AUTOMATIC FAULT DETECTION IN STREET LIGHTS

A PROJECT REPORT

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In partial fulfilment for the award of the degree

of

BACHELOR OF ENGINEERING

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

UNIVERSITY COLLEGE OF ENGINEERING, DINDIGUL – 624622

ANNA UNIVERSITY: CHENNAI 600 025

APRIL 2024

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ACKNOWLEDGEMENT

All praise, honour and glory to the Lord Almighty, the source of all knowledge for his gracious presence and guidance to apply required knowledge and effort to complete the work in time.

It is indeed a great pleasure to express our sincere thanks to our Dean **Dr.S.SUTHA M.E., Ph.D.,** University college of Engineering, Dindigul for his sincere guidance and encouragement in all aspects for the project.

We highly indebted to our Head of the Department of Electronics and Communications Engineering **Dr.S.SUTHA M.E., Ph.D.,** for her guidance, support and encouragement throughout the course of our project.

We would like to thank our project Co-ordinator **Dr.S.SUTHA M.E., Ph.D.,** for providing with great sincerity, for the valuable guidance, support throughout the development of this project

Its pleasure to express our sincere gratitude to our project guide **Dr.S.AISWARYA M.E., Ph.D.,** Department of Electronics and Communications Engineering University college of Engineering, Dindigul for providing necessary information regarding the project and also for her support in completing the project

We wish to convey our sincere thanks to all the teaching and non-teaching staffs of ECE Department. Our heartfelt gratitude and thanks to our parents and friends for their perceptual support.

We also humble extend our sincere gratitude to our loving family and friends for their constant support during this project work.

ABSTRACT

Solar energy is the energy that comes from the sun in the form of light and heat. This renewable energy can be turned into electricity or other useful forms of energy, thereby it significantly reducing the energy consumption and costs of the street lighting system. The project "Automatic Fault Detection in Street Lights", focuses on creating a system to quickly identify problems with street lights, thereby making public spaces safer and more reliable. The old methods of checking street lights are slow and requires a lot of manual work. The system aims to speed things up and make it easier by using components such as an Arduino UNO board, LCD display, LED lights, LDR sensor, Ultrasonic sensor, Solar panel, and Battery. The Arduino UNO board is the main component responsible for coordinating and controlling the operation of the entire system. The system uses sensors called LDR sensor, or Light Dependent Resistor sensor is a device that used to detect the intensity of the light this helps us quickly identify. If the solar lights are working or not working, so we can fix any problems and keep them operational. The Ultrasonic sensor is a device that used to sense the movement of vehicles, pedestrians, or animals on the road. If there is any object comes within a threshold distance of the ultrasonic Sensor, the light will turn ON, otherwise the light will turn OFF. If any fault is detected in the system, it will show the error message on the LCD screen. The system saves energy by turning lights ON by using ultrasonic sensor in our system helps to save money on repairs by finding problems early, so there is less need for fixing them often like with regular street lights, also using solar power and LED lights helps the environment by reducing pollution and using less energy, reliable, bright lights make public places safer for everyone.

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CHAPTER 1
INTRODUCTION

1.1 OVERVIEW

In the olden days, we used manual operation for street lights, requiring manpower to operate them. If the person responsible for operation was late, the lights would remain ON until morning, leading to electricity wastage. Moreover, detecting faults in the street lights required manual inspection by a technician, which could result in delays and potential accidents.

To address these issues, an automatic fault street light system was introduced. Presently, we rely on automated systems, which operate based on preset schedules. However, these systems have limitations, especially when there are variations in sunrise and sunset times due to seasonal and climatic changes. Therefore, a new automatic system is needed.

Moreover, the manual operation of street lights posed safety risks, particularly in instances where lights failed to illuminate due to oversight or malfunction. Inadequate lighting on roads and thoroughfares could lead to accidents, posing a threat to both motorists and pedestrians alike. Additionally, the manual nature of fault detection meant that identifying and rectifying issues with street lights required physical inspection by technicians, often resulting in delays and prolonged periods of inadequate illumination.

Furthermore, the manual operation of street lights was not conducive to adapting to changes in environmental conditions, such as fluctuations in sunset and sunrise times due to seasonal variations. This lack of flexibility meant that street lights may have been left. ON for longer periods during certain times of the year, leading to increased energy consumption and associated costs.

Overall, while the manual operation of street lights served its purpose during earlier times, it was inherently inefficient, costly, and posed safety risks. These limitations necessitated the development of more sophisticated and automated solutions to address the evolving needs of urban lighting management.

In our proposed system, we are using an LDR sensor to measure how bright it is outside. This helps us deal with the problems we talked about before. Additionally, we are integrating an Ultrasonic sensor to detect the movement of vehicles or pedestrians on the road. When the Ultrasonic sensor detects an object nearby, it triggers the lights to turn ON automatically. Conversely, if there is no activity, the lights stay OFF, contributing to energy conservation efforts.

Additionally, our system can find faults quickly. If there is any problem with the lights, such as a malfunction or breakdown, the system promptly alerts us by displaying an error message on the LCD screen. This allows for quick identification and resolution of issues, ensuring that the street lights operate smoothly and reliably, this helps us fix issues fast and make sure the street lights work well.

By incorporating these sensors and diagnostic features into the street light system, we aim to enhance efficiency, safety, and reliability in urban lighting management. With this approach, we are confident that our system will provide a more responsive and sustainable solution for lighting up our cities.

For developing our proposed automatic street light system, we are using Wokwi online simulator, a powerful tool for simulating and testing electronic circuits. Wokwi provides us with a virtual environment where we can design, simulate, and debug our circuitry before implementing it in the real world. By using Wokwi online simulator, we can efficiently prototype and refine our system, ensuring its functionality and reliability before deployment.

This allows us to streamline the development process and minimize potential errors, ultimately leading to a more robust and effective street lighting solution. With the support of Wokwi online simulator, we are confident in our ability to create a street light system that meets the demands of modern urban environments.

Overall, our proposed automatic street lights system is designed to be more efficient, safer, and reliable for urban areas, it is a smarter solution for modern cities.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The literature surrounding automatic fault detection in street lights without IoT presents a rich landscape of research and technological advancements aimed at improving urban lighting management. While many studies primarily focus on IoT-based solutions, recent inquiries have emerged to explore non-IoT approaches, emphasizing cost-effectiveness, scalability, and sustainability.

2.1.1 NATIONAL HIGHWAY STREET LIGHT FAULTY DETECTION AND MONITORING SYSTEM:

In 2019, Praveen et al. [1] proposed a novel method aimed at revolutionizing street light fault detection and monitoring processes. The method offers a straightforward yet highly effective solution, leveraging modern technology to streamline operations while enhancing energy efficiency.

By introducing a system that enables remote control through Internet of Things (IoT) infrastructure, the need for manual on-site work is significantly reduced. This innovative approach not only eliminates the logistical challenges associated with traditional fault detection methods but also ensures prompt and efficient response to any issues that may arise.

Central to this system is the utilization of the Node MCU ESP8266 microcontroller, renowned for its energy-efficient operation and robust fault detection capabilities. Despite the complexity of its design, the Node MCU ESP8266 proves to be an ideal choice for the task at hand, offering a reliable platform for managing street light operations effectively. Its integration into the system allows for real-time monitoring and control, enabling swift identification and resolution of any faults or malfunctions.

However, it is essential to recognize the system is reliance on internet connectivity for its remote control and monitoring functionalities. While this dependency may present certain challenges, the benefits it brings in terms of convenience, efficiency, and cost-effectiveness are undeniable. By leveraging IoT technology, this system provides unprecedented levels of automation and oversight, ultimately leading to enhanced energy conservation and substantial cost savings for municipalities and local authorities.

By embracing modern technology and leveraging the capabilities of the Node MCU ESP8266 microcontroller, this system sets a new standard for efficiency and reliability in street light management, paving the way for smarter, more sustainable urban infrastructure.

In this project the major issue is internet dependency, as relying on internet connectivity for remote control and monitoring may lead to system downtime or limited functionality, especially in areas with poor or unstable internet coverage. The NodeMCU ESP8266 microcontroller's design is complex, with few GPIO pins, limited processing power, flash memory, and it consumes more power.

In conclusion, Praveen et al.'s innovative approach to street light fault detection and monitoring represents a significant advancement in the field, offering a comprehensive solution that addresses both operational challenges and sustainability goals.

2.1.2 IOT BASED AUTOMATIC DAMAGED STREET LIGHT FAULT DETECTION MANAGEMENT SYSTEM:

In 2020, Ashok Kumar Nanduri et al. [2] introduced an IoT-based automatic damaged street light fault detection management system, representing a significant step forward in optimizing street light operations. Their innovative system capitalizes on advanced technology to automate street light control, aiming to conserve power and enhance operational efficiency. At the core of this system lies the PLC XD26 microcontroller, a powerful device known for its capabilities in automation and control. By leveraging the PLC XD26, the system can effectively monitor street light functionality and detect faults with minimal human intervention, one of the primary leads of this system is its potential to significantly reduce energy consumption.

Through automated control mechanisms, unnecessary illumination can be avoided, thereby conserving power. Additionally, the system enables remote monitoring capabilities, allowing stakeholders to oversee street light operations in real-time. This feature not only enhances operational efficiency but also facilitates prompt response to any detected faults or malfunctions, ensuring timely maintenance and repair.

However, despite its promising benefits, there are notable drawbacks associated with the implementation of this system. One significant concern is the high cost associated with deploying the PLC XD26 microcontroller. The initial investment required for acquiring and integrating this technology may pose a barrier to adoption, particularly for municipalities or organizations with limited financial resources.

Moreover, the setup and maintenance of the system entail a degree of complexity, which could potentially hinder seamless deployment and operation. Furthermore, the system's reliance on internet connectivity for remote monitoring introduces a level of vulnerability. In areas with unstable or unreliable internet access, the effectiveness of the remote monitoring functionality may be compromised, leading to potential disruptions in street light management operations.

Additionally, concerns regarding data security and privacy must be addressed to ensure the integrity and confidentiality of the information transmitted through the IoT infrastructure. While Ashok Kumar Nanduri et al.'s IoT-based automatic damaged street light fault detection management system offers compelling lead in terms of power conservation and operational efficiency, careful consideration must be given to its implementation challenges and associated costs.

The decision to adopt such a system should be informed by a thorough assessment of its feasibility, considering factors such as budgetary constraints, technical expertise, and reliability of internet connectivity. Despite these challenges, the potential long-term benefits of improved street light management justify further exploration and investment in innovative IoT solutions.

In this project the major issues they are facing Internet dependency: Reliance on internet connectivity for remote control and monitoring may result in system downtime or limited functionality in areas with poor or unstable internet coverage.

The PLC XD26 microcontroller is complex to design and requires a specific type of programming called ladder logic. It is also more expensive and not as flexible for testing. Because fewer people use it, there is not as much help available if you run into problems. It might not work with all the parts you want to use, and getting it set up can be costly.

2.1.3 AUTOMATIC STREET LIGHT CONTROL AND FAULT DETECTION SYSTEM WITH CLOUD STORAGE:

In 2017, Gowdhaman et al. [3] introduced a method to revolutionize street lamp management through automatic control and fault detection, integrated with cloud storage. Their approach aimed to address inefficiencies of manual operation by utilizing technology, notably an Arduino board. Leveraging the Arduino board's capabilities, the system autonomously controls street lamp operations while detecting and reporting faults in real-time.

The key lead of this method is its emphasis on achieving economical operation. By automating street lamp control and fault detection, municipalities can potentially reduce costs associated with manual monitoring and maintenance. Moreover, immediate response to fault information minimizes downtime, enhancing operational efficiency. However, challenges exist. The system's reliance on internet connectivity for cloud storage introduces vulnerability, particularly in areas with limited access. Implementation and maintenance complexity may pose challenges, especially for organizations with limited resources.

Ensuring seamless integration and addressing compatibility issues complicates deployment. Thus, careful evaluation of feasibility and practicality is paramount. Factors such as internet reliability, scalability, and maintenance requirements must be assessed for viability. Gowdhaman et al.'s system represents a significant advancement in street lamp management, offering benefits in automation and real-time fault detection.

In this project the major issues they are facing Internet dependency: Reliance on internet connectivity for remote control and monitoring may result in system downtime or limited functionality in areas with poor or unstable internet coverage. Challenges like internet reliance and implementation complexity underscore the need for careful evaluation before adoption. Nevertheless, with proper planning, this approach holds promise for more efficient operations, such as internet dependency.

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CHAPTER 3
PROPOSED METHODOLOGY

3.1 PROPOSED SYSTEM

The system uses solar panels on each lamp post to power the streetlights, this energy makes the streetlights work, so the system does not need electricity from the grid. Light Dependent Resistor (LDR) sensor and Ultrasonic sensors control the operation of the lights based on sunlight visibility and motion detection. Each streetlight has a status checking LDR sensor for fault detection, sending data to the LCD display.

