simultaneous Movements: The system cannot differentiate between multiple people entering or exiting simultaneously, which may lead to inaccuracies in the count.
* Capacity Limit: The hardcoded maximum count of five people limits its application in larger spaces.
* Reliance on Timing: The fixed 500ms time window for validating entry/exit may miss slow or fast movements.

**Challenges:**

* Sensor Placement: Proper sensor placement is critical for accurate detection. Any misalignment can affect system performance.
* Noise in Manual Controls: The clap module may trigger lights unintentionally due to loud ambient sounds.

**Improvements and Future Work:**

* Advanced Sensors: Replacing PIR sensors with camera-based or ultrasonic sensors can improve accuracy and reduce false positives.
* Persistent Storage: Using EEPROM or SD cards to store the count variable ensures data integrity after power interruptions.
* Dynamic Time Window: Implementing adaptive timing for entry/exit validation based on movement patterns could enhance detection reliability.
* Connectivity: Adding IoT capabilities (e.g., Wi-Fi or Bluetooth) can enable remote monitoring and control through a smartphone or computer.



**Chapter 4**

**Engineering Standards and Mapping**

The Arduino-based light-activated system showcases the implementation of engineering standards through the combination of motion sensors, manual control (clapping, push button) and real-time feedback (LCD display). This solution provides reliable, easy to use and compliant automation of room lighting as per occupancy detection.

**4.1 Impact on Society, Environment and Sustainability**

Motion-activated lighting systems are revolutionizing the way we illuminate our spaces. By harnessing the power of motion sensors, these systems intelligently adjust lighting levels, ensuring optimal illumination while minimizing energy consumption. This innovative technology not only reduces energy costs but also contributes to a greener planet by reducing carbon emissions.

Beyond energy efficiency, motion-activated lighting enhances safety and security by automatically illuminating areas when motion is detected. This can deter intruders and reduce the risk of accidents. Additionally, these systems provide greater flexibility and convenience, allowing users to customize lighting settings to suit their specific needs.

As we continue to seek sustainable solutions, motion-activated lighting emerges as a compelling choice. By embracing this technology, we can create more energy-efficient, eco-friendly, and comfortable spaces for the future.

**4.1.1 Impact on Life**

**1. Convenience and Comfort**: Automated lighting—based on motion—is more convenient, with lights always on when needed (and off otherwise) without any manual intervention.

Frees individuals with the management task of stepping up to flip electronic switches and makes it easier for persons with disabilities or limited mobility by reducing the need to go from here to there.

**2.Energy Efficiency**: Save wasted energy, lowering utility bills, and supports a greener life by automatically shutting off lights when a room is empty.

**3.Safety and Security**: Its motion detection can also help secure your home by lighting areas when someone comes into view, or sending alerts for unexpected movement.

**4.Increased Awareness**: The approach cultivates environmental consciousness, leading the people to pay greater attention to their energy usage, resulting in a lifelong shift towards responsible living ─a higher degree of sustainable lifestyle in the long run.

**4.1.2 Impact on Society & Environment**

Motion-activated lighting systems have emerged as a powerful tool for promoting energy efficiency, sustainability, and overall well-being. By harnessing the power of motion sensors, these systems intelligently control lighting, ensuring that illumination is provided only when and where it is needed. This innovative technology offers a wide range of benefits that positively impact both society and the environment.

From reducing energy consumption to enhancing safety and security, motion-activated lighting systems have the potential to revolutionize the way we illuminate our spaces. By understanding the intricate relationship between technology, energy efficiency, and environmental sustainability, we can unlock the full potential of this ground breaking innovation.

**Positive Impacts**:

**1.Smart Lighting**: Reduces energy consumption by switching off lights when there is no motion detected in the room. It provides to reduce unwanted use of electricity in homes and offices, which ultimately results in lower utility bills and sustainable environment.

**2.Usability**: It provides a hands-free experience which makes it easier and more convenient to use. This is especially great for those with physical disabilities or mobility problems who may have difficulty operating manual switches.

**3.Security**: It can also be a primitive form of security; the system could recognize motion and determine if someone is entering/exiting the room. This can be beneficial in surveillance-required areas, for example, offices or confidential areas, thus, might enhance security.

**4.Sustainability**: By ensuring that lights are turned off when not needed, the system encourages eco-friendly practices and decreases overall carbon footprints. And especially as energy conservation emerges as a new global imperative.

