Project Report

Project Title: IlluminateTech: Smart Classroom Lighting Solutions

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Abstract

In the modern era of technology and sustainability, the need for intelligent solutions to enhance efficiency and convenience is paramount. "IlluminateTech: Smart Lighting Solutions" presents a comprehensive project aimed at revolutionizing the traditional lighting systems within educational institutions. The project integrates cutting-edge hardware components such as Arduino Uno, HC-SR501 PIR Motion Sensor, LDR, NodeMCU ESP8266 Development Board, and a range of supporting elements to create an automated lighting ecosystem.

A prototype, ingeniously fashioned from cardboard, manifests the envisioned transformation within the confines of the Computer Science and Engineering department at Jahangirnagar University. Room 101 embodies motion sensitivity, activating lights upon detection of movement, while Room 102 exemplifies remote accessibility, enabling users to manipulate lighting via smartphones or computers through an IoT cloud platform. The streetlights epitomize environmental consciousness, seamlessly transitioning between on and off states based on ambient light levels.

The project has a multitude of benefits ranging from energy efficiency, convenience, and flexibility to maintenance longevity and sustainability. By optimizing lighting control and promoting efficient usage, significant energy savings are envisaged, concurrently mitigating environmental impact. The incorporation of remote access capabilities ensures unparalleled convenience, facilitating lighting control from any location. Moreover, the prolonged lifespan of light bulbs and reduced operational costs underscore the project's economic viability. Ultimately, "IlluminateTech: Smart Lighting Solutions" epitomizes innovation tailored for educational institutions, heralding a paradigm shift towards intelligent and sustainable lighting ecosystems.

IlluminateTech: Smart Classroom Lighting Solutions

Introduction:

In an era characterized by rapid technological advancements and growing environmental consciousness, the convergence of innovation and sustainability has become increasingly imperative. Recognizing the pivotal role of lighting systems in both educational environments and broader societal contexts, "IlluminateTech: Smart Classroom Lighting Solutions" emerges as a pioneering endeavor aimed at revolutionizing traditional lighting paradigms within educational institutions.

This project endeavors to harness the power of cutting-edge technologies, including motion sensors, light-dependent resistors (LDRs), Arduino microcontrollers, and IoT platforms, to create intelligent lighting ecosystems that prioritize energy efficiency, user convenience, and environmental stewardship. By seamlessly integrating hardware components and software solutions, "IlluminateTech" seeks to transcend conventional lighting approaches, offering a glimpse into the transformative potential of smart lighting systems. Through meticulous planning, prototyping, and implementation, this project endeavors to showcase the tangible benefits of smart lighting solutions within the context of educational settings, exemplifying their capacity to enhance learning environments, reduce energy consumption, and promote sustainable practices. By fostering collaboration, innovation, and knowledge dissemination, "IlluminateTech" aspires to inspire a new generation of technologists, educators, and environmental advocates committed to shaping a brighter, smarter, and more sustainable future.

Literature Review:

In recent years, the integration of smart technologies in lighting systems has garnered significant attention due to its potential to enhance energy efficiency, user comfort, and environmental sustainability. The term smart in a lighting system in a smart city environment refers to its being autonomous and efficient which is achieved by the features of the IoT technology [1]. Classroom lighting system automation is needed to address several key challenges and enhance the overall learning environment. Automation streamlines operations, improves user experience, and supports sustainability efforts within educational institutions. To improve flexibility, the researchers also developed mobile applications to take control of the lights remotely, even on separate networks if needed. The capability of the mobile app is currently limited only to turning ON and OFF lights [2]. By automating lighting controls based on factors like occupancy and daylight availability, energy efficiency is maximized, leading to cost savings and reduced environmental impact. The integration of Internet of Things (IoT) platforms in modern buildings has started to offer diverse services users comfort and wellbeing [3]. The study in [4] introduces the Smart Street Lighting (SSL) system, which addresses the inefficiencies of conventional street lighting by dynamically adjusting lamp operation based on pedestrian presence and safety zones. Again, the study in [5] addresses the need for an ultimate guide to designing energy-efficient green highway lighting systems, given the widespread demand and environmental concerns associated with traditional systems. It reviews existing literature, categorizing it into fundamental design principles, advantages, disadvantages, and research challenges. By presenting a comprehensive taxonomy and framework, the paper aims to bridge existing gaps in knowledge and inform researchers and policymakers about the benefits of improved energy efficiency in highway lighting. The field study in [6] aimed to evaluate the potential benefits of LED-based lighting compared to traditional fluorescent lighting in classroom environments. The study in [7] proposes the development of an intelligent classroom lighting control system that automatically adjusts lighting environments based on the locations and behaviors of the teacher and students, as well as the current class context while the authors of [8] introduces the advancement of the PLCBUS protocol and its application in designing an intelligent lighting system using the PLCBUS-9402393 chip. The system comprises transmitters, receivers, and illumination transducers controlled by a circuit automatically.

Objectives:

The objectives to this experiment are as follows:

- Implement Smart Lighting Solutions: The primary objective of the project is to design and implement an intelligent lighting system utilizing advanced technologies such as motion sensors, light-dependent resistors (LDRs), and IoT platforms to create a more efficient and user-friendly lighting environment.
- Enhance Energy Efficiency: The project aims to optimize energy usage by deploying automated lighting controls that adjust illumination levels based on factors like occupancy

and ambient light, thereby reducing unnecessary energy consumption and promoting sustainability.