This efficient, modern solution aims to eliminate manual work, increase energy efficiency, reduce costs, and provide immediate fault information. By using solar energy, the system not only becomes more environmentally friendly but also more cost effective in the long run, as the recurring cost of electricity is significantly reduced.

A user interface serves as the central component of the system, providing operators with real-time insights into the health status of street lights. Through intuitive dashboards and visualizations, operators can monitor the performance of individual street lights, track historical data trends, and receive timely alerts for detected faults.

Additionally, the interface facilitates remote configuration and management, allowing operators to adjust system parameters and customize alerts according to specific requirements. One of the key advantages of this approach is its cost-effectiveness and scalability.

By eliminating the need for internet connectivity and centralized servers, the system reduces infrastructure requirements and operational costs significantly. Moreover, its modular architecture allows for seamless integration with existing street light networks, minimizing disruption during deployment.

Overall, the proposed system offers a robust and efficient solution for automatic fault detection in street lights, enhancing operational efficiency, and ensuring the reliability and sustainability of urban lighting infrastructure. As cities continue to evolve, investing in innovative technologies like this system will be essential for creating smarter, more livable urban environments for future generations.

3.2 BLOCK DIAGRAM

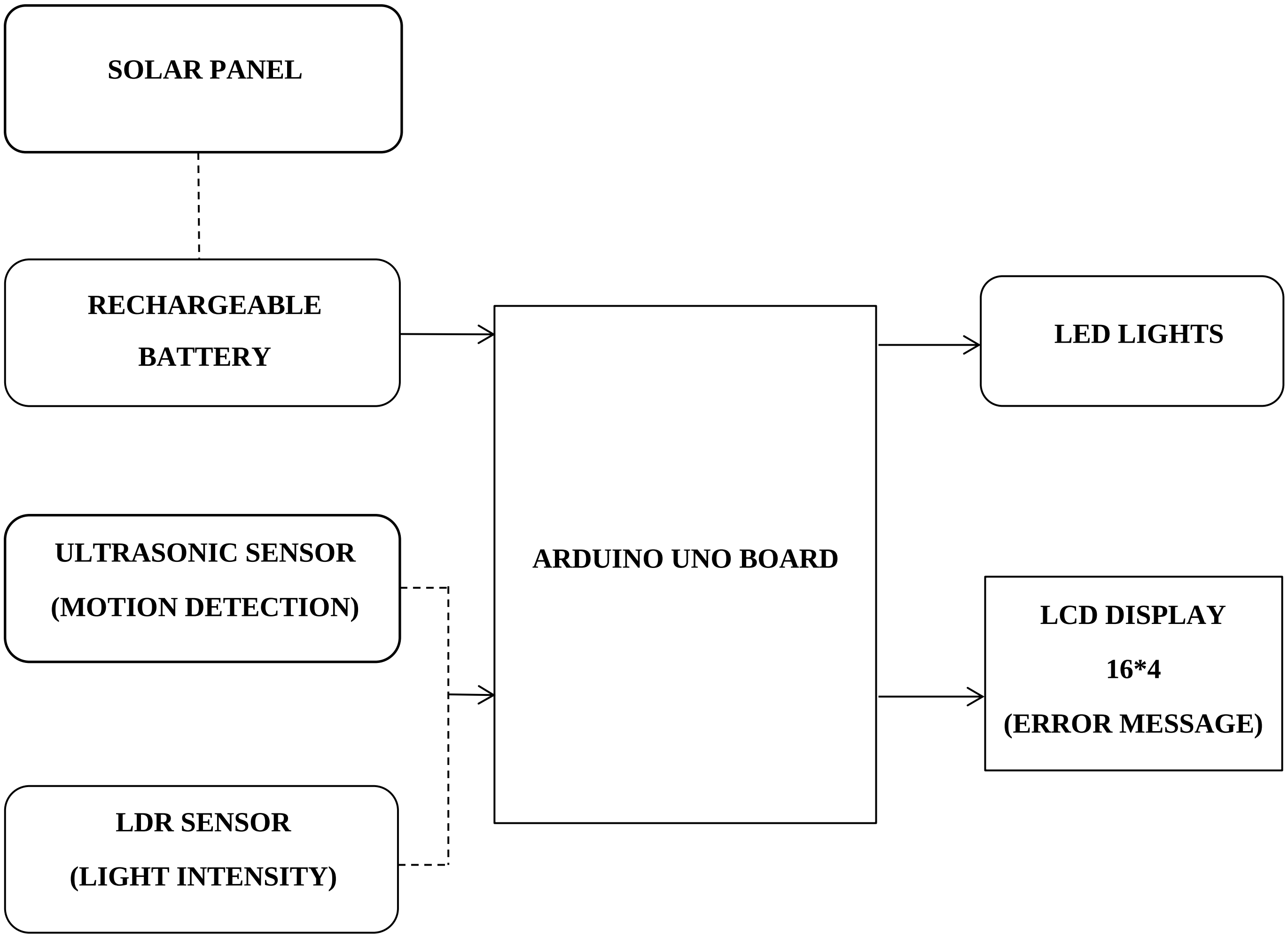

Figure 3.1 BLOCK DIAGRAM

The Block diagram of the proposed automatic fault detection system for street lights without IoT is designed with a modular, scalable, and efficient architecture. It includes four key components: Light Dependent Resistor (LDR) sensors, Ultrasonic sensors, an LCD display, and a microcontroller (Arduino UNO Board). The design aims to optimize energy efficiency and ensure reliable street lighting by integrating these advanced technologies The system begins with connecting three LDR sensors to the Arduino Uno board.

These sensors monitor ambient light levels to assess the performance and functionality of solar-powered street lights. This data helps ensure that the lights adjust according to the amount of natural light available, maximizing energy savings and optimizing performance.

Next, three ultrasonic sensors are also connected to the Arduino Uno. These sensors detect the movement of objects within their range, such as vehicles, pedestrians, or animals. If an object is detected, the corresponding LED street light will automatically switch ON. If there is no movement, the light remains OFF, reducing unnecessary energy consumption and promoting more efficient use of resources.

The system controls three LED lights connected to the Arduino Uno board. These lights symbolize street lights and are controlled based on input from the ultrasonic sensors. By adapting the brightness and activation of the lights according to detected movement, the system balances the need for effective illumination and energy conservation.

The system also features an LCD screen integrated into the design. This screen displays output and status information in real-time, providing a clear and immediate view of the system's functioning. If any faults or issues arise within the system, the LCD screen shows an error message, allowing for prompt identification and resolution of problems. The entire system is designed to be energy-efficient, leveraging solar panels to power the street lights. This environmentally conscious approach aligns with modern goals of sustainability and responsible resource management.

Overall, the automatic fault detection system represents a significant advancement in street lighting technology by combining smart sensors, efficient controls, and clear status displays to enhance performance, save energy, and improve the safety and quality of public spaces.

CHAPTER 4

SOFTWARE AND HARDWARE DESCRIPTION

4.1 SOFTWARE DESCRIPTION

4.1.1 ARDUINO IDE

The Arduino Integrated Development Environment (IDE) is a software tool that includes a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus.

It facilitates the development of programs for Arduino and Gen uino hardware by allowing users to write, compile, and upload code to their microcontrollers. Additionally, it enables communication with the Arduino hardware for debugging and monitoring purposes. This revised description provides a more comprehensive overview of the Arduino IDE's features and functionalities.

Figure 4.1 ARDUINO IDE

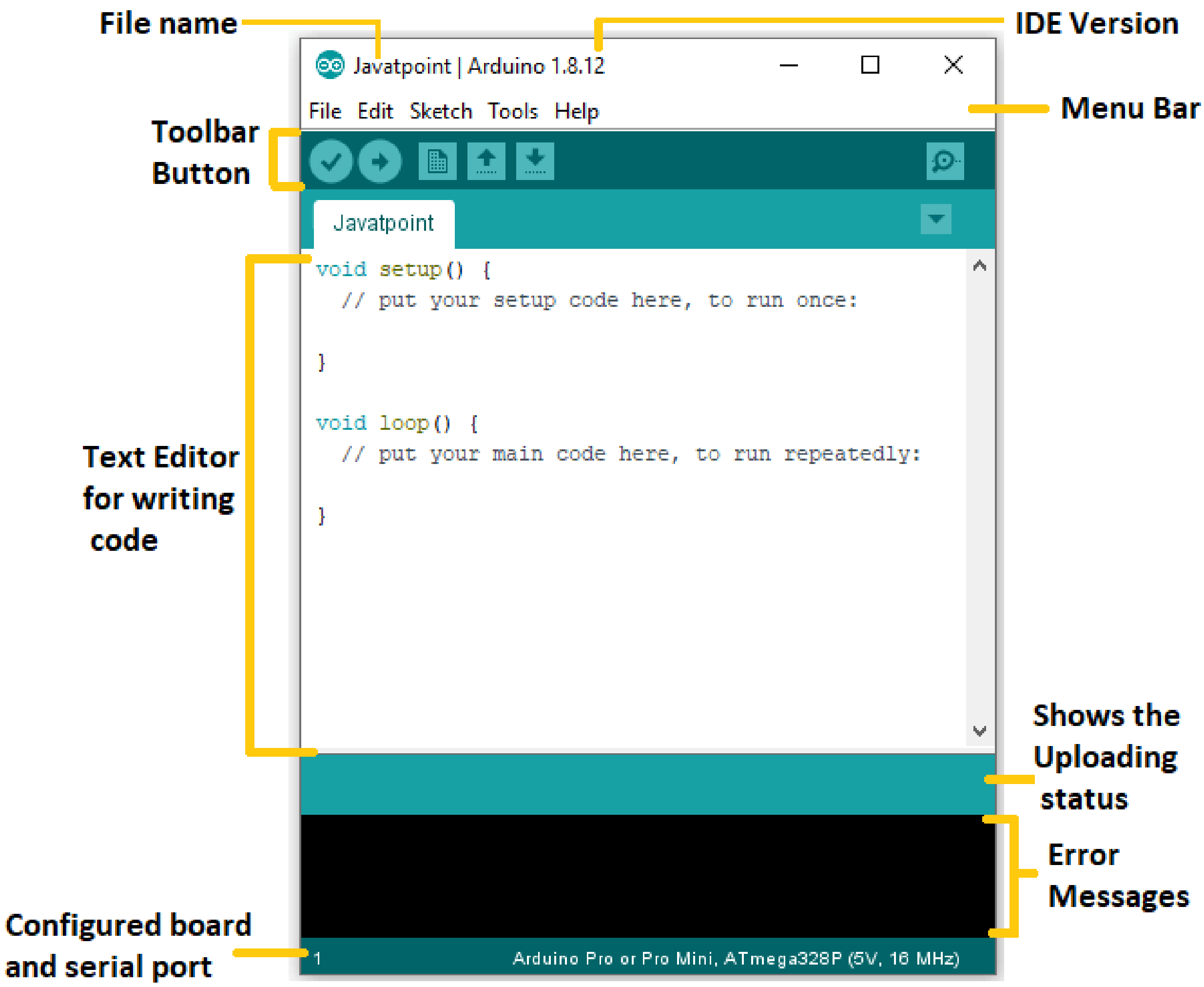

Figure 4.2 ARDUINO IDE DISPLAY IN DETAIL

The Arduino IDE (Integrated Development Environment) is a software platform used for programming and developing projects with Arduino boards. It provides a user-friendly interface and a set of tools that simplify the process of writing, compiling, and uploading code to Arduino microcontrollers.

The Arduino IDE is based on an open-source platform, making it accessible to beginners and experienced developers alike. It supports a simplified version of the C++ programming language, making it easier for users to write code and interact with the Arduino hardware.

One of the key features of the Arduino IDE is its code editor, which offers syntax highlighting, auto-completion, and error checking. These features help users write clean and error-free code.

The IDE also provides a serial monitor that allows real-time communication with the Arduino board, enabling users to send and receive data during program execution.

The Arduino IDE supports a wide range of Arduino boards, including the popular Arduino Uno, Nano, Mega, and more. It includes a built-in library manager that allows users to easily add and manage libraries for additional functionalities. Additionally, the IDE offers a vast collection of example codes and tutorials, helping users get started quickly and learn from existing projects.

In addition to the standard features, the Arduino IDE can be extended through the use of plugins and libraries. These extensions offer additional functionalities and capabilities, such as support for different hardware modules, communication protocols, and advanced programming techniques.

Overall, the Arduino IDE provides a user-friendly and accessible environment for programming Arduino boards. It simplifies the process of writing code, compiling, and uploading it to the board, making it an ideal choice for beginners and enthusiasts interested in creating interactive projects and prototypes. Programs written using Arduino Software (IDE) are called sketches.

These sketches are written in the text editor and are saved with the file extension. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information.

The bottom right-hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor. Versions of the Arduino Software (IDE) prior to 1.0 saved sketches with the extension. It is possible to open these files with version 1.0, and you will be prompted to save the sketch with the extension upon saving.

The following are the basic menu elements present in the Arduino IDE Software for coding, compiling, and uploading a sketch onto an Arduino. Each menu has a different icon for easy identification. These icons are shown below along with their operations.

