AUTONOMOUS LIGHT FOLLOWING ROBOT WITH OBSTACLE AVOIDANCE USING LDR AND ULTRASONIC SENSOR

A PROJECT REPORT

Submitted by

SHIVEN YADAV S

in partial fulfillment for the award of the degree
of

B.Tech Computer Science and Engineering

RV UNIVERSITY
प्रज्ञाः ★ धीराः
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Shiven Yadav S

10th May, 2024

Abstract

This report presents the design and implementation of an autonomous light-following robot with obstacle avoidance capabilities, achieved using Light Dependent Resistors (LDR) and Ultrasonic sensors. The project leverages an Arduino Uno R3 microcontroller to integrate these sensors and manage the robot's behavior. The primary objective is to create a robot that can autonomously navigate towards light sources while avoiding obstacles, providing a foundation for applications in hazardous environments where human presence is impractical or dangerous. The methodology involves a comprehensive hardware setup, including LDRs for detecting light intensity, Ultrasonic sensors for distance measurement, servo motors for sensor orientation, and a motor driver shield for controlling the robot's movement. The control logic is developed and implemented using the Arduino Integrated Development Environment (IDE). Rigorous testing in various scenarios ensured the reliability and efficiency of the robot. This project demonstrates the potential of integrating simple yet effective sensors and microcontrollers to develop intelligent robotic systems with practical applications in surveillance, industrial automation, agriculture, healthcare, and disaster response. Future enhancements could include advanced sensors like LIDAR and machine learning algorithms to improve navigation and obstacle avoidance in complex environments.

Introduction

The advancement of autonomous robotics has significantly transformed various industries, enhancing efficiency and safety in environments that are hazardous or challenging for humans. This project focuses on developing an autonomous light-following robot with obstacle avoidance capabilities, utilizing an Arduino Uno R3 microcontroller, Light Dependent Resistors (LDR), and Ultrasonic sensors. The primary goal is to design a robot that can intelligently navigate towards light sources while dynamically avoiding obstacles, thereby expanding its utility in applications such as automated surveillance, industrial inspection, and rescue missions in disaster-stricken areas.

Literature Survey: Autonomous robots equipped with light-following and obstacle-avoidance capabilities have been explored in various research studies. Notably, the International Journal of Advances in Science and Technology published an article titled "Light Following and Obstacle Avoiding Robot," which discusses different path planning algorithms and their effectiveness in optimizing robotic navigation. Such literature provides valuable insights into the design considerations and potential challenges associated with autonomous robotics, guiding the development of our project.

Work Done: The project began by procuring the necessary components. For light-following and obstacle-avoiding functionality, we chose an LDR and an Ultrasonic sensor, together with a servo motor for the ultrasonic sensor to detect objects across a range of angles. A chassis, Arduino Uno R3, and Motor Driver Shield served as the robot's brain, with Bo motors and wheels used for movement. The hardware components were carefully connected. The Arduino IDE was used to program the control logic, allowing the components to work together to control the robot. After multiple tests and adjustments, any encountered problems were resolved.

Materials and Components

Arduino Uno R3: The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. It has 20 digital input/output pins, of which 6 can be used as PWM outputs and 6 as analog input pins.

Specifications:

- Microcontroller: ATmega328
- Operating voltage: 5V
- Digital I/O pins: 14 (6 provide PWM output)
- Analog input pins: 6

LDR (LM393)

The LDR operates on the principle of photoconductivity. When light falls on its photoconductive material, the material's electrons absorb energy, moving from the valence band to the conduction band, thus increasing conductivity as light intensity increases.

Ultrasonic Sensors

Ultrasonic sensors emit high-frequency sound pulses at regular intervals, which propagate through the air. If these pulses strike an object, they reflect back to the sensor as an echo signal. The sensor calculates the distance to the target based on the time span between emitting the signal and receiving the echo.