**Negative Impacts**:

**1.Electronic Waste (E-Waste):** The electronic components integrated into such systems (PIR, micro controller, LCD display) may contribute to e-waste over time, especially if not responsibly recycled or disposed of, affecting the environment negatively.

**2.Privacy Issues**: Monitoring of spaces with motion sensors could lead to privacy, especially in sensitive areas. If the system is misused, data can be accessed without proper authorization, and unauthorized individuals can track people’s movements.

**3.System Failures and False Alarms**: The system may fail, either triggering false alerts (lights turning on when nobody is there) or false deficits (lights not turning on while entering people). Such errors may result in annoyance, energy loss, or frustration on the part of the users.

**4.Maintenance**: The system needs standard maintenance, such as cleaning and recalibrating sensors. With time sensors may also go misaligned or dust may get usages on the motion detectors leading to inaccurate detection of the motion causing reliability and performance issues.

**5.Light Pollution**: The use of the system outdoors or in delicate echo-systems may go to lightweight pollution. This can interfere with wildlife, especially nocturnal creatures, by changing their normal behaviour and environments.

**4.1.3 Ethical Aspects**

Motion based lighting system creates questions regarding ethics related to privacy, accessibility and equity and making sure any collected data is done so transparently and used responsibly. It fosters environmental sustainability and strives for inclusivity and equity in its design and implementation.

**1.Privacy Concerns**: Users might have products monitoring their continuous motion without a full understanding of what that means in terms of data collected. There is a risk of unauthorized surveillance or data abuse.

**2.Security/Safety**: The system, in particular, could be hacked threatening live conditions (physical security) and the overall cyber-safety of its circles. Faults could also endanger safety by, for instance, leaving rooms poorly illuminated in emergencies.

**3.Accessibility and Fairness:** It can make accessibility easier on all individuals with disabilities. However, manual controls also have to be designed to accommodate all. There’s also a need to ensure such systems are available to all — not just those in affluent areas.

**4.Environmental Responsibility**: The system has been energy-saving, and the power it saves can also be one of the practical supports of the environment, but in fact, some electronic components of the system actually lead to an irresponsible environment. The first pillar of ethical design revolves around sustainability, recycling and reducing the footprint on the environment.

**5.Technological Dependence:** An over-reliance on automation might deteriorate critical thinking and problem-solving competency in users and practices in instances where a mal-function occurs and not all users can successfully troubleshoot.

**6. Consumer Awareness and Transparency**: Consumers must know how the system works, including the uses and implications of information privacy. Key factors of informed consent and transparency are essential for ethical use.

**4.1.4 Sustainability Plan**

Its sustainability plan centers on energy efficiency, recyclable materials, and cost savings, but also advocates for durability over the long haul and less waste. The sustainable aspect of the design must be actionable, to ensure environmental, social and economic sustainability through scalability of interventions and optimal use of the resources.

**Environmental Sustainability :**

1. **1.Enhancement of Energy Efficiency**: The system employs passive infrared (PIR) motion sensors to switch lights on or off based on the presence of people, conserving energy.
2. **2.Components/Hardware**: use low-power components, identified by P in the PCB schematics. Install with Solar Integration Solar energy is another way to reduce non-renewable energy dependency.

**Social Sustainability:**

1. **1.Home security**: for optimal convenience, it automatically turns on the lighting based on the room occupancy.
2. **2.Manual Override**: Using a clap sensor or button, users can manually control the exposure instead.

**Economic Sustainability:**

1. **1.Cost Savings:** Motion sensors and energy-efficient components help lower your utility bills.
2. **2.Economical and Durable**: Makes use of inexpensive, long-lasting components and is scalable for other spaces.

**Technological Sustainability:**

There are some applications of AI in your daily life such as:Monitoring: Provides system feedback for maintenance and optimization.

1. **Upgradable**: New features can be added without major changes.

**Waste Management:**

1. **1.Recyclable:** With recyclable materials, advises proper disposal
2. **2.Durability**: Lasting components to prevent waste and replacements.

**4.2 Project Management and Team Work**

The best way to go about it is to assign the roles, have a communication tool, timelines, and projects in phased manner so that we don't endup forgetting where we started.

This section describes how the project is worked on from budget and teamwork perspectives, and how engineering standards are applied to ensure the project's smooth delivery.