4.2 HARDWARE DESCRIPTION

4.2.1 ARDUINO UNO BOARD

Arduino UNO is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic projects. The Arduino UNO board serves as the central processing unit in the “Automated fault detection system”, facilitating sensor interfacing, processing, communication, control logic implementation, power management, and system customization.

The ATmega328P microcontroller is used in the Arduino Uno microcontroller module (datasheet). 14 optical input/output pins, 6 analogue inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button are among the 14 optical input/output pins, 6 analogue inputs, a USB connection, a power jack, an ICSP header, and a reset button on this frame. It has anything you will need to get going. The Arduino uno is shown in Figure 4.3.

Simply connect the microcontroller to a computer via USB, or power it with an Alternating Current-to-Direct Current converter or a battery. It uses SRAM for memory, Flash and EEPROM for storage. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on a programming language C and C++.

The following are some of the most significant applications created with Arduino UNO. Arduino UNO is a versatile platform that can be utilized in numerous applications such as home automation, robotics, Internet of Things (IoT), prototyping, and education.

It can be used to control lights, temperature, and other home devices, build robots that can navigate and interact with the environment, create smart devices for data exchange, quickly develop and test new concepts for electronic projects, and teach programming and electronics concepts to students of all levels. Arduino UNO's compatibility with a wide range of sensors and components.

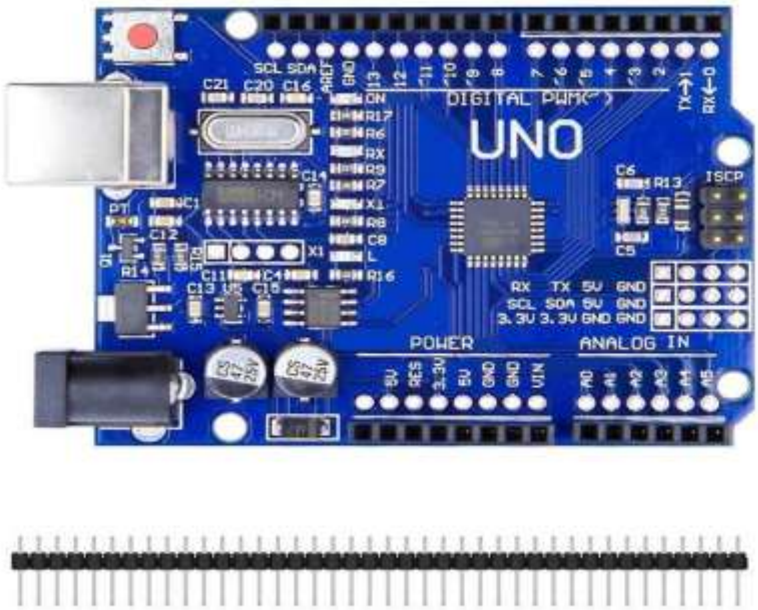

Figure 4.3 ARDUINO UNO BOARD

Each of the 14 digital pins and 6 analog pins on the Uno can be used as an input or output, under software control (using Pin Mode (), digital Write (), and digital Read () functions. They operate at 5 volts. Each pin can provide or receive20 mA as the recommended operating condition and has an internal pull-up resistor(disconnected by default) of 20-50K ohm.

A maximum of 40mA must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. The Unohas 6 analog inputs, labeled A0 through A5; each provides 10 bits of resolution (i.e. 1024 different values).

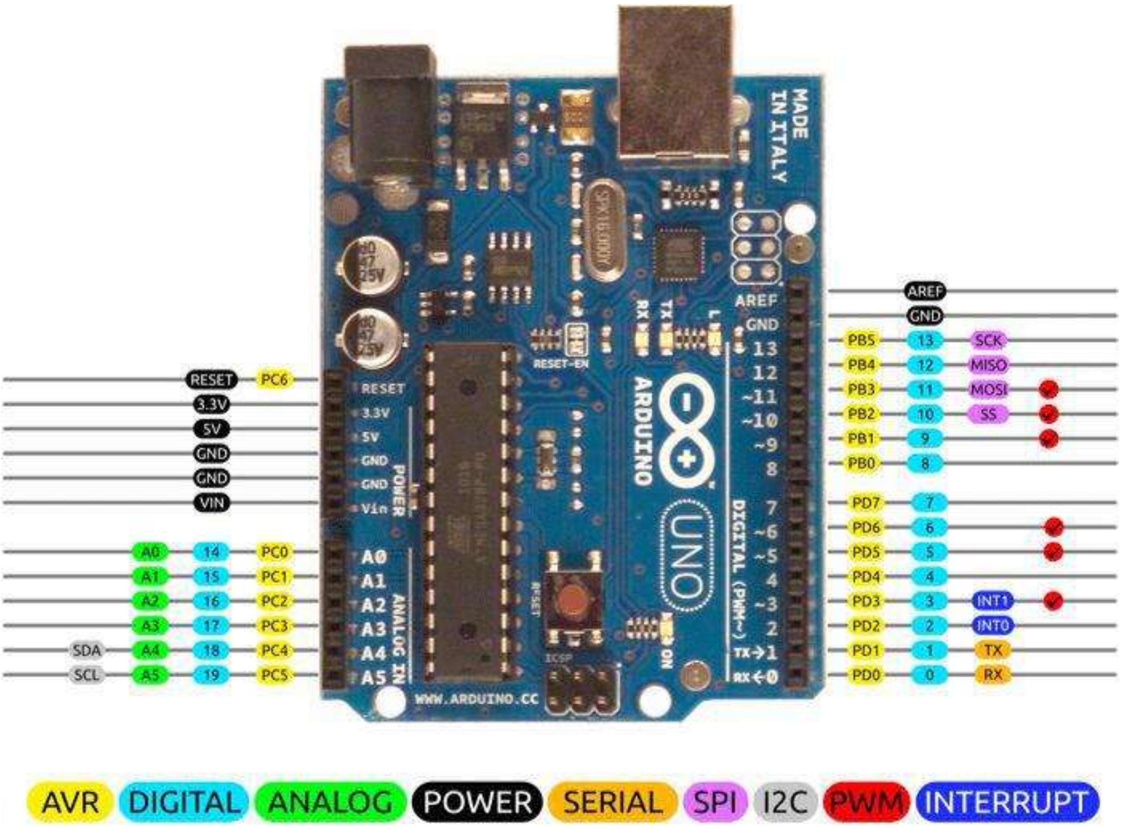

Figure 4.4 PIN CONFIGURATION OF ARDUINO UNO

By default, they measure from ground to 5 volts, though it is possible to change the upper end of the range using the AREF pin and the analog Reference () function. In addition, some pins have specialized functions: Serial / UART: pins 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTLserial data.

These pins are connected to the corresponding pins of the ATmega8U2 USB- to-TTL serial chip. External interrupts: pins 2 and 3. These pins can be configured to trigger an interruption a low value, a rising or falling edge, or a change in value. PWM (pulse width modulation): pins 3, 5, 6, 9, 10, and 11. Can provide 8-bit PWM output with the analog Write () function. SPI (Serial Peripheral Interface): pins 10 (SS), 11 (MOSI), 12 (MISO), and 13 (SCK).

These pins support SPI communication using the SPI library. TWI (two-wire interface) / I²C: pin SDA(A4) and pin SCL (A5). Support TWI communication using the Wire library. AREF (analog reference): Reference voltage for the analog inputs. Rather than requiring a physical press of the reset button before an upload, the Arduino / Genuino Uno board is designed in a way that allows it to be reset by software running on a connected computer.

One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nano farad capacitor. When this line is asserted (taken low), the reset linedrops long enough to reset the chip.[9] This setup has other implications.

When theUno is connected to a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second orso, the bootloader is running on the Uno. While it is programmed to ignore malformed data (pin diagram is shown in the figure 4.9), it will intercept the first few bytes of data sent to the board after a connection is opened.

4.2.2 SOLAR PANEL

Solar panels are those devices which are used to absorb the sun's rays and convert them into electricity or heat. A solar panel is a collection of solar cells. Lotsof small solar cells spread over a large area can work together to provide enough power to be useful.

The more light that hits a cell the more electricity it produces, sospacecraft are usually designed with solar panels that can always be pointed at the Sun even as the rest of the body of the spacecraft moves around, much as a tank turret can be aimed independently of where the tank is going. Solar panel is shown Figure 4.5.

Figure 4.5 SOLAR PANEL

Solar panel refers either to a photovoltaic module, a solar thermal energy panel, or to a set of solar photovoltaic (PV) modules electrically connected and mounted on a supporting structure. A PV module is a packaged, connected assembly of solar cells. Solar panels can be used as a component of a larger photovoltaic system to generateand supply electricity in commercial and residential applications. Today, solar panels and complete solar panel systems are used to power awide variety of applications. Yes, solar panels in the form of solar cells are still beingused in calculators.

However, they are also being used to provide solar power toentire homes and commercial buildings, such as Google's headquarters in CaliforniaSolar panel can be used for a wide variety of applications including remote Today, solar panels and complete solar panel systems are used to power a widevariety of applications Yes, solar panels in the form of solar cells are still being usedin calculators.

However, they are also being used to provide solar power to entire homes and commercial buildings, such as Google's headquarters in California, a solar panel is a flat construction resembling a window, built with technology that allows it to passively harvest the heat of the sun or create electricityfrom its energy through photovoltaics. Passive solar panels include those used to heat water for home heating and to provide hot water on tap.

Most solar panels are made from crystalline silicon type solar cells. These cells are composed of layers ofsilicon, phosphorous, and boron (although there are several different types ofphotovoltaic cells). These cells, once produced, are laid out into a grid. Solar panels are those devices which are used to absorb the sun's rays and convert them intoelectricity or heat.

4.2.3 LDR SENSOR

Light dependent resistors, LDRs or photoresistors are electronic components that are often used in electronic circuit designs where it is necessary to detect the presence or the level of light.

LDRs are very different to other forms of resistor thatare widely used in other electronic designs. They are specifically designed for theirlight sensitivity and the change in resistance this causes. These electronic like the carbon film resistor, metal oxide film resistor, metal film resistor and the like that are widely used in other electronic designs. They are specifically designed for their light sensitivity and the change in resistance this causes.

These electronic components can be described by a variety of names from light dependent resistor, LDR, photoresistor, or even photo cell, photocell or photoconductor is shown in Figure 4.6.

Figure 4.6 LDR SENSOR

Although other electronic components such as photodiodes or photo- transistor can also be used, LDRs or photo-resistors are a particularly convenient touse in many electronic circuit designs.

They provide large change in resistance for changes in light level. The resistance of an LDR is measured in ohms (Ω), and it varies over a wide range depending on the amount of light it is exposed to.

In bright conditions, the resistance of an LDR can be very low, allowing current to flow easily through it. In contrast, in darkness or low light conditions, the resistance increases, restricting the flow of current. LDRs find numerous applications in light-sensing circuits. They are commonly used in automatic lighting systems, such as streetlights, where they can detect changes in ambient light and trigger the activation or deactivation of the light source.

LDRs are also used in cameras and light meters to measure and control exposure settings. The response time of an LDR is relatively slow compared to other electronic components, which means it may take some time for the resistance to change when transitioning between light and dark conditions. This characteristic can be compensated for through circuit design or by using additional components, such as capacitors or operational amplifiers.

In conclusion, LDRs are light-sensitive resistorsthat offer a variable resistance depending on the intensity of light falling on them, their ability to respond to changes in ambient light makes them invaluable in applications requiring light detection and control, contributing to the automation andefficiency of various systems.

4.2.4 ULTRASONIC SENSOR

An ultrasonic sensor is an essential component in various automated systems, particularly in scenarios where the detection of movement or proximity is crucial. Operating on the principle of emitting ultrasonic waves and analyzing their reflections, these sensors play a pivotal role in ensuring safety, efficiency, and convenience in a multitude of applications.

In the context of urban infrastructure, ultrasonic sensors are deployed in street lighting systems to detect the presence of vehicles, pedestrians, or animals on roads or sidewalks. This capability enables the system to dynamically adjust the brightness of the street lights based on the surrounding activity.

When an object is detected in close proximity to the ultrasonic sensor, indicating potential movement or presence, the street lights illuminate brightly, providing optimal visibility for road users and enhancing safety. Conversely, in the absence of detected movement, the lights dim to conserve energy while maintaining sufficient illumination levels for ambient conditions.

Beyond street lighting, ultrasonic sensors find extensive use in automotive applications, such as parking assistance systems and collision avoidance mechanisms. In manufacturing and industrial settings, they facilitate object detection, monitoring conveyor belt operations, and ensuring precise positioning of machinery. Additionally, in home automation, ultrasonic sensors contribute to intelligent lighting control, occupancy sensing, and intruder detection, enhancing security and energy efficiency.

Figure 4.7 ULTRASONIC SENSOR

Ultrasonic sensor is a device that used to sense the movement of vehicles, pedestrians, or animals on the road. If there is any object comes near the Ultrasonic Sensor, the light will ON. Otherwise, the light will OFF. The versatility and reliability of ultrasonic sensors make them indispensable in diverse fields, ranging from robotics, healthcare to agriculture and consumer electronics.