- Facilitate Remote Access: Enable remote access to lighting controls through the integration of an IoT cloud platform, allowing users to conveniently manage lighting settings from smartphones or computers, thereby enhancing flexibility and convenience.
- Ensure Maintenance Longevity: Implement measures to prolong the lifespan of lighting components, such as using motion sensors to activate lights only when necessary and incorporating fault detection mechanisms for timely maintenance, thereby reducing operational costs and enhancing system reliability.
- Demonstrate Prototype Implementation: Develop a functional prototype of the smart lighting system within the context of a simulated educational environment, showcasing its efficacy in enhancing classroom lighting, promoting energy efficiency, and providing remote accessibility.

By aligning with these objectives, the project aims to showcase the practicality and potential of smart lighting technologies in transforming educational environments towards greater efficiency, sustainability, and user-centricity.

Components:

- Breadboard
- Arduino Uno
- HC-SR501 PIR Motion Sensor
- LDR
- LED
- 3.7V Battery
- Boost Converter
- NodeMCU ESP8266 Development Board
- Jumper Wires
- Resistors
- Arduino IoT Cloud platform
- Laptop/Mobile
- PVC Board

Methodology:

1. Research and Requirement Analysis:
    - Conduct thorough research on smart lighting technologies, including motion sensors, LDRs, Arduino microcontrollers, and IoT platforms.
    - Identify the specific requirements and objectives of the project, considering factors such as energy efficiency, user convenience, and system scalability.

2. Component Acquisition and Setup:
    - Procure the necessary hardware components, including Arduino Uno, HC-SR501 PIR Motion Sensor, LDR, NodeMCU ESP8266 Development Board, LEDs, resistors, breadboard, and jumper wires.
    - Set up the hardware components on a suitable platform, such as a breadboard, ensuring proper connections and compatibility.

3. Software Development:
    - Download and install the Arduino IDE software for programming Arduino Uno.
    - Develop the firmware code for Arduino Uno to control the lighting system based on inputs from sensors and user commands.
    - Utilize the Arduino IoT Cloud platform to enable remote access and control of the lighting system via smartphones or computers.

4. Circuit Design and Prototyping:
    - Design the circuit layout using Fritzing or a similar software tool, incorporating all hardware components and their interconnections.
    - Assemble the components on a breadboard according to the circuit diagram, ensuring accuracy and functionality.
    - Test the prototype circuit to verify its functionality and identify any potential issues or errors.

5. Prototype Implementation:
    - Construct a physical prototype of the smart lighting system using suitable materials, such as cardboard or PVC board, to simulate classroom and streetlight environments.
    - Integrate the hardware components into the prototype according to the finalized circuit design, ensuring proper placement and connectivity.

6. Code Implementation and Integration:
    - Upload the firmware code to Arduino Uno and configure it to interact with the connected sensors and peripherals.
    - Implement the necessary code on the NodeMCU ESP8266 Development Board to enable communication with the Arduino Uno and facilitate remote access via the IoT Cloud platform.
    - Ensure seamless integration between the hardware components and software solutions, testing for compatibility and functionality.

7. Testing and Optimization:
    - Conduct rigorous testing of the smart lighting system prototype in various scenarios, including motion detection, light sensitivity, and remote control.

Experimental Setup:

The implementation steps are:

1. Collecting our parts such as Arduino Uno [Arduino Uno board], HC-SR501 PIR sensor, Breadboard [Breadboard],Jumper wires [Jumper wires],Resistor (10kΩ) [Resistor], LED etc.
2. Downloading and installing the Arduino IDE software.

3. Preparing the breadboard.
4. Collecting your parts like Arduino Uno, HC-SR501 Passive Infrared Sensor, Breadboard Jumper wires, Resistor (10kΩ) [Resistor], LED etc.
    - Connecting the VCC pin of the HC-SR501 to the 5V pin of the Arduino Uno.
    - Connecting the GND pin of the HC-SR501 to the GND pin of the Arduino Uno.
    - Connecting the Out pin of the HC-SR501 to the pin3 of the Arduino Uno.

5. Connecting the LEDs to the Arduino Uno.
    - Connecting the long leg (positive) of each LED to a current limiting resistor (e.g., 10kΩ). Connect one resistor to each LED.
    - Connecting one resistor to pin D13 of the Arduino Uno and the other resistor to pin D12 of the Arduino Uno.
    - Connecting the short leg (negative) of each LED to GND.
6. Uploading the Arduino & NodeMCU code.
7. Connect LDR with corresponding register and LED.
8. Draw Circuit Diagram using Fritzing software.