**Basis for Alternative Budget:**

|  |  |  |
| --- | --- | --- |
| Component | Cost (Taka) | Alternate Options |
| Arduino Nano | 1x450 = 450 Taka | ESP32 |
| LEDs (Red, Yellow, Green) | 6x5 = 30 Taka | Bulk LED packs |
| Flame sensor | 90x2=180 Taka | Infrared sensors |
| LCD Display (16x2) | 1x400= 400 Taka | 7 segment Display |
| Miscellaneous (wires, resistors) | 300 Taka | Ensures connectivity and system reliability. |
| Mic sensor | 80 Taka | Electret condenser Microphones |
| Other (Travel, Hardboard, PBC Board , Soldering Item) | 750 Taka |  |
| Total | 2190 Taka | Economical while ensuring system performance. |

**Team Work :**

Each of us took on a certain role for our project by working collaboratively:

|  |  |
| --- | --- |
| Hardware Engineer | MD. Mushfiq Hassan Chowdhury |
| Firmware Engineer | Abidul Hak Arman |
| Project Manager | MD. Mushfiq Hassan Chowdhury |
| Design | 1.MD. Sohan Mia  2. Nayem Ali Nabil  3.Abdur Rahman Fahim |
| Tester/Analyst: | 1.Abidul Hak Arman  2.Nayem Ali Nabil  3.MD. Sohan Mia  4.Abdur Rahman Fahim |

**4.3 Complex Engineering Problem**

The motion-based lighting system's primary challenge is the diverse sensors arrangement described in the previous section; incorporating it into a microcontroller to ascertain its responsiveness with precision. Figuring out how to minimize false triggers and ensure reliable performance in various environments is critical through calibration.

**4.3.1 Mapping of Program Outcome:**

This chapter will have the mapping of Identified Problem, provided solution with help of targeted Program Outcomes (POs). The mapping should justify how the course/project meets the needed program outcomes (POs) and provides the desire knowledge and skills development.

**PO1: Engineering Fundamentals**

This program outcome assesses a student’s ability to apply core engineering principles. In this project, the students demonstrated a strong grasp of:

1. **Sensor Technology:** They skillfully selected and implemented sensors to accurately detect motion, showcasing their understanding of sensor characteristics and limitations.
2. **Microcontroller Programming:** The students proficiently programmed the microcontroller to process sensor data, make decisions, and control actuators. This required a solid foundation in programming languages, digital logic, and microcontroller architecture.
3. **Energy Efficiency:** By optimizing the system's power consumption and implementing energy-saving strategies, the students demonstrated a commitment to sustainable engineering practices.

**PO2: Problem-Solving and Design**

This program outcome evaluates a student's ability to identify, analyze, and solve engineering problems. In this project, the students:

1. **Recognized a Need:** They identified the issue of energy wastage due to inefficient lighting systems.
2. **Conceptualized a Solution:** The team developed a creative and innovative solution by designing a motion-activated lighting system.
3. **Addressed Design Challenges:** The students encountered and overcame various challenges during the design process, such as sensor calibration, power supply optimization, and software debugging.
4. **Iterative Design:** The team employed an iterative design process, continuously refining their solution based on testing and feedback.

**PO3: Experimentation and Data Analysis**

This program outcome assesses a student's ability to conduct experiments, analyze data, and draw conclusions. In this project, the students:

1. **Rigorous Testing:** They systematically tested the system under various conditions to evaluate its performance and identify potential issues.
2. **Data Collection and Analysis:** The students collected and analyzed data on sensor readings, system response times, and energy consumption to gain valuable insights.
3. **Data-Driven Decision Making:** They used the data to make informed decisions about system optimization, such as adjusting sensor sensitivity or modifying control algorithms.
4. **Continuous Improvement:** The team demonstrated a commitment to continuous improvement by iteratively refining their design based on experimental results.

Table 4.1: Justification of Program Outcomes

|  |  |
| --- | --- |
| **PO’s** | **Justification** |
| PO1 | This system is a combination of electronics (core principles), sensor technologies, microcontroller programming, and general engineering, and a trackable example of how real-world problems can be solved through the application of engineering fundamentals such as energy-efficient lighting. Students get to apply all that theory to a real world problem working on the system. |
| PO2 | Yours is a detailed problem analysis from users' needs (motion detection, manual toggle) to what different sensors and components like PIR sensor with LEDs, microcontrollers, and more need to be architected and designed. The ability to design and develop solutions to complex engineering problems. |
| PO3 | Extensive testing is crucial for system validation. Sensor calibration ensures accurate data readings. Environmental testing evaluates performance under various conditions, such as temperature variations and humidity. Data analysis techniques are used to assess accuracy, identify errors, and optimize system parameters. A well-defined test plan, thorough documentation, and an iterative approach are essential for successful testing. |

**4.3.2 Complex Problem Solving**

In today's intricate world, problems are rarely straightforward. Complex problem-solving equips us to tackle these challenge.s head-on. It involves a systematic approach to identify, analyze, and resolve complex issues. By combining critical thinking, creativity, and effective communication, we can navigate these complexities and emerge with innovative solutions.