With advancements in technology, modern ultrasonic sensors offer improved accuracy, longer detection ranges, and enhanced environmental robustness, further expanding their potential applications and contributing to the development of smarter, more interconnected systems for the benefit of society.

4.2.5 I2C CONTROLLER

In the "Automated Fault Detection in Street Lights" project, the I2C controller plays a vital role in facilitating communication among the various components involved. Operating on the I2C protocol, this controller serves as the linchpin for enabling seamless interaction between different elements within the system, such as sensors, microcontrollers, and display modules.

What makes the I2C protocol particularly advantageous is its ability to establish communication pathways between disparate parts of the system with remarkable efficiency and simplicity. With just two wires, the I2C controller streamlines the communication process, making it exceptionally easy and straightforward to establish connections between devices. Whether they are situated on the same circuit board or spread across different integrated circuits (ICs).

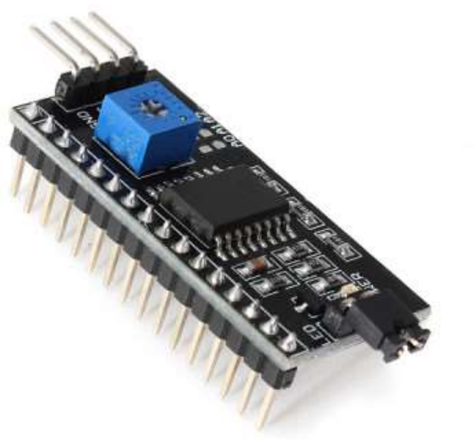

Figure 4.8 I2C CONTROLLER

This streamlined communication capability not only enhances the overall efficiency of the project but also simplifies the integration of various components, ultimately contributing to the smooth functioning of the automated fault detection system in street lights.

4.2.6 LCD DISPLAY

A Liquid Crystal Display (LCD) is a thin, flat panel display device used for electronically displaying information such as text images and moving picture. Polarization of lights is used here to display objects. The LCD display serves as a visual interface for showing information about the status of the streetlights, fault detection results, or any other relevant data.

The liquid crystals act as a shutter that allows or blocks light passing through them, creating images on the screen. LCD displays offer several advantages over other display technologies. They are energy-efficient, have a low power consumption, are thin and lightweight, and produce clear and sharp images with high contrast ratios. They are also widely available and can be manufactured in a range of sizes and resolutions.

An LCD display typically consists of several layers, including a backlight, a polarizer, a glass substrate, a color filter, and a liquid crystal layer. The backlight provides the light source for the display, while the polarizer and glass substrate helpto control the orientation of the liquid crystals. The color filter is used to create colored images on the screen, and the liquid crystal layer acts as a shutter that controls the amount of light passing through the display.

LCD displays can be usedfor a wide range of applications, from simple text displays to high-resolution video screens. They are commonly used in consumer electronics, medical devices. Automotive displays, and industrial equipment. In addition to standard LCD displays, there are also several variations, such as OLED (Organic Light Emitting Diode) displays, which use organic compounds to produce light, and e-paper displays, which use electronic ink to display text and images.

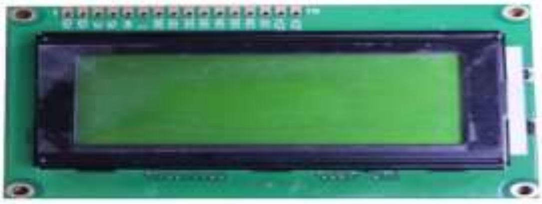

Figure 4.9 LCD DISPLAY

Automotive displays, and industrial equipment. In addition to standard LCD displays, there are also several variations, such as OLED (Organic Light Emitting Diode) displays, which use organic compounds to produce light, and e-paper displays, which use electronic ink to display text and images.

Overall, LCD displaysare a popular choice for electronic devices due to their energy efficiency, clarity, andflexibility in size and resolution. LCD displays consist of several layers, including abacklight, polarizing filters, a layer of liquid crystals, and electrodes. The LCD display is shown in Figure 4.9. The liquid crystals are controlled by electric currents, which alter theirorientation and allow or block the passage of light through the display.

This manipulation of light creates the images and colors that we see on the screen. LCD displays offer numerous advantages, including slim and lightweight designs, high resolution, low power consumption, and excellent color reproduction. These qualities have made LCD displays the preferred choice for devices such as smartphones, televisions, computer monitors, and digital signage.

4.2.7 JUMPER WIRES

Jumper wires (also called jumper wires) for solderless bread boarding can be obtained in ready to-use jump wire sets or can be manually manufactured. The lattercan become tedious work for larger circuits. Ready-to-use jump wires come in different qualities, some even with tiny plugs attached to the wire ends.

Figure 4.10 JUMPER WIRES

Jump wire material for ready-made should usually be solid copper, tin-plated assuming no tiny plugs are to be attached to the wire ends. The Jumping wire is shown in Figure 4.10. Shorter stripped wires might result in bad contact with the board's spring clips (insulation being caught in the springs). Longer stripped wires increase the likelihood of short-circuits on the board. Needle-nose pliers and tweezers are helpfulwhen inserting or removing wires, particularly on crowded boards.

4.2.8 LED LIGHTS

A light-emitting diode (LED) is a semiconductor device that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device. Appearing as practical electronic components in 1962, the earliest LEDs emitted low-intensity infrared (IR) light.

Infrared LEDs are used in remote-control circuits, such as those used with a wide variety of consumer electronics. The first visible-light LEDs were of low intensity and limited to red. Shown in Figure 4.11.

Figure 4.11 LED LIGHTS

Early LEDs were often used as indicator lamps, replacing small incandescent bulbs, and in seven-segment displays. Later developments produced LEDs available in visible, ultraviolet (UV), and infrared wavelengths with high, low, or intermediate light output, for instance, white LEDs suitable for room and outdoor lighting. LEDs have also given rise to new types of displays and sensors, while their high switching rates are useful in advanced communications technology with applications as diverse as aviation lighting, fairy lights, strip lights, automotive headlamps, advertising, general lighting, traffic signals, camera flashes, lighted wallpaper, horticultural grow lights, and medical devices.

LEDs have many advantages over incandescent light sources, including lower power consumption, a longer lifetime, improved physical robustness, smaller sizes, and faster switching. In exchange for these generally favorable attributes, disadvantages of LEDs include electrical limitations to low voltage and generally to DC (not AC) power, the inability to provide steady illumination from a pulsing DC or an AC electrical supply source, and a lesser maximum operating temperature and storage temperature.

4.2.9 BATTERY

Batteries are devices with one or more electrochemical cells that provide power to electrical devices like flashlights and mobile phones. When in use, the positive terminal is the cathode and the negative terminal is the anode. A redox reaction inside the battery supplies electrical energy.

Batteries can be primary (single-use) or secondary (rechargeable). Primary batteries, like alkaline batteries, are used once and discarded. Secondary batteries, like lithium-ion batteries, can be recharged multiple times.

Lithium batteries, with metallic lithium as the anode, offer high charge density and are used in various devices. They can produce voltages from 1.5 V to 3.7 V depending on their design and chemical compounds. Lithium batteries is shown in Figure 4.12.

Figure 4.12 LITHIUM BATTERY

A rechargeable lithium-ion battery contains cells that generate power. Each cell has Positive electrode. Made of lithium-cobalt oxide (LiCoO2) or lithium iron phosphate (LiFePO4). Negative electrode Made of carbon (graphite), electrolyt chemical substance between the electrodes.

Charging Lithium ions flow from the positive electrode to the negative electrode, taking the longer path around the circuit. Electrons and ions combine at the negative electrode, depositing lithium. Discharging Ions flow back from the negative electrode to the positive electrode through the electrolyte. Electrons flow through the circuit, powering your device. When the battery is fully discharged, it needs recharging again.

4.2.10 CONNECTING WIRES

Connecting wires allow electric current to flow between points with minimal resistance, ensuring efficient power transfer. Copper wires are often chosen because of their low resistance, making them perfect for transferring energy with little loss. This leads to better performance and energy efficiency in electrical systems, supporting the smooth operation of various devices.

4.2.11 BATTERY HOLDER

An 18650-battery holder keeps your rechargeable 18650 lithium-ion batteries secure and ready to power your gadgets like flashlights, laptops, and power banks. It is usually made of plastic or metal and designed to fit one or more batteries perfectly, with metal contacts to connect the battery to your device or charger. Some holders have safety features to prevent overcharging, over-discharging, or short circuits.

They make swapping out batteries easy and allow for simple charging without special equipment. These holders are durable and protect your batteries from bumps and knocks. While the holder might be bulky for small devices, smaller, lightweight options are available for size-sensitive applications.

Figure 4.13 BATTERY HOLDER

Overall, an 18650-battery holder is a reliable, versatile accessory that provides a secure and convenient power source for electronic devices.

4.2.12 BREADBOARD

A breadboard, or protoboard, is a tool for creating temporary electronic circuit prototypes. It allows components and wires to be easily inserted and connected without soldering, making it simple to assemble and disassemble circuits. This flexibility is ideal for testing and experimenting with electronic designs. Breadboards have conductive holes for placing components, making them great for testing analog and digital circuits.

However, they have limitations such as parasitic capacitance and resistance, which can impact circuit performance, as shown in Figure 4.14.

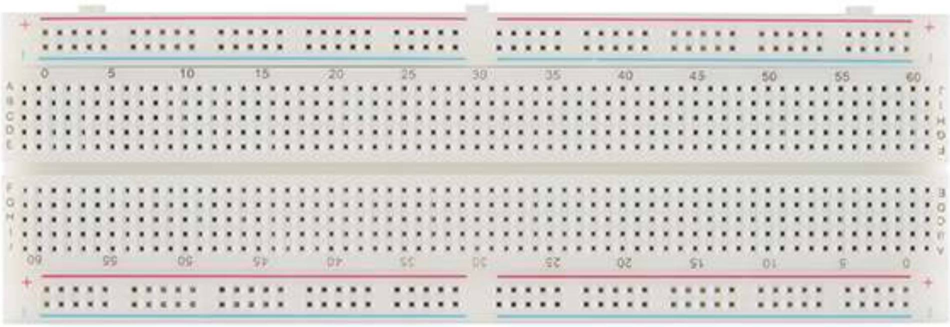

Figure 4.14 BREADBOARD

Connections on a breadboard may be less reliable, especially with movement or wear and tear. Breadboards are best suited for low-frequency applications (up to 10 MHz) and short-term use, rather than high-frequency or long-term applications due to connection and signal integrity issues.

CHAPTER 5
RESULTS AND DISCUSSIONS

5.1 SOFTWARE RESULTS

5.1.1 INTRODUCTION

Wokwi is an online tool that lets you simulate microcontroller projects, such as those involving Arduino and ESP32 boards, in your web browser. It's perfect for creating and testing projects without needing physical hardware.

Wokwi allows you to set up virtual circuits and write code to control different lights based on measurements from the ultrasonic sensor. You can easily simulate the system, turning lights on and off according to the sensor readings. Using Wokwi helps you test and debug your code quickly, which saves you time compared to working with real hardware. You can catch and fix problems early in your project's development, making it easier to get your street light system working correctly.

Key features of Wokwi include:

User-friendly Interface: Wokwi offers an intuitive drag-and-drop interface that makes it easy to create and modify virtual circuits. Users can quickly add components such as LEDs, ultrasonic sensors, and microcontrollers to their projects.

Real-time Simulation: The platform provides real-time simulation of code execution and circuit behavior. Users can upload their code, test different scenarios, and see how their circuits respond in real-time.

Code Editor: Wokwi includes a built-in code editor that supports popular programming languages like Arduino C/C++. This allows users to write, compile, and debug their code within the platform.

Component Library: Wokwi offers a comprehensive library of components, including sensors, displays, motors, and more.

Users can easily add these components to their projects and configure their properties.

Debugging Tools: Wokwi provides tools for debugging, such as breakpoints and watch expressions, allowing users to monitor variables and track code execution.

Community and Collaboration: Wokwi has a growing community of users who share projects and ideas. Users can also collaborate on projects, sharing their work with others for feedback and assistance.

Wokwi is a valuable resource for developers, educators, and hobbyists working on microcontroller projects. It allows for rapid prototyping and testing without the need for physical hardware, making it a convenient and efficient platform for exploring and creating innovative electronic projects.

5.1.2 SOFTWARE OUTPUT

- When the ultrasonic sensor detects an object at a distance of 170 cm, it initiates the action to turn ON "light 1." This means the sensor is programmed to measure distances, and when the sensor measures an object or obstruction at exactly 170 cm away, it automatically activates "light 1" by turning it ON.
- This condition is set up to ensure the light operates when needed, such as when a person or vehicle is approaching. This response helps improve safety and visibility in the area.