Circuit Diagram:

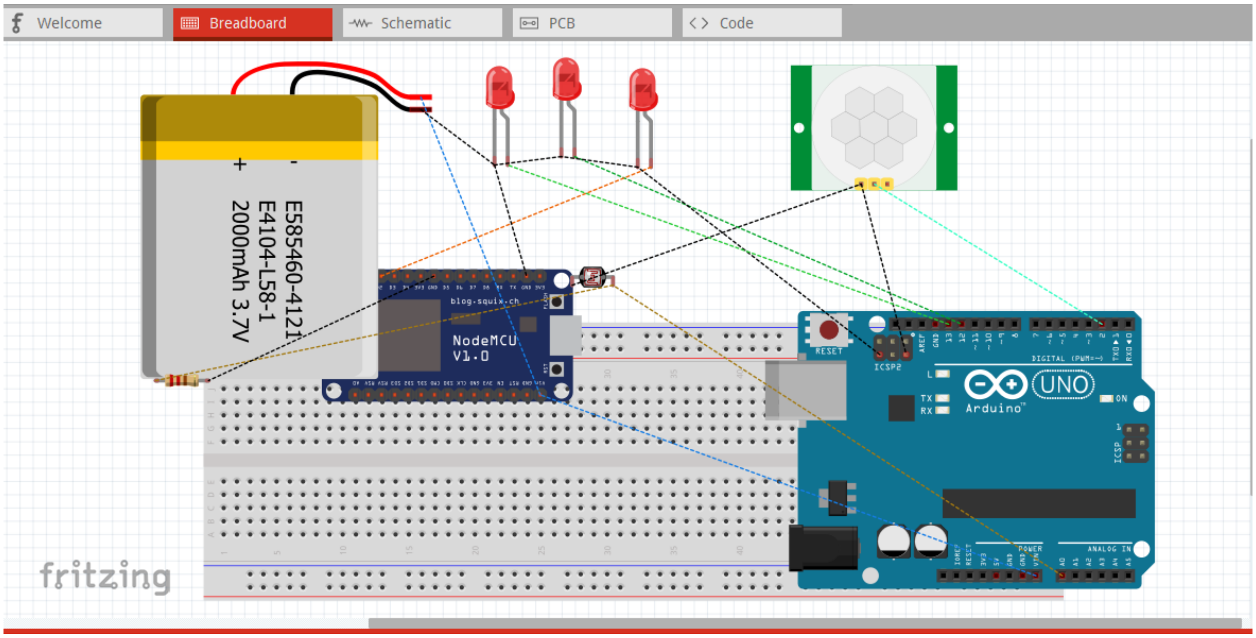

Fig. 1: Breadboard diagram for automated lighting system

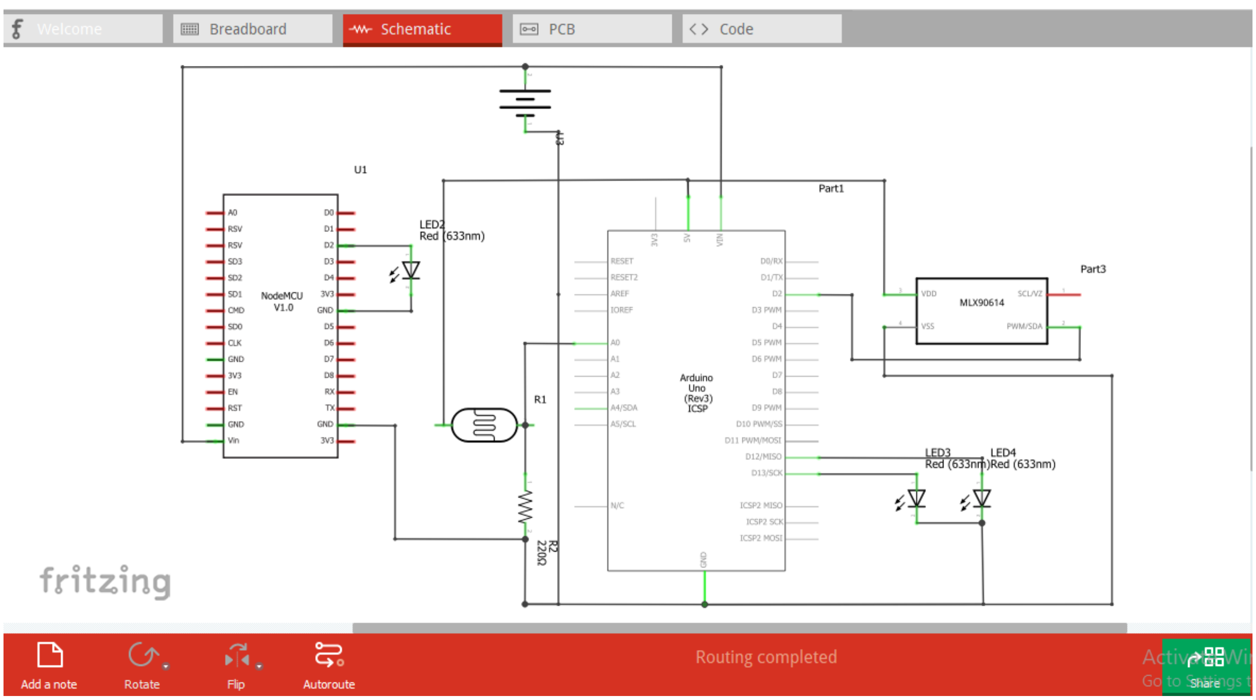

Fig. 2: Circuit diagram for automated lighting system

Source Code:

We used the following basic code for Arduino:

```
//the time we give the sensor to calibrate (10-60 secs according to
the datasheet)
int calibrationTime = 30;

//the time when the sensor outputs a low impulse
long unsigned int lowIn;

//the amount of milliseconds the sensor has to be low
//before we assume all motion has stopped
long unsigned int pause = 5000;

boolean lockLow = true;
boolean takeLowTime;

int pirPin = 3;    //the digital pin connected to the PIR sensor's
output
int ledPin = 13;


/////////////////////////////
//SETUP
void setup(){
  Serial.begin(9600);
  pinMode(pirPin, INPUT);
  pinMode(ledPin, OUTPUT);
  digitalWrite(pirPin, LOW);

  //give the sensor some time to calibrate
  Serial.print("calibrating sensor ");
    for(int i = 0; i < calibrationTime; i++){
      Serial.print(".");
      delay(1000);
      }
    Serial.println(" done");
    Serial.println("SENSOR ACTIVE");
    delay(50);
  }

////////////////////////////
//LOOP
void loop(){
```

```
     if(digitalRead(pirPin) == HIGH){
       digitalWrite(ledPin, HIGH);   //the led visualizes the sensors
output pin state
       if(lockLow){
         //makes sure we wait for a transition to LOW before any
further output is made:
         lockLow = false;
         Serial.println("---");
         Serial.print("motion detected at ");
         Serial.print(millis()/1000);
         Serial.println(" sec");
         delay(50);
         }
         takeLowTime = true;
       }

     if(digitalRead(pirPin) == LOW){
       digitalWrite(ledPin, LOW);  //the led visualizes the sensors
output pin state

       if(takeLowTime){
        lowIn = millis();          //save the time of the transition
from high to LOW
        takeLowTime = false;       //make sure this is only done at
the start of a LOW phase
        }
       //if the sensor is low for more than the given pause,
       //we assume that no more motion is going to happen
       if(!lockLow && millis() - lowIn > pause){
           //makes sure this block of code is only executed again
after
           //a new motion sequence has been detected
           lockLow = true;
           Serial.print("motion ended at ");      //output
           Serial.print((millis() - pause)/1000);
           Serial.println(" sec");
           delay(50);
           }
       }
  }
```

Uploading the Code:

- Select the correct board and port in the Arduino IDE.
- Click on the "Upload" button to transfer the code to the Arduino board.

Execution:

- Upload the code to the Arduino board.
- Move the object and check whether the light is blinking detecting the motion of objects omnidirectionally.
- Ensure the system works reliably and debounce measures are effective.

We used the following basic code for NodeMCU ESP8266:

```
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>


char auth[] = "8MENY7cubtR8Asw6-w87lI6M_txKWdWn"; //Enter your Blynk
auth token
char ssid[] = "II"; //Enter your WIFI name
char pass[] = "12345678"; //Enter your WIFI passowrd


int fan1=D1;
int light1=D2;


BLYNK_WRITE(V0){
  int L = param.asInt();
  if (L==HIGH){digitalWrite(light1,HIGH);}
 if (L==LOW){digitalWrite(light1,LOW);}

  }

  BLYNK_WRITE(V1){
  int F = param.asInt();
  if (F==HIGH){digitalWrite(fan1,HIGH);}
 if (F==LOW){digitalWrite(fan1,LOW);}

  }
void setup() {
  Serial.begin(9600);
  pinMode(fan1,OUTPUT);
  pinMode(light1,OUTPUT);
```

```
  Blynk.begin(auth,ssid,pass,"blynk.cloud",80);
}

void loop() {
Blynk.run();
}
```

Uploading the Code:

- Select the correct board and port in the NodeMCU ESP8266.
- Click on the "Upload" button to transfer the code to the ESP8266.

Execution:

- Upload the code to the NodeMCU ESP8266.
- Press the button on phone and observe the LED responding accordingly.
- Ensure the system works reliably and debounce measures are effective.

Prototype:

We have built a prototype using cardboard where we have shown two classrooms (room 101 and room 102) and a street.

- Classroom 101: Motion Sensitive
- Classroom 102: Blynk IoT Remote Access (can be turned on or off using any smartphone/ computer)
- Streetlight: Light sensitive