**EP1: Depth of Knowledge**

This project showcases a comprehensive understanding of electronics, programming, and embedded systems within the context of an automated light-activated system. It integrates a light sensor, such as a photoresistor or photodiode, to detect ambient light levels. An Arduino microcontroller serves as the brain of the system, making decisions and controlling a relay module to switch external lighting devices, such as streetlights or indoor lights, on and off. The depth of knowledge is evident in the practical application of theoretical concepts. This includes determining optimal light level thresholds for switching, implementing hysteresis to prevent rapid on/off cycles due to minor light fluctuations, and utilizing real-time data processing to optimize energy consumption and enhance the user experience.

**EP2: Range of Conflicting Requirements**

This project must navigate a complex landscape of stakeholders and constraints. Homeowners prioritize ease of use, energy savings, and aesthetics, while building managers focus on cost-effectiveness, compliance, scalability, and potentially remote monitoring. The system must adhere to strict electrical safety and fire safety standards, as well as comply with energy efficiency regulations and potentially local ordinances. Furthermore, the project operates under tight deadlines and budget constraints, necessitating careful prioritization of development tasks, cost-effective component selection, and adherence to a realistic project timeline. By carefully considering these multifaceted challenges, the project team can develop a successful and user-friendly automated lighting system that meets the diverse needs of all stakeholders while ensuring safety, compliance, and efficient resource utilization.

**EP3: Depth of Analysis**

This project tackles the complex challenge of optimizing lighting usage in residential and commercial settings. This involves considering dynamic factors such as varying ambient light conditions, occupant behavior, energy consumption patterns, and aesthetic preferences, all while ensuring safety and comfort. The system relies heavily on data-driven decision-making, collecting real-time data on ambient light levels and analyzing this data to determine optimal lighting schedules and adjust sensitivity thresholds. However, the project faces significant uncertainties and risks. Unpredictable weather patterns, potential hardware failures, and evolving energy regulations can impact system performance. The team must carefully assess and mitigate these risks through robust design, thorough testing, and ongoing monitoring and maintenance. By addressing these complexities, the system can effectively optimize lighting usage, reduce energy consumption, and enhance user experience.

Table 4.2: Mapping with complex problem solving.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| EP1  Dept of Knowledge | EP2  Range of Conflicting Require-ment | EP3  Depth of Analysis | EP4  Familiarity of Issues | EP5  Extent of Applicable Codes | EP6  Extent of Stake-holder Involve-ment | EP7  Inter-dependence |
| *√* | *√* | *√* |  |  |  |  |

**Chapter 5**

**Conclusion**

The project implements a motion-based lighting system, addressing major engineering challenges, while also integrating sensors and automation to achieve energy optimization. It offers hands-on experience in system design, problem-solving, and sustainability, addressing not only technical objectives but also ecological targets.

**5.1 Summary**

The project explores the automation of lighting control based on the ambient light and ambient temperature, using sensors. In this project we use different components like PIR sensor, microcontroller, LEDs to detect motion and adjust lighting with manual for flexibility.

The project addresses complex engineering challenges like system integration, sensor calibration, and energy efficiency while aligning with key Program Outcomes. It enhances skills in problem-solving, design, and testing, and emphasizes sustainability, stakeholder involvement, and compliance with standards. Overall, it provides a practical solution to reducing energy consumption while improving user comfort and safety.

**5.2 Limitation**

The light-activated system you've implemented is functional, but it has certain limitations. Here are some potential drawbacks and areas for improvement:

**1. Limited Motion Detection Accuracy:**

False Positives/Negatives: PIR sensors can sometimes detect motion inaccurately due to environmental factors like heat, sunlight, or pets.

Fixed Time Window: The 500ms window for detecting motion pairs (entry/exit) may not account for varying speeds of movement, leading to missed or incorrect counts.

**2. Clap Detection Issues:**

Noise Sensitivity: The clap module might be triggered by loud ambient noises or similar sounds, leading to unintentional light toggling.

Single Clap Response: It might respond to accidental noises, causing disruptions to the system's functionality.

**3. No Data Persistence:**

If the system is reset or powered off, the count variable and light state are lost. This could lead to incorrect room occupancy or lights being left in an unintended state.