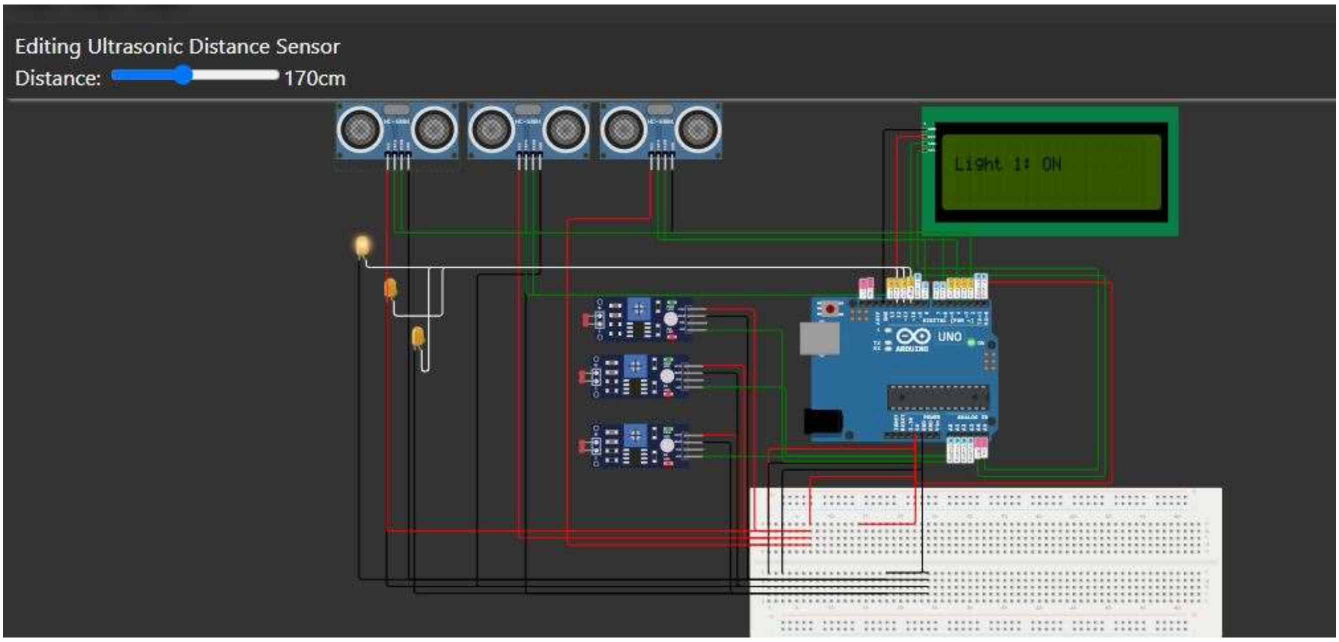

Figure 5.1 LED LIGHT 1: ON CONDITION

- If the ultrasonic sensor measures a distance of 201 cm, then "light 2" will be turned OFF according to the programmed conditions or logic.
- This response is programmed to ensure that the light is only ON when necessary and is turned OFF when not needed, helping to conserve energy and maintain an efficient lighting system.

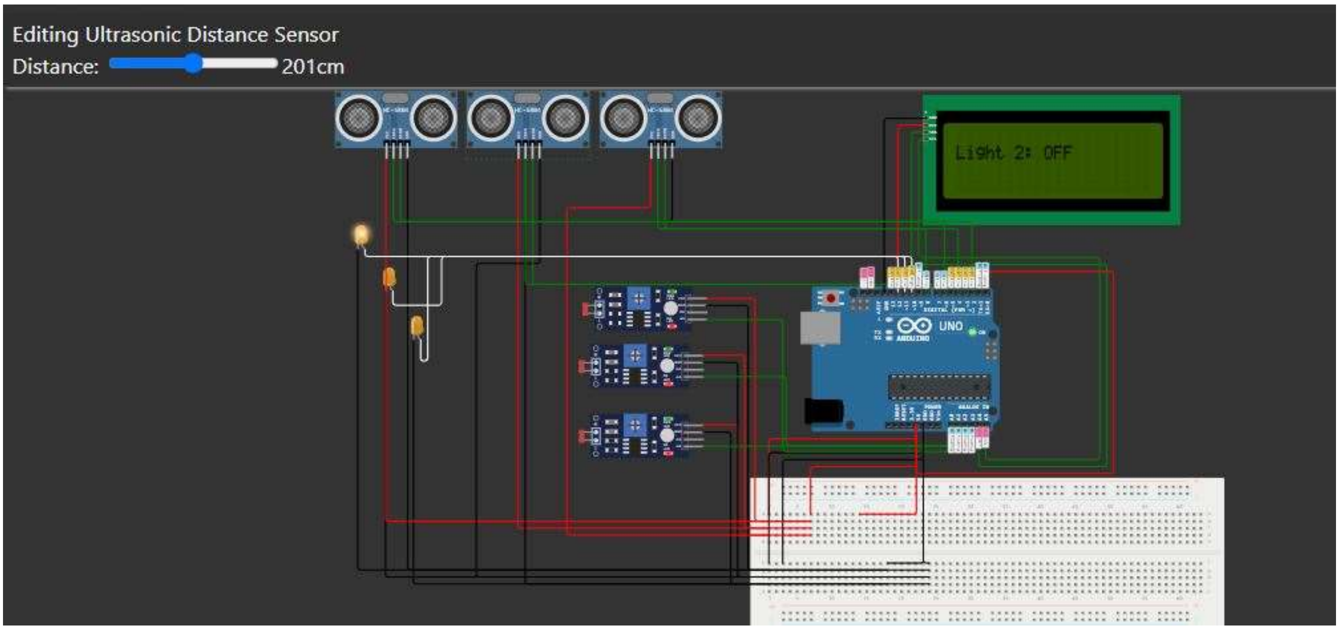

Figure 5.2 LED LIGHT 2: OFF CONDITION

- When the ultrasonic sensor measures a distance of 200 cm, it meets the condition to turn ON "light 3." This means the sensor has detected an object at exactly 200 meters away, which signals the need to turn ON "light 3."
- This programmed response is designed to illuminate the area when something is at this specific distance, enhancing safety and visibility while ensuring that the light operates efficiently based on actual needs.

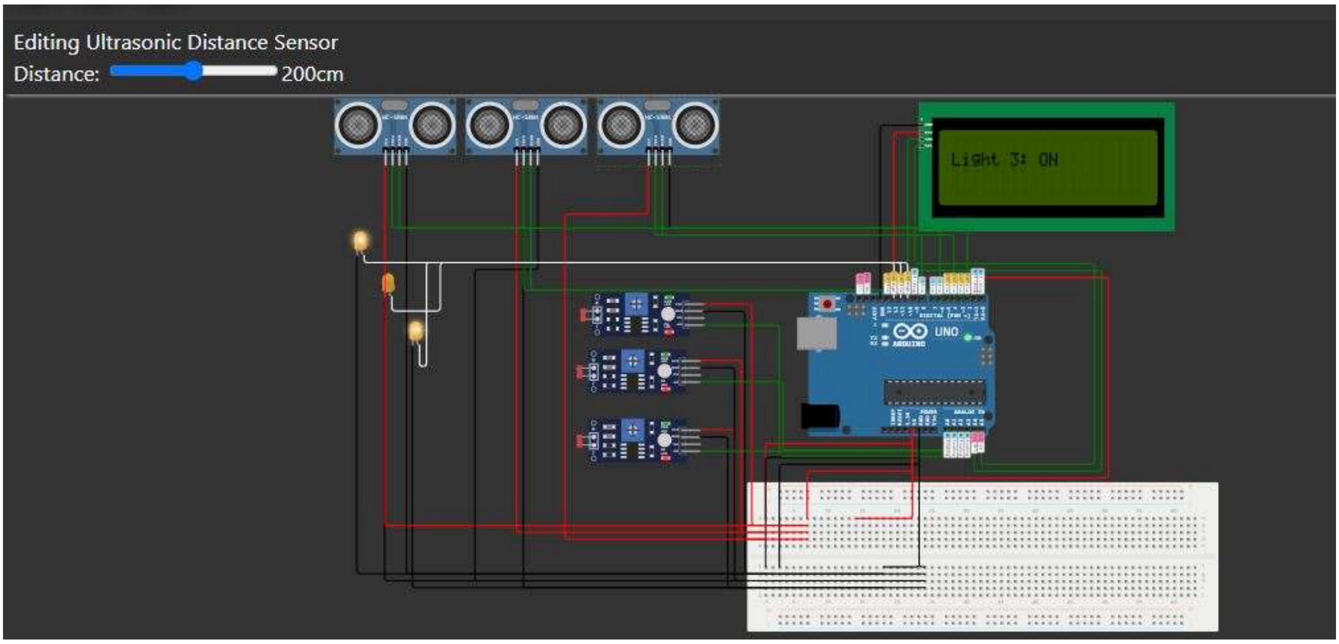

Figure 5.3 LED LIGHT 3: ON CONDITION

The connections between the ultrasonic sensor and the lights (LEDs) involve signals sent from the sensor based on measured distances. The sensor is readings dictate whether the lights should be turned on or off according to specific conditions programmed into the system.

By controlling the lights based on actual needs, the project aims to improve safety and visibility while conserving energy and ensuring efficient lighting management.

5.2 HARDWARE RESULTS

5.2.1 INTRODUCTION

Arduino IDE (Integrated Development Environment) is an indispensable software platform meticulously engineered to streamline the programming and management of Arduino boards, the cornerstone of countless electronics and microcontroller-based endeavors. Whether you're a novice enthusiast or a seasoned professional, Arduino IDE emerges as the preferred choice for conceptualizing, prototyping, and refining a diverse range of projects spanning various domains.

Within the scope of our project, Arduino IDE assumes a pivotal role in orchestrating the functionality of the Arduino board, serving as the nucleus of our system's operations. The IDE presents a user-centric interface, facilitating seamless navigation through the intricacies of coding, compiling, and deploying scripts onto the Arduino board, a hallmark feature of Arduino IDE lies in its extensive repository of libraries tailored to accommodate a myriad of sensors and components integral to our project's architecture. From ultrasonic sensors to LDR sensors and LCD displays, these libraries furnish a comprehensive toolkit, expediting the integration of essential hardware elements into our codebase.

Furthermore, Arduino IDE boasts a built-in serial monitor, a dynamic tool that fosters real-time communication with the Arduino board. This invaluable resource proves instrumental during the iterative process of debugging and performance optimization, enabling swift diagnosis and rectification of potential issues.

The IDE's innate adaptability extends to its seamless compatibility with a diverse array of Arduino board models. Through intuitive configuration settings, users can fine-tune their code to align with the specifications of their chosen board, thereby maximizing efficiency and efficacy, in tandem with its robust technical capabilities, Arduino IDE cultivates a vibrant and collaborative ecosystem teeming with tutorials, forums, and an abundance of educational resources.

Arduino IDE stands as an indispensable ally in the realization of our automatic streetlight system, embodying a harmonious fusion of simplicity, efficiency, and versatility essential for navigating the intricate landscape of embedded systems development.

5.2.2 HARDWARE OUTPUT

we use the Arduino IDE software to write and upload code to the Arduino. This helps us control the different sensors and devices in our system, such as the LDR sensors for light detection and ultrasonic sensors for detecting objects within a threshold distance. The software lets us decide when to turn lights ON or OFF based on what the sensors find. It can also show error messages on an LCD screen if there is a problem, helping us quickly find and fix issues.

The Arduino IDE is a straightforward and helpful tool for building and improving the project. The hardware prototype of the project, as shown in Figure 5.4, demonstrates how the various components, such as the Arduino, LDR sensors, Ultrasonic sensor, solar panel and LED Lights, are integrated and work together. This prototype serves as a physical representation of the project is design and functionality.