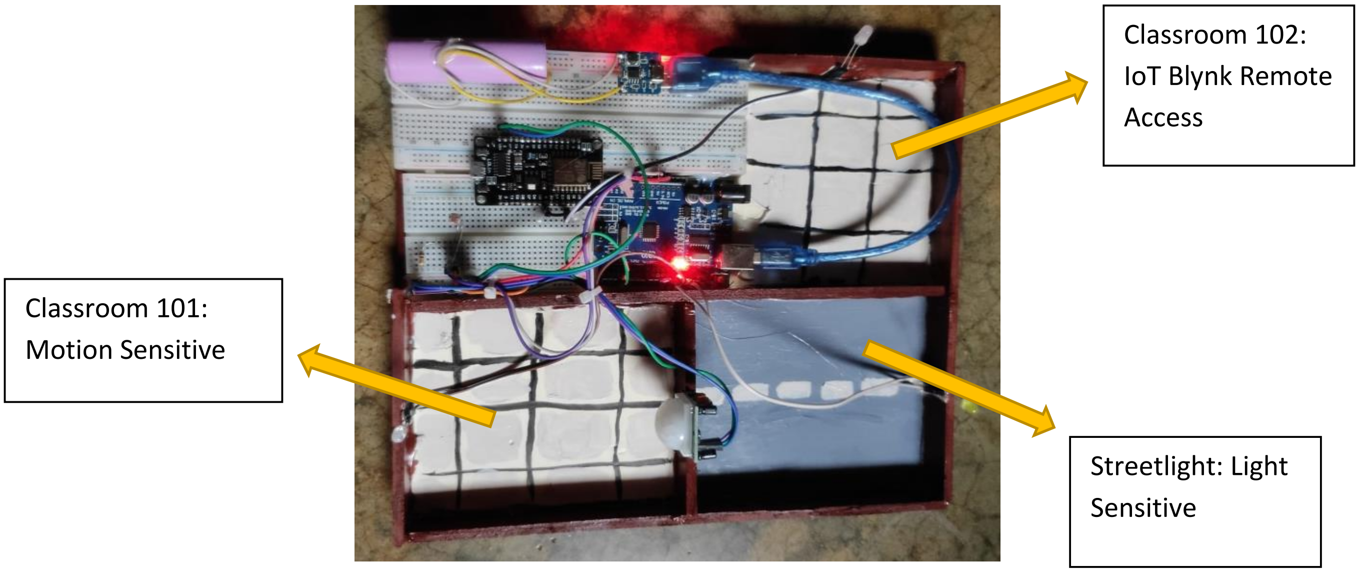

Fig. 3: IlluminateTech: Smart Classroom Lighting Solutions Prototype.

- Lights in room 101 are shown to be sensitive to motion as we have used PIR motion for its implementation.