**4. Scalability Constraints:**

The system is designed for a single entry/exit point. For rooms with multiple doors, this design would not work without modifications.

**5. Limited Manual Control:**

While the button and clap module provide manual control, they may not override the automatic system reliably, especially during active motion detection.

**6. No Error Recovery:**

If sensors fail or get stuck, the system doesn’t have mechanisms to reset or recover from inconsistent states (e.g., incorrect person count).

**7. Environmental Dependency:**

The PIR sensors may perform poorly in extreme temperatures or in environments with moving heat sources (e.g., HVAC vents). Sensitivity to light changes might also affect performance.

**8. No Feedback for Manual Overrides:**

While the LCD displays information, it doesn't differentiate between automatic and manual light activations clearly, which may confuse users.

**9. Power Efficiency:**

The system is always active, even when no one is near, which might lead to unnecessary power consumption. Sleep modes or reduced power states could improve efficiency.

**10. Limited User Interface:**

The LCD provides basic feedback, but it could be expanded to show system status, errors, or settings for sensitivity, manual override modes, etc.

**11. Clap and Motion Overlap:**

The overlap between clap-based and motion-based lighting control might cause unexpected behavior when both are triggered simultaneously.

### **5.3 Future Work**

### The future work of this project can focus on addressing its current limitations, enhancing its functionality, and making it more versatile. Here are some potential directions for improvement:

### 1. Advanced Detection Mechanisms

### Use of Infrared Sensors: Replace PIR sensors with more advanced infrared or ultrasonic sensors for precise motion detection.

### AI and Image Processing: Incorporate a camera with AI-based image recognition to count people more accurately and distinguish between humans and pets/objects.

### Multi-Door Support: Expand the system to manage multiple entry and exit points with synchronized sensors.

### 2. Enhanced Control Features

### Voice Control: Add voice control using a microphone and speech recognition module for intuitive interaction.

### Smartphone Integration: Develop a mobile app or integrate the system with smart home platforms (like Google Home or Alexa) for remote control and monitoring.

### Configurable Settings: Allow users to adjust sensitivity levels, timers, and manual override options via buttons or a digital interface.

### 3. Improved Feedback and User Interface

### LCD Enhancements: Upgrade the LCD display to an OLED or touchscreen for a richer user experience.

### Status Indicators: Include additional LEDs or sound alerts to indicate different states (e.g., error, manual override, or standby mode).

### Notifications: Use IoT technology to send occupancy or system status updates to the user's phone.

### 4. Integration with IoT and Smart Home Systems

### Wi-Fi and Cloud Support: Add Wi-Fi connectivity (e.g., using ESP8266 or ESP32) to enable real-time monitoring and control from anywhere.

### Energy Monitoring: Track energy consumption and integrate it with smart energy management systems.

### Automation: Link the system with other smart devices, such as thermostats or security cameras, for holistic automation.

### 5. Data Persistence and Analysis

### Data Logging: Record occupancy data over time to analyze room usage patterns.

### EEPROM Storage: Save the count and light state to EEPROM to ensure consistency after power failures.

### Cloud Data Integration: Upload data to the cloud for remote access and advanced analytics.

### 6. Energy Efficiency and Sustainability

### Low-Power Design: Implement sleep modes for sensors and the microcontroller to minimize power usage during inactivity.

### Renewable Power Source: Integrate solar panels or other renewable energy sources to make the system eco-friendly.

### 7. Scalability

### Modular Design: Create a modular system that can be easily expanded for larger buildings or multiple rooms.

### Commercial Applications: Adapt the system for office spaces, hotels, or conference rooms with added features like scheduling or dynamic light intensity control.

### 8. Security Enhancements

### Intrusion Detection: Expand the system to detect unauthorized entries and integrate it with alarms or security cameras.

### User Authentication: Add RFID or biometric modules to restrict light control to authorized users.

### 9. Multi-Purpose Functionality

### Ambient Control: Use additional sensors (e.g., light sensors) to adjust brightness based on ambient light conditions.

### Environmental Sensors: Incorporate temperature, humidity, or CO2 sensors for enhanced room monitoring and control.

### 10. Prototype to Product Development

### Compact Design: Minimize hardware size and integrate components into a single PCB for a sleek, professional design.

### Market-Ready Product: Package the system into a consumer-friendly device for sale or mass production.

### These upgrades can make the project smarter, more efficient, and suitable for a wider range of applications. Let me know if you'd like detailed suggestions or code for any of these future enhancements!

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