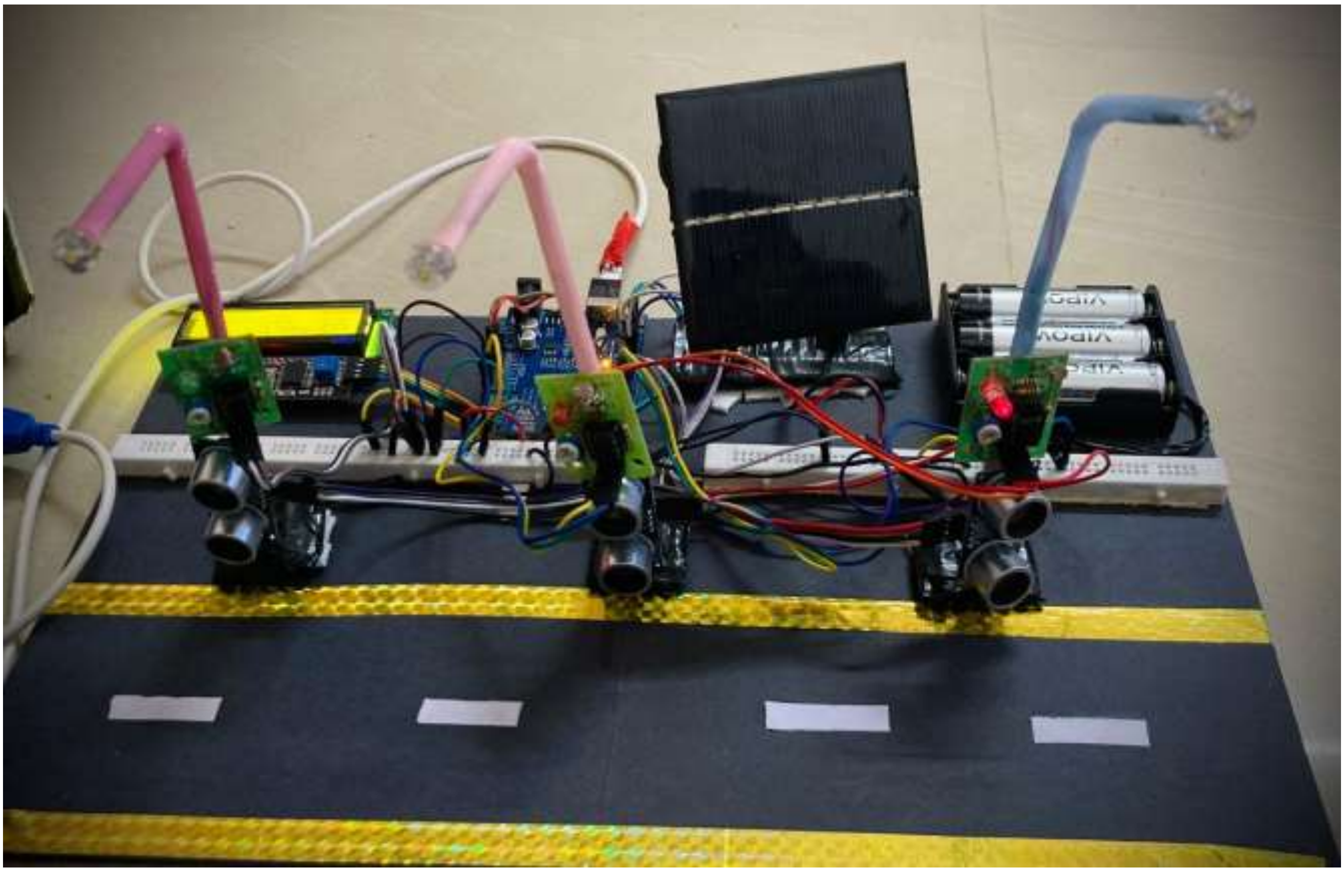

Figure 5.4 HARDWARE PROTOTYPE

During the day time, the lights will be OFF position. As the sunlight fades, the intensity of the lights increases. When the ultrasonic sensor detects an object within a threshold distance, it activates 'light 2' to turn ON.

The LED light functions properly, so no 'LED fault' message is displayed. This setup ensures the light operates effectively when a person or object approaches, improving safety and visibility in the area. Since no object is detect within a threshold distance the LED lights 1 and 3, they remain OFF.

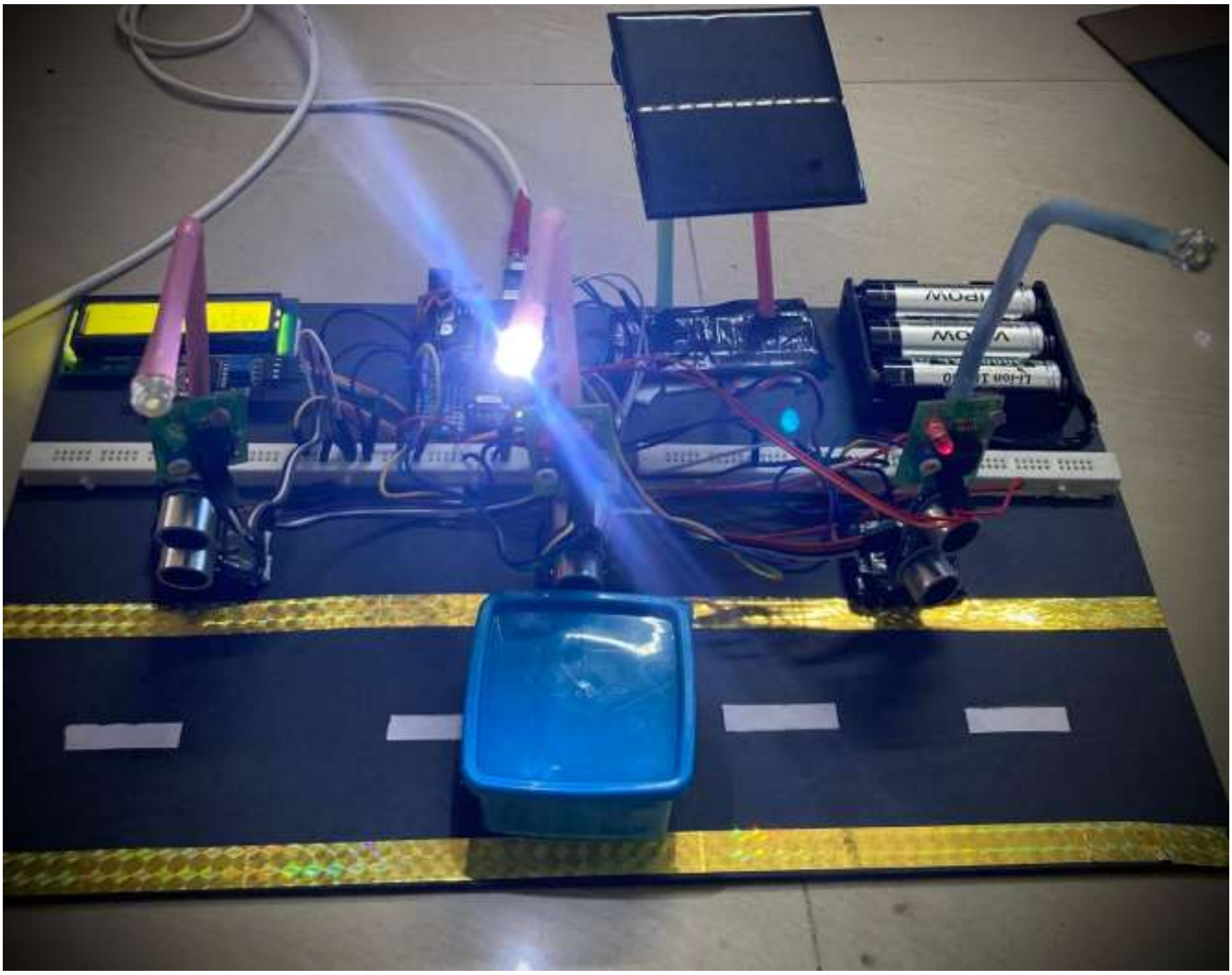

Figure 5.5 LED LIGHT 2: ON CONDITION

If the ultrasonic sensor senses movement (such as a person, vehicle, or animal), within a threshold distance, it triggers LED 3 to light up. LED light 3 is turned ON, this action can help improve visibility and safety by providing light when movement is detected, as shown in Figure 5.6.

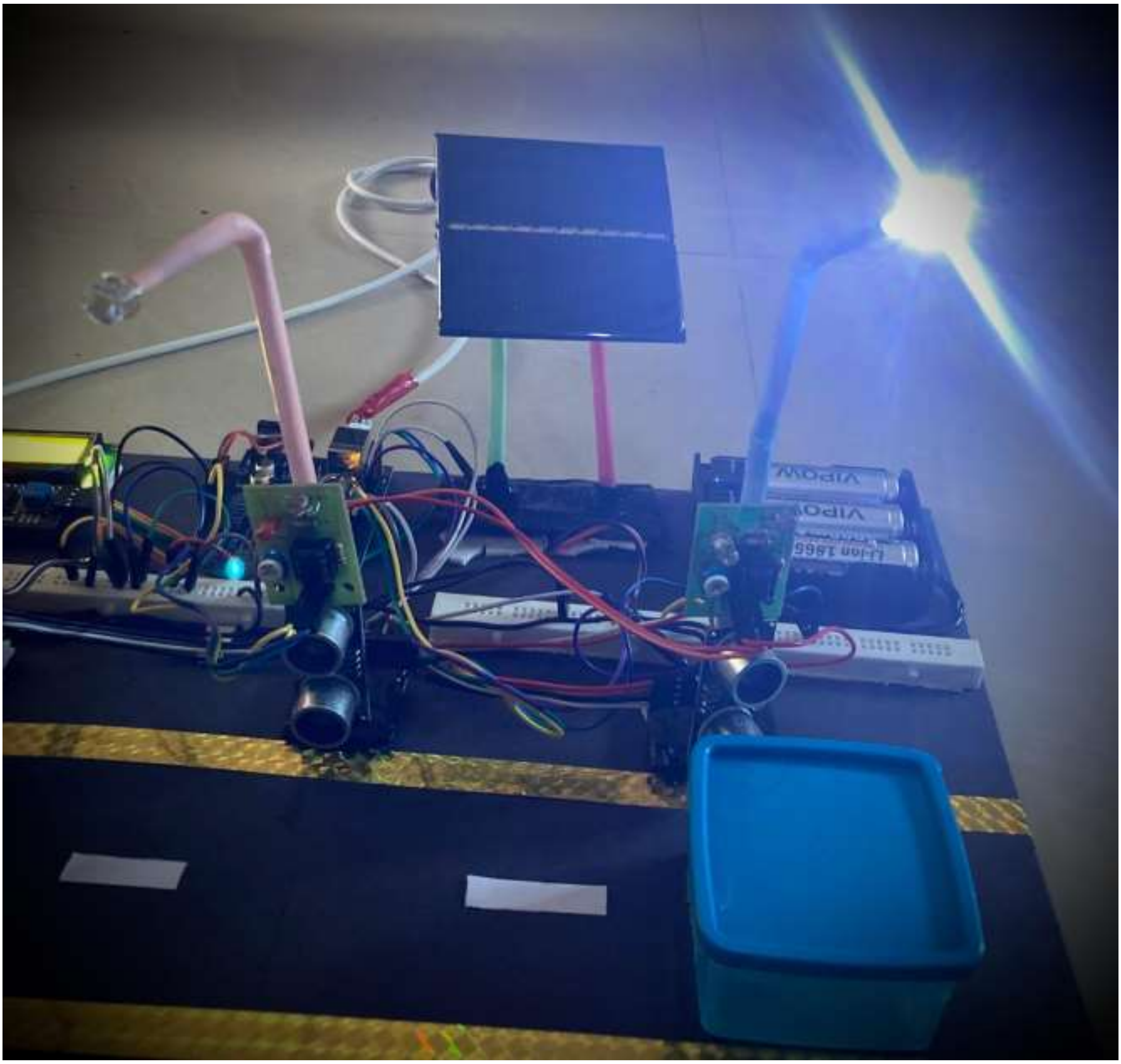

Figure 5.6 LED LIGHT 3: ON CONDITION

If the ultrasonic sensor detects movement at a threshold distance and it sends the sensor to turn ON LED 1, but LED 1 is faulty and not working properly, as shown in Figure 5.7, An error message about the LED fault is displayed on the LCD screen, as shown in Figure 5.8.