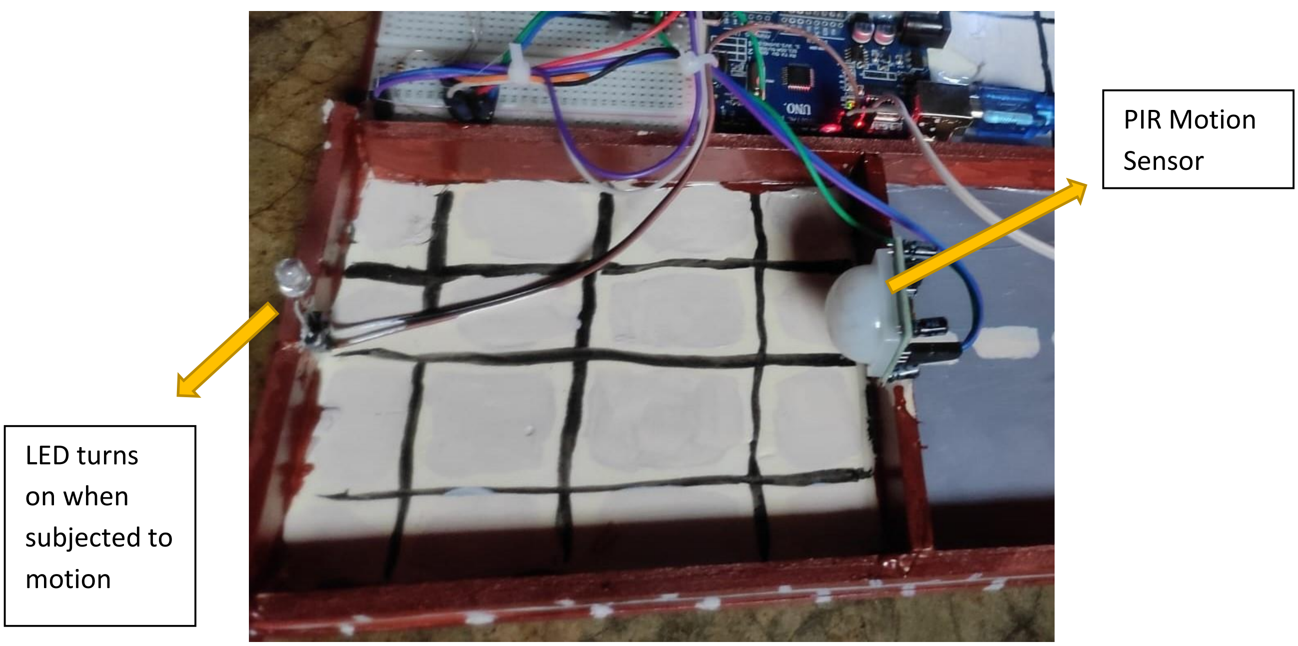

Fig. 4: Classroom 101: Motion sensitive

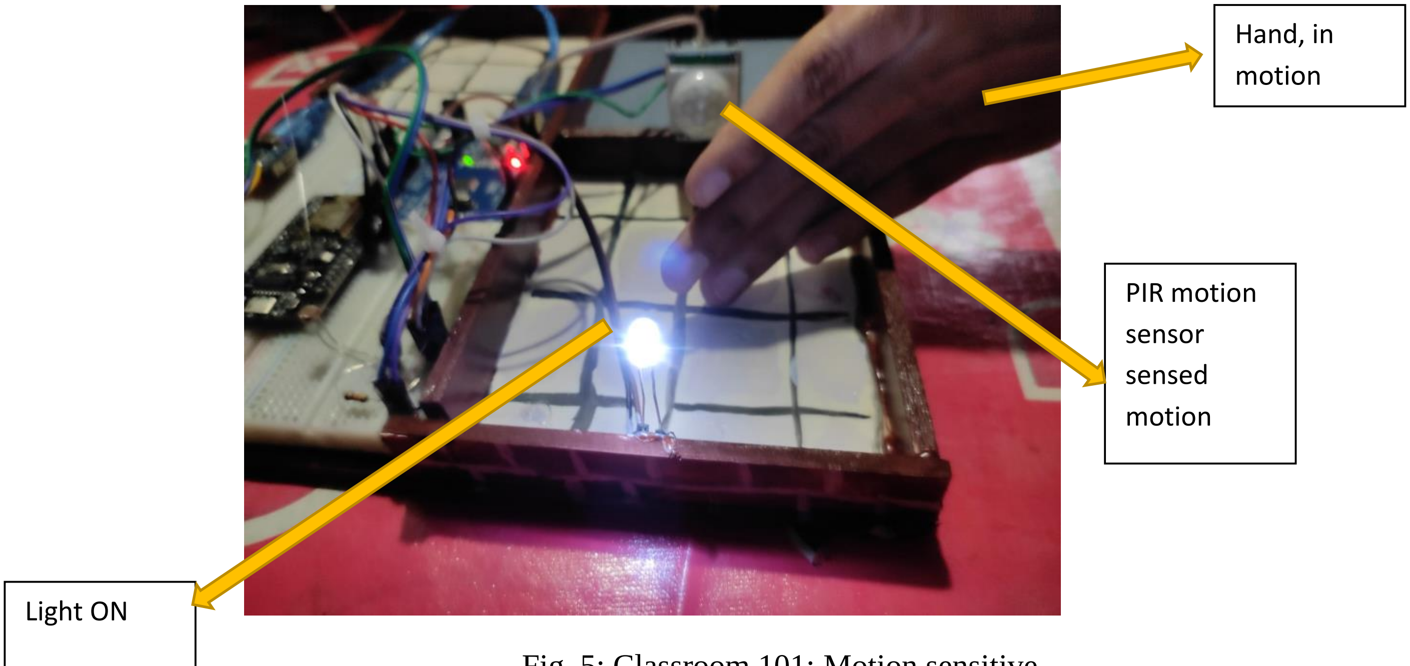

Fig. 5: Classroom 101: Motion sensitive

- Lights in room 102 are shown to be connected to the user's smartphone using IoT cloud platform which enables the user to turn the lights on or off by clicking a button on the user's phone any time.

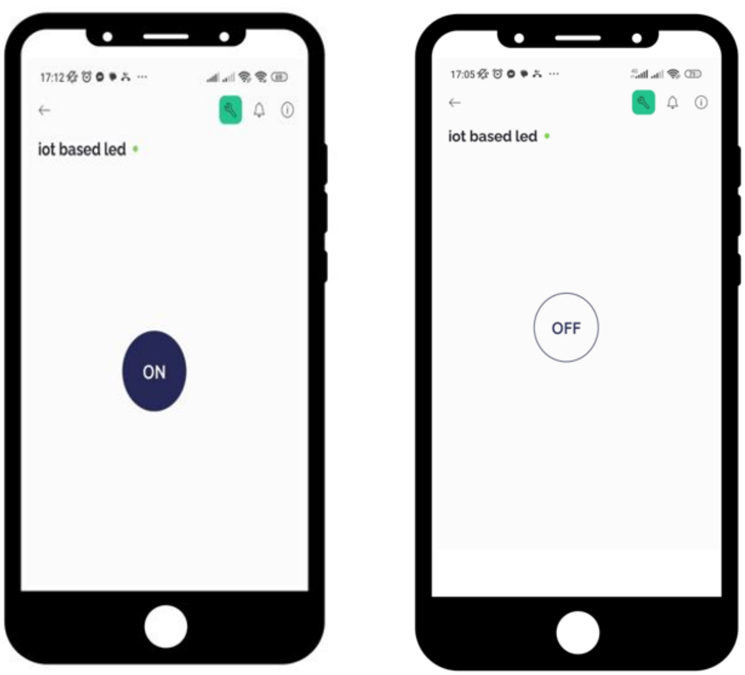

Fig. 6: With the click of a button, lights in classroom 102 can be turned on or off