Pin details:

- Vcc: +5V power supply
- ECHO: Output pin
- TRIG: Input pin
- GND: Ground

Servo Motors

A servo motor is an electromechanical device that works as part of a closed-loop system, providing torque and velocity as received from the servo controller. It utilizes a feedback device to close the loop, comparing its actual position and adjusting movement to minimize the difference.

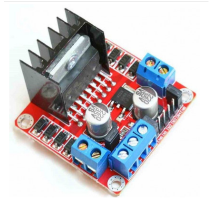
Motor Driver Shield

The L298N is a dual H-bridge motor driver allowing speed and direction control of two DC motors simultaneously. The speed is determined by the PWM pulse width sent to the "Enable" input. Wider pulses result in faster motor spinning.

Direction control pins:

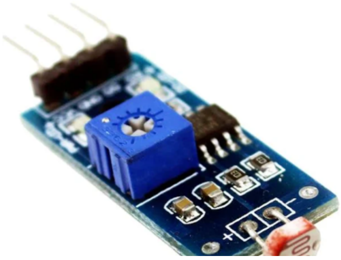
- IN1 and IN2 control motor A
- IN3 and IN4 control motor B

Servo motor

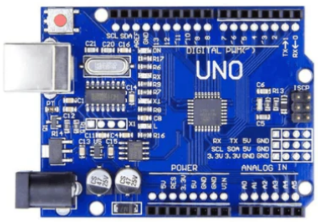


Motor Driver Shield

UltrasonicSensor



LDR sensor

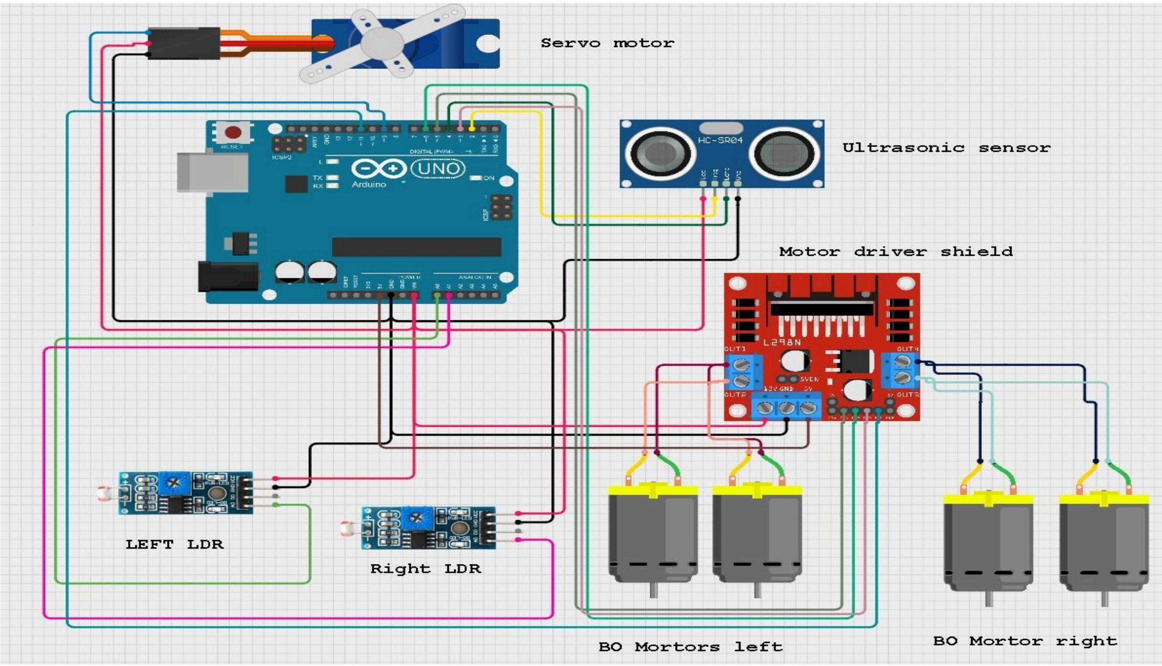


Arduino R3

CIRCUIT AND FLOWCHART