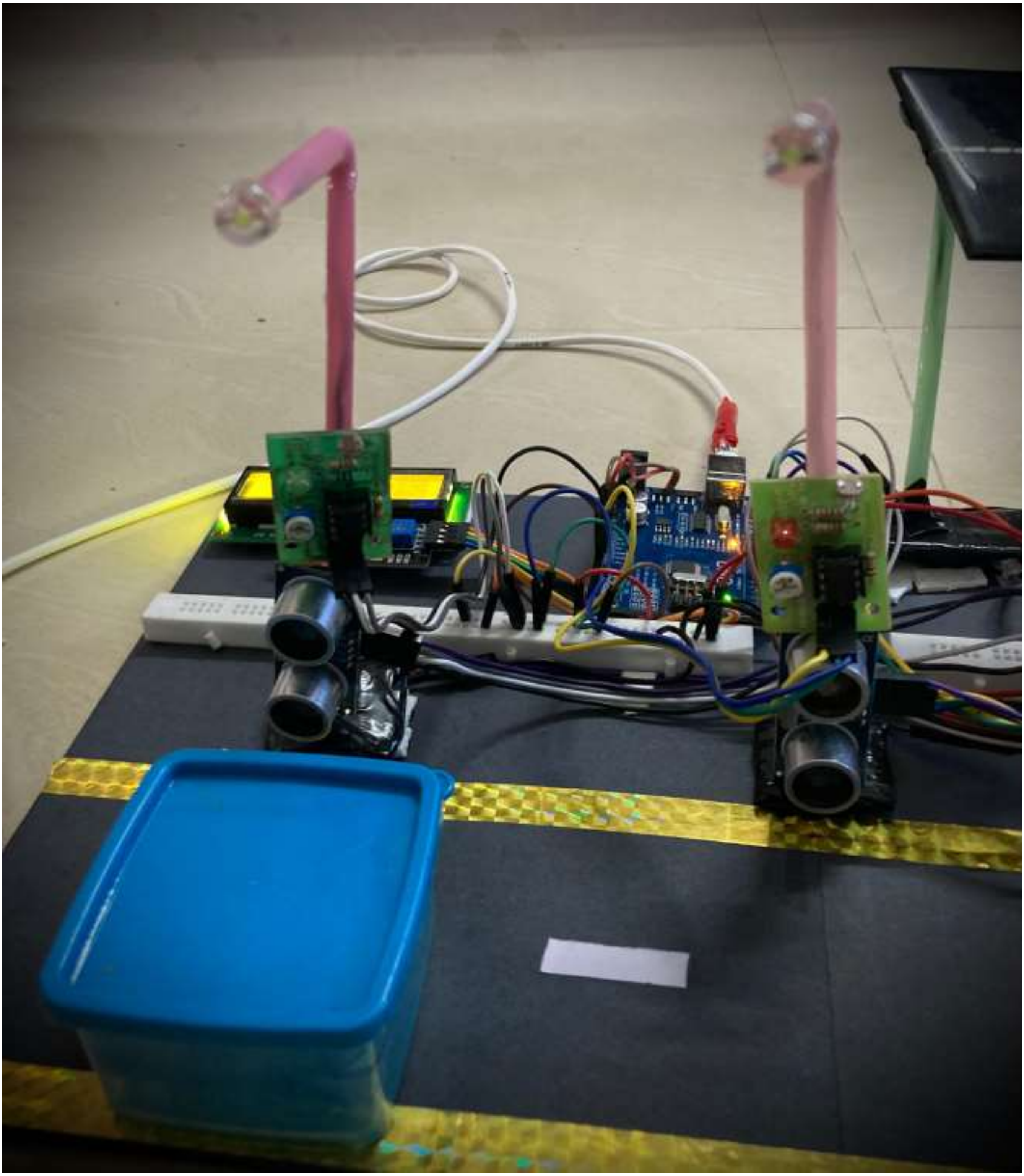

Figure 5.7 LED LIGHT: 1 NOT WORKING

The LED 1 is not working properly, as shown in Figure 5.7. It will show the error message on the LCD display. An error message that says "LED FAULT 1" is displayed on the LCD display. This is illustrated in Figure 5.8.

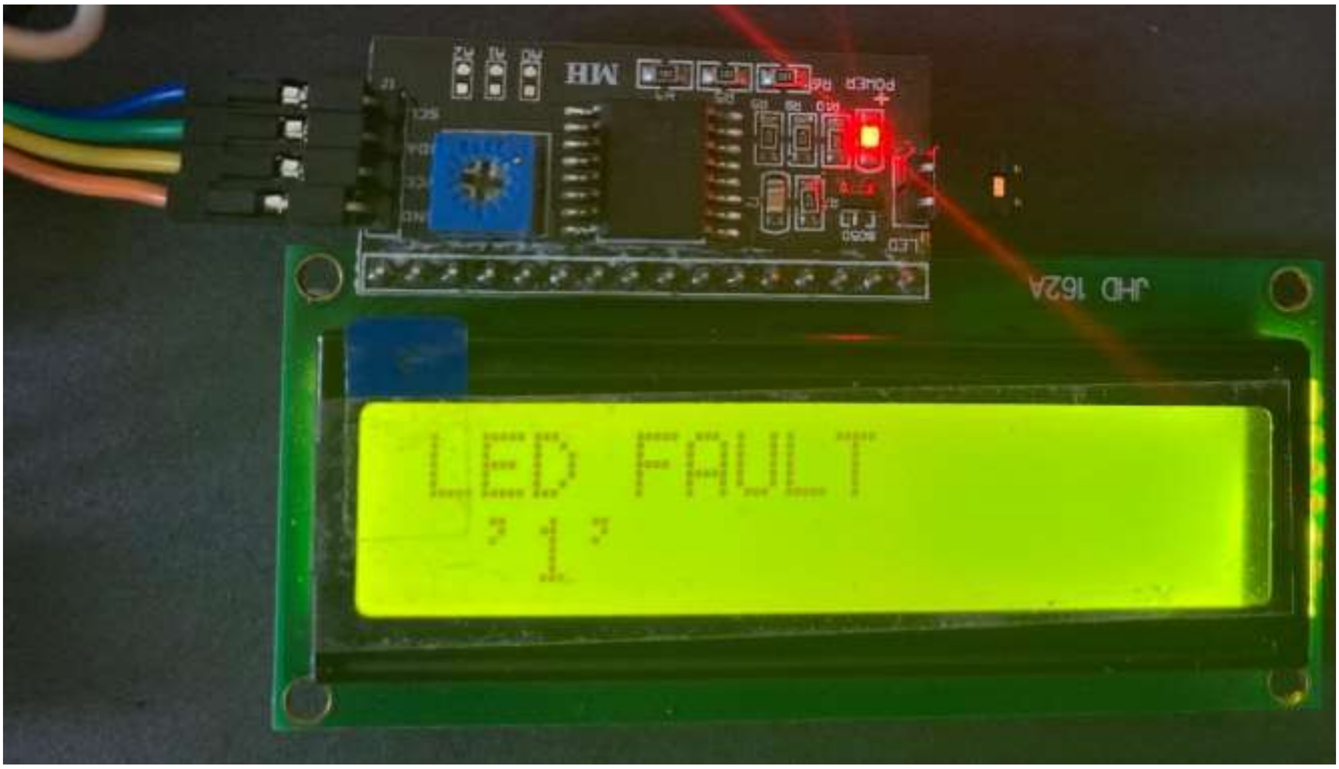

Figure 5.8 ERROR MESSAGE: LED FAULT 1

If the ultrasonic sensor detects any movement beyond the threshold distance, it does not detect any object, so the LED light 3 is turn OFF position.

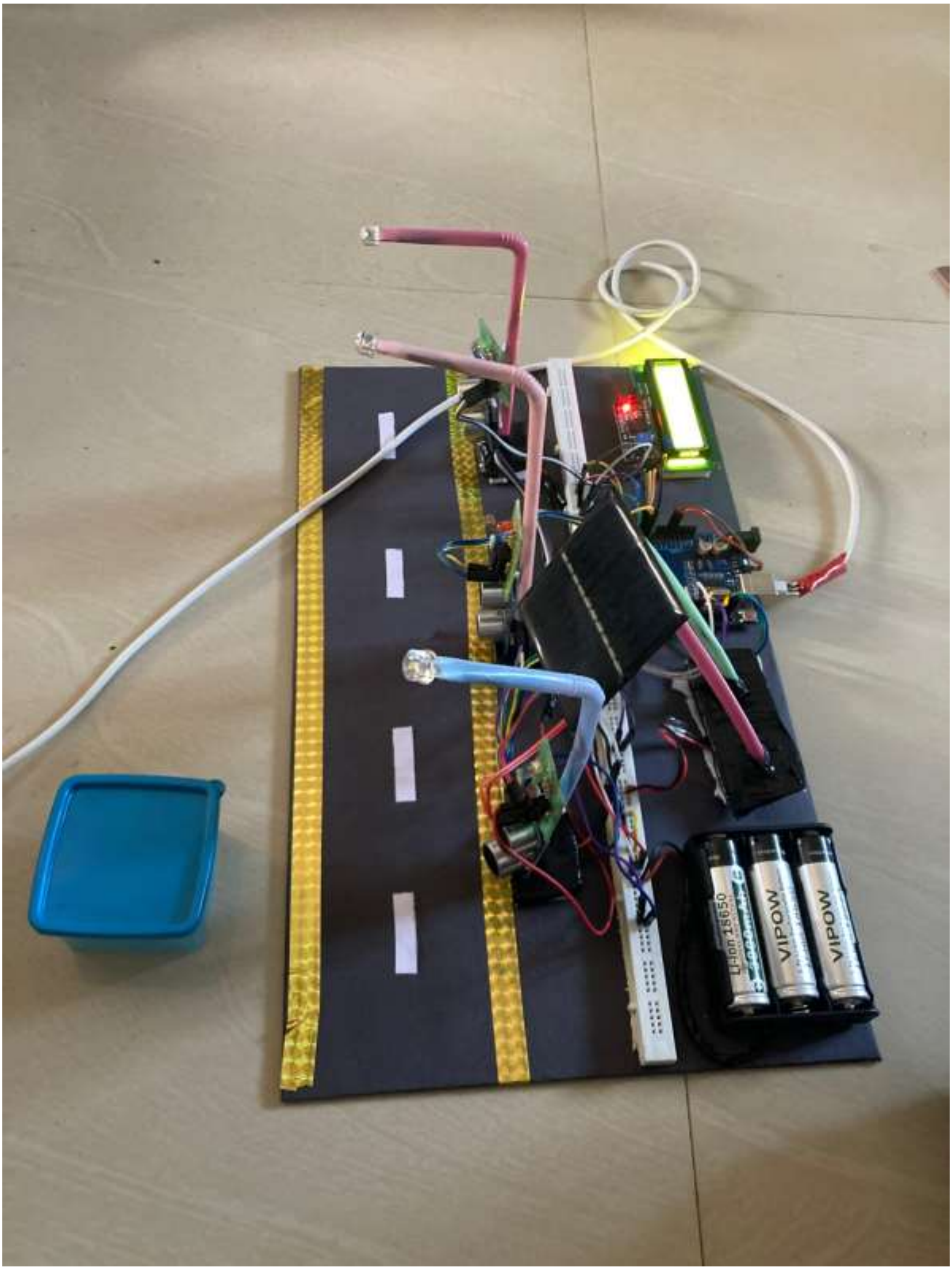

Figure 5.9 OBJECT OUT OF THRESHOLD DISTANCE

If the ultrasonic sensor senses movement (such as a person, vehicle, or animal), within a threshold distance, it triggers LED 3 to light up, so the LED light 3 is turn ON position.

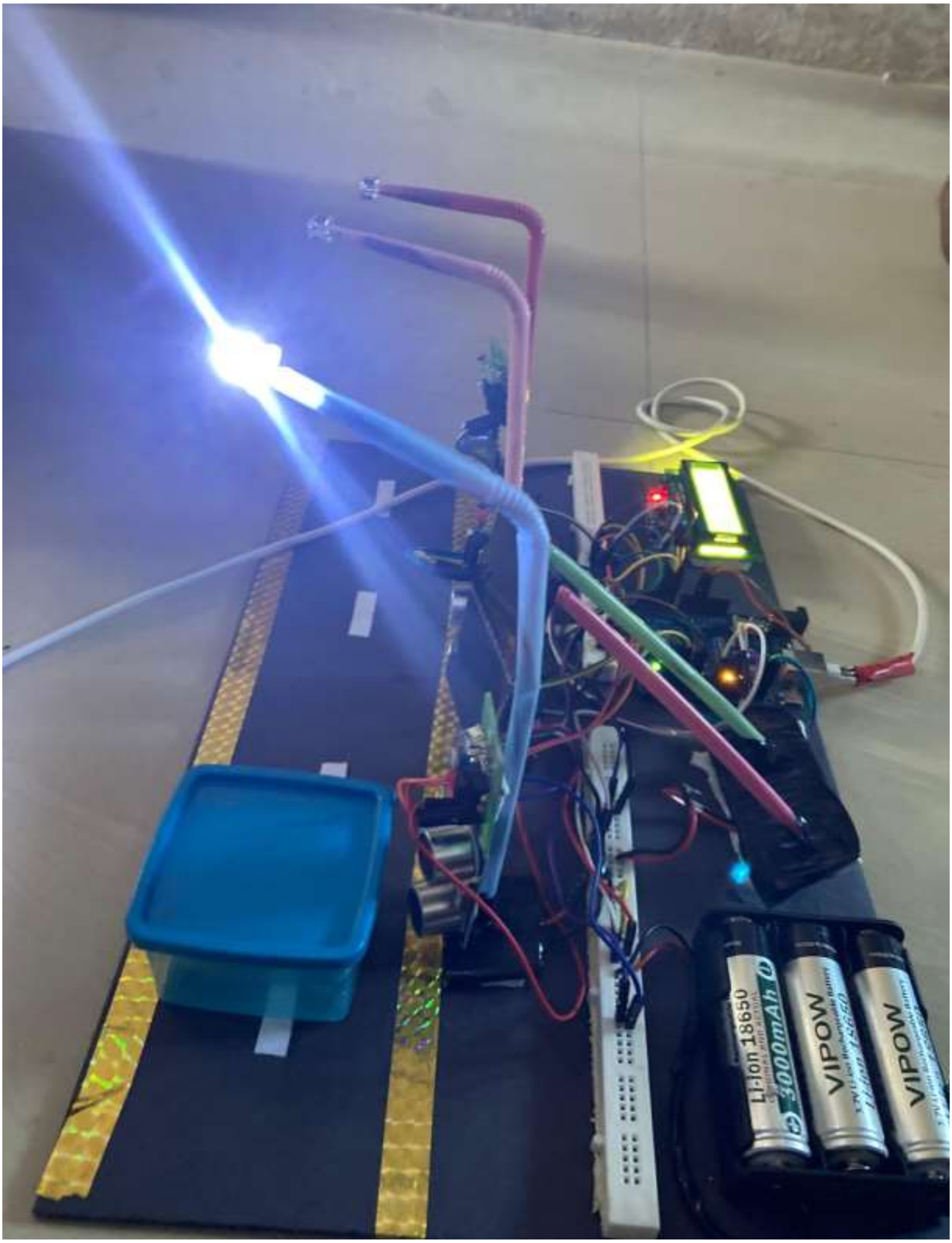

Figure 5.10 OBJECT IN THE THRESHOLD DISTANCE

When a vehicle or pedestrian comes within a threshold distance, all ultrasonic sensor detect their movement, triggering all LED lights to turn ON. LED lights 2 and 3 turn ON, but LED light 1 is faulty and not working properly, as shown in Figure 5.11.