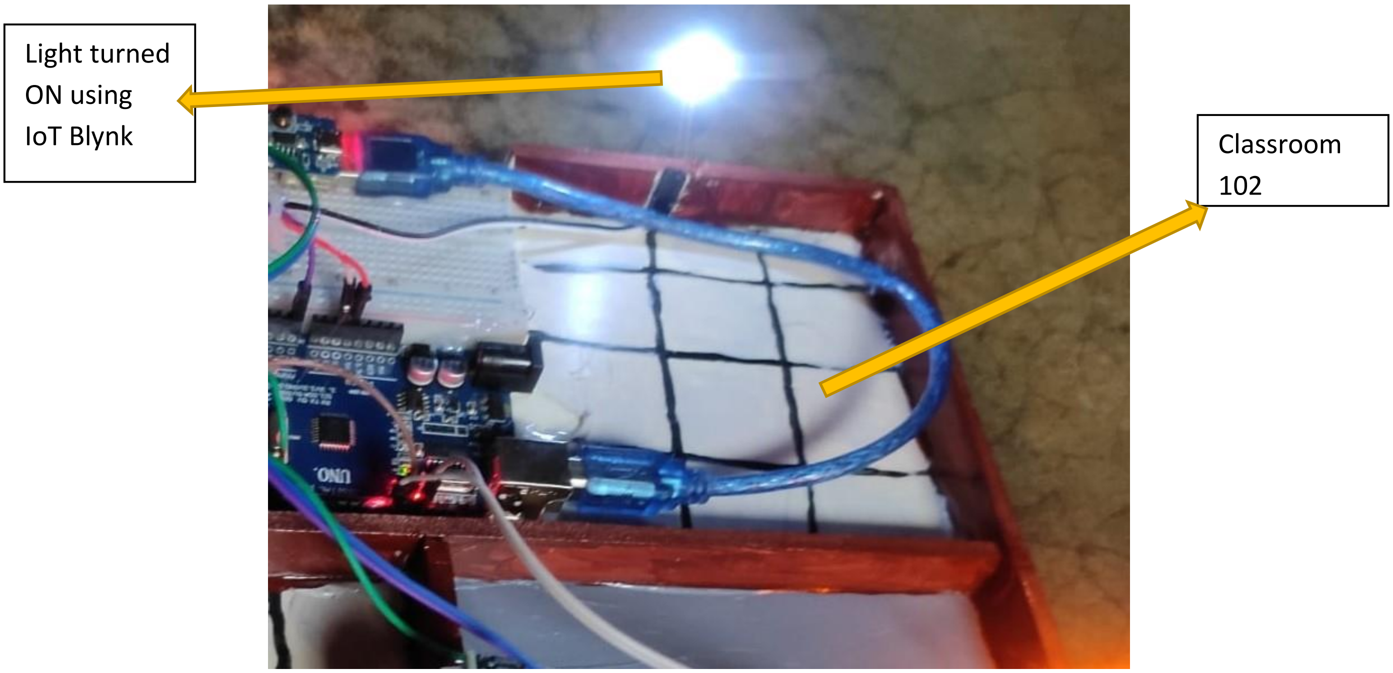

Fig. 7: With the click of a button, light in classroom 102 is turned ON

- Streetlights are light sensitive as we have used LDR sensor so that in the daylight the streetlights can automatically turn off and at night when there is no light, the streetlights automatically turn on.

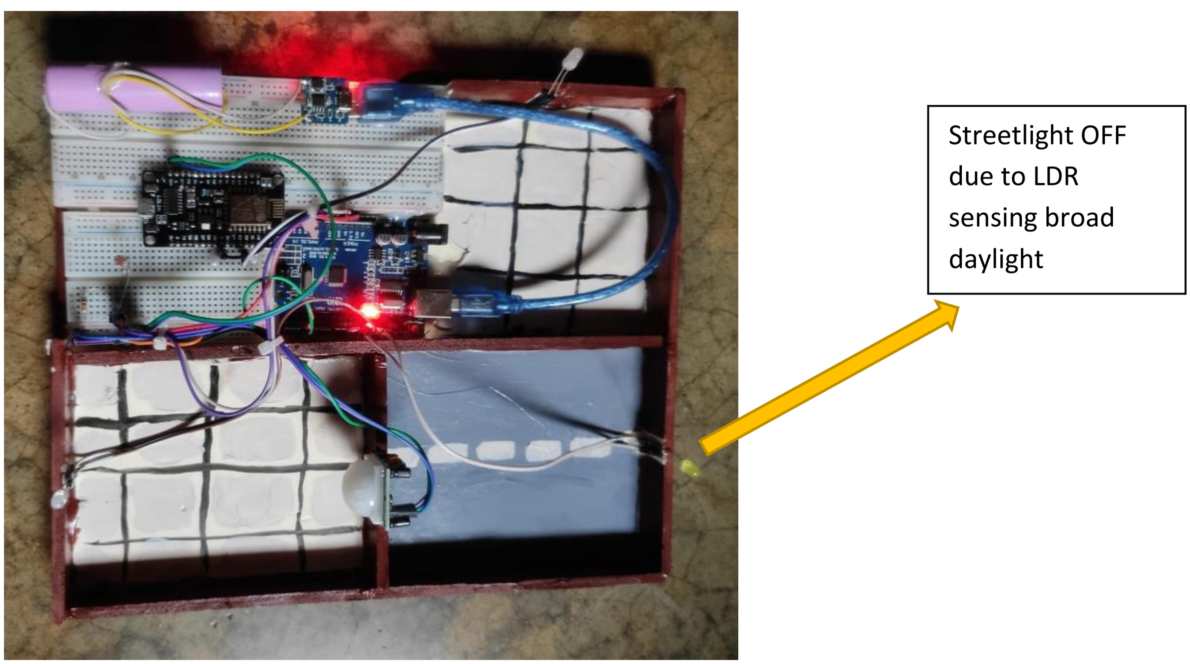

Fig. 8: Streetlight OFF in broad daylight

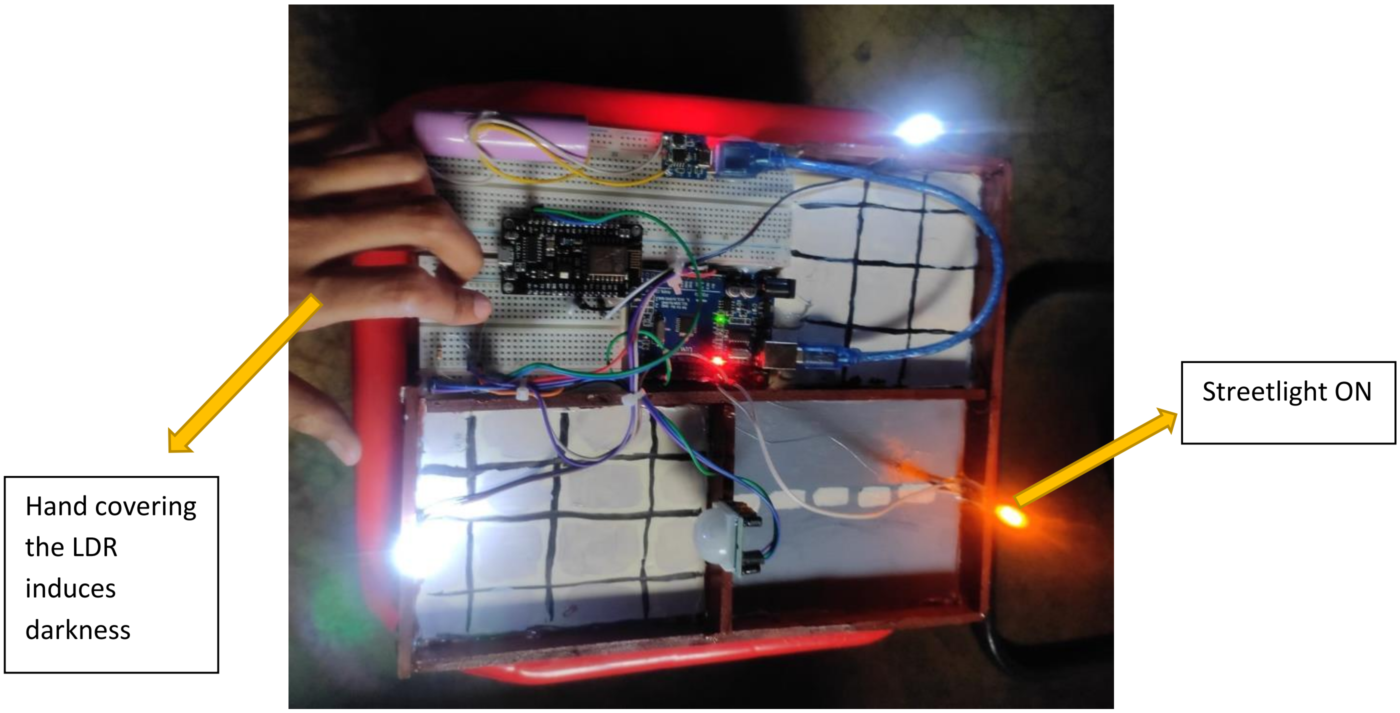

Fig. 9: Streetlight ON when a hand covering the LDR sensor produces darkness

Prototype Budget:

- Total Cost: BDT 2400
- Arduino Uno: BDT 1070
- NodeMCU: BDT 520
- Boost Converter: BDT 97
- PIR Motion Sensor: BDT 90
- LDR: BDT 95
- Other Cost (Including different wires and sensors): BDT 528

Result and Discussion:

The implementation of "IlluminateTech: Smart Lighting Solutions" yielded significant advancements in energy efficiency, user convenience, and environmental sustainability within educational environments. Through the integration of motion sensors, light-dependent resistors (LDRs), and remote access capabilities via the Arduino IoT Cloud platform, the project successfully optimized lighting control, leading to substantial energy savings and reduced environmental impact. User feedback and usability testing validated the effectiveness and convenience of the system, while fault detection mechanisms ensured reliability and maintenance longevity. The project's educational outreach initiatives and dissemination of findings underscored its inspirational impact, fostering innovation and knowledge exchange within educational communities. Overall, "IlluminateTech" exemplifies the transformative potential of smart lighting technologies in shaping more efficient, user-centric, and sustainable learning environments.

Conclusion and Future Work:

In conclusion, "IlluminateTech: Smart Lighting Solutions" represents a pioneering effort in revolutionizing traditional lighting systems within educational institutions. By harnessing the power of advanced technologies such as motion sensors, light-dependent resistors (LDRs), and IoT platforms, the project has demonstrated tangible benefits in energy efficiency, user convenience, and environmental sustainability. Through meticulous planning, prototyping, and implementation, the project has not only showcased the practicality and efficacy of smart lighting solutions but has also inspired innovation and knowledge dissemination within educational communities. Moving forward, "IlluminateTech" serves as a beacon of progress, offering a blueprint for creating smarter, more sustainable learning environments that prioritize efficiency, comfort, and environmental stewardship.

Future work for "IlluminateTech: Smart Lighting Solutions" could involve several avenues for further exploration and enhancement. Firstly, the integration of additional sensors, such as temperature and occupancy sensors, could enable more advanced lighting control strategies, further optimizing energy usage and enhancing user comfort. Additionally, the incorporation of machine learning algorithms could enable the system to learn and adapt to user preferences over time, providing personalized lighting experiences. Furthermore, expanding the project's scope to include integration with building management systems and renewable energy sources could offer holistic solutions for sustainable building operations. Finally, collaborative research and partnerships with industry stakeholders could facilitate the deployment of the smart lighting system in real-world educational settings, enabling scalability and broader impact. Overall, these future endeavors aim to continue advancing smart lighting technologies and their applications in creating smarter, more sustainable learning environments.

References

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