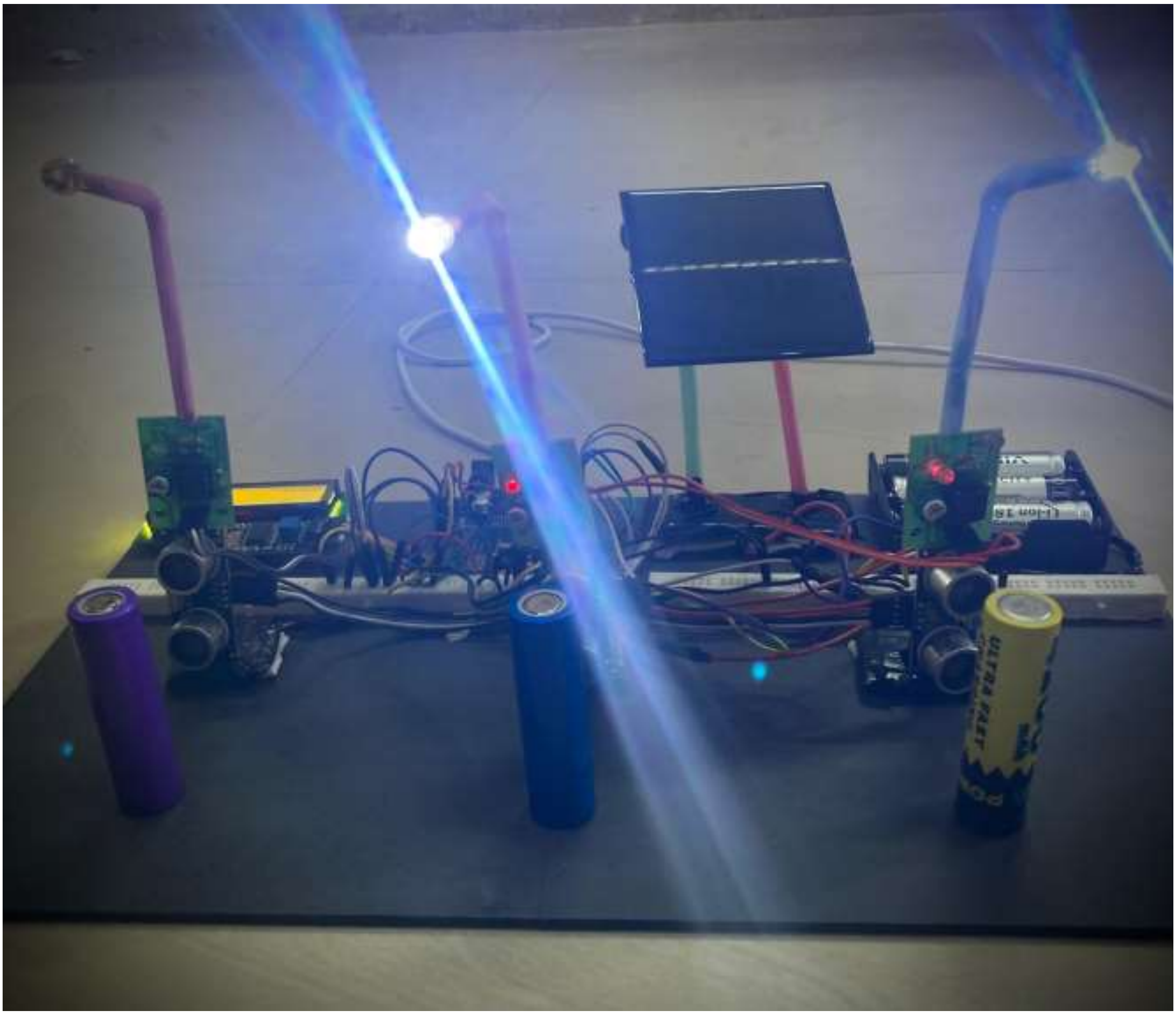

Figure 5.11 LED LIGHTS: ON CONDITION

When it is daytime, the lights are OFF. If there is power cut or light not properly work, a sensor called LDR will detect it and send a message to the LCD display screen. This setup saves energy by adjusting the brightness of the LED lights using renewable energy sources without shortening their lifespan.

It also helps by detecting light failures remotely, reducing the need for people to manually check them. Additionally, solar-powered streetlights give better light, use electricity more efficiently, and lower costs for maintenance after they are installed.

The ultrasonic sensors are responsible for detecting the movement of vehicles and pedestrians within a threshold distance, which triggers the streetlights to become ON. This ensures the safety of pedestrians and drivers while also conserving energy by not lighting up the entire street unnecessarily.

The LDR sensors, on the other hand, detect the level of ambient light and adjust the streetlight intensity accordingly. During the day when there is ample sunlight, the streetlights are turned OFF completely, saving energy and reducing operational costs.

In the event of a light failure, the LDR sensors detect the absence of ambient light and send a message to the LCD display. This remote monitoring system reduces the need for manual inspection and maintenance, saving time and reducing manpower.

Overall, the automatic street light intensity controller using Arduino provides optimal electricity usage, reducing energy consumption and operational costs, while providing better illumination and ensuring pedestrian and driver safety. Additionally, the use of renewable resources such as solar power makes this system environmentally friendly and sustainable in the long run.

CHAPTER 6
CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

In conclusion, the integration of automatic street light fault detection effectively utilizes solar energy to generate electricity, ensuring its availability for future generations. This energy can be harnessed for domestic purposes as well. Remote monitoring aids in identifying faulty streetlights, thereby reducing the need for manpower.

Which helps as to save power compared to traditional systems. Real-time implementation could lead to significant energy savings and increased electricity generation through various techniques.

Here the solar panel is used in street light system reducing energy consumption and promoting efficiency. The LDR sensor is used to detect the light intensity, by detecting the intensity we can check whether the light is ON or OFF, Ultrasonic sensor is used here to detect the movement, by detecting the movement the lights only turn ON when there is any movement, otherwise the light remains OFF.

Overall, the automatic street light system using Arduino demonstrates how technology can contribute to the creation of smart and sustainable cities. It has the potential to reduce energy consumption, minimize light pollution, and enhance road safety. The project can serve as a valuable reference for future endeavors aimed at developing smart lighting systems for cities.

6.2 FUTURE SCOPE

The automatic street light system using Arduino offers a smart solution for energy-efficient lighting systems. It automatically adjusts streetlight brightness based on ambient light levels, saving energy and reducing light pollution. In the future, this technology is expected to evolve significantly. By incorporating advanced sensors, it can be integrated with other smart city technologies like traffic management systems.

With the help of these sensors, the system can predict ambient light levels and adjust light intensity accordingly, optimizing energy consumption and reducing maintenance costs. Additionally, integrating renewable energy sources such as solar panels with the controller can decrease reliance on the power grid, ensuring uninterrupted lighting even during power outages.

This advancement will make it easier for maintenance personnel to detect and resolve issues in the system. We are also working on a GSM module, which sends messages to specific people. This means they can check the lights from far away and change things if they need to.

Overall, the future scope of automatic street light using Arduino looks promising, especially with the integration of advanced sensors and renewable energy sources. This technology has the potential to significantly contribute to the creation of smart and sustainable cities.

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ANNEXURE

PROGRAM

Arduino UNO code:

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// Constants
const int LDR_PIN1 = A0;       // First LDR analog pin
const int LDR_PIN2 = A1;       // Second LDR analog pin
const int LDR_PIN3 = A2;       // 3 LDR analog pin
const int LED_PIN1 = 11;       // First LED pin
const int LED_PIN2 = 12;       // Second LED pin
const int LED_PIN3 = 13;       // 3 LED pin
const int TRIGGER_PIN1 = 2;    // First ultrasonic sensor trigger pin
const int ECHO_PIN1 = 3;       // First ultrasonic sensor echo pin
const int TRIGGER_PIN2 = 4;    // Second ultrasonic sensor trigger pin
const int ECHO_PIN2 = 5;       // Second ultrasonic sensor echo pin
const int TRIGGER_PIN3 = 6;    // 3 ultrasonic sensor trigger pin
const int ECHO_PIN3 = 7;       // 3 ultrasonic sensor echo pin

// Variables
int ldrValue1 = 0;             // First LDR value
int ldrValue2 = 0;             // Second LDR value
int ldrValue3 = 0;             // 3 LDR value
int ultrasonicDistance1 = 0;   // First ultrasonic sensor distance
int ultrasonicDistance2 = 0;   // Second ultrasonic sensor distance
```

```
int ultrasonicDistance3 = 0;   // 3 ultrasonic sensor distance
LiquidCrystal_I2C lcd(0x3F, 16, 2); // I2C LCD display

void setup() {
  pinMode(LED_PIN1, OUTPUT);
  pinMode(LED_PIN2, OUTPUT);
  pinMode(LED_PIN3, OUTPUT);
  pinMode(TRIGGER_PIN1, OUTPUT);
  pinMode(ECHO_PIN1, INPUT);
  pinMode(TRIGGER_PIN2, OUTPUT);
  pinMode(ECHO_PIN2, INPUT);
  pinMode(TRIGGER_PIN3, OUTPUT);
  pinMode(ECHO_PIN3, INPUT);
  lcd.init();
  lcd.backlight();
}

void loop() {
  // Read LDR values
  ldrValue1 = analogRead(LDR_PIN1);
  ldrValue2 = analogRead(LDR_PIN2);
  ldrValue3 = analogRead(LDR_PIN3);

  // Read ultrasonic sensor distances
  ultrasonicDistance1 = readUltrasonicDistance(TRIGGER_PIN1, ECHO_PIN1);
  ultrasonicDistance2 = readUltrasonicDistance(TRIGGER_PIN2, ECHO_PIN2);
  ultrasonicDistance3 = readUltrasonicDistance(TRIGGER_PIN3, ECHO_PIN3);



  // Check if ultrasonic sensor 1 detects movement
```

```
if (ultrasonicDistance1 < 10) {
  digitalWrite(LED_PIN1, HIGH); // Turn on first LED
  lcd.setCursor(0, 0);
  lcd.print("L11");

  // Check LDR value 1
  if (ldrValue1 >= 400) {
    lcd.setCursor(0, 1);
    lcd.print("LD11");
    Serial.println(ldrValue1);
  } else if (ldrValue1 <= 300) {
    lcd.setCursor(0, 1);
    lcd.print("LD10");
  }
} else {
  digitalWrite(LED_PIN1, LOW); // Turn off first LED
  lcd.setCursor(0, 0);
  lcd.print("L10");
}

// Check if ultrasonic sensor 2 detects movement
if (ultrasonicDistance2 < 10) {
  digitalWrite(LED_PIN2, HIGH); // Turn on second LED
  lcd.setCursor(6, 0);
  lcd.print("L21");

  // Check LDR value 2
  if (ldrValue2 >= 400) {
    lcd.setCursor(6, 1);
    lcd.print("LD21");
```

```
    Serial.println(ldrValue2);
  } else if (ldrValue2 <= 300) {
    lcd.setCursor(6, 1);
    lcd.print("LD20");
  }
} else {
  digitalWrite(LED_PIN2, LOW); // Turn off second LED
  lcd.setCursor(6, 0);
  lcd.print("L20");
}

  // Check if ultrasonic sensor 3 detects movement
if (ultrasonicDistance3 < 10) {
  digitalWrite(LED_PIN3, HIGH); // Turn on 3 LED
  lcd.setCursor(12, 0);
  lcd.print("L31");

  // Check LDR value 1
  if (ldrValue3 >= 400) {
    lcd.setCursor(12, 1);
    lcd.print("LD31");
    Serial.println(ldrValue3);
  } else if (ldrValue3 <= 300) {
    lcd.setCursor(12, 1);
    lcd.print("LD30");
  }
} else {
  digitalWrite(LED_PIN3, LOW); // Turn off 3 LED
  lcd.setCursor(12, 0);
  lcd.print("L30");
```

```
  }
}

// Function to read ultrasonic sensor distance
int readUltrasonicDistance(int triggerPin, int echoPin) {
  digitalWrite(triggerPin, LOW);
  delayMicroseconds(2);
  digitalWrite(triggerPin, HIGH);
  delayMicroseconds(10); // Increased delay for better accuracy
  return pulseIn(echoPin, HIGH) / 58; // Convert time to distance in cm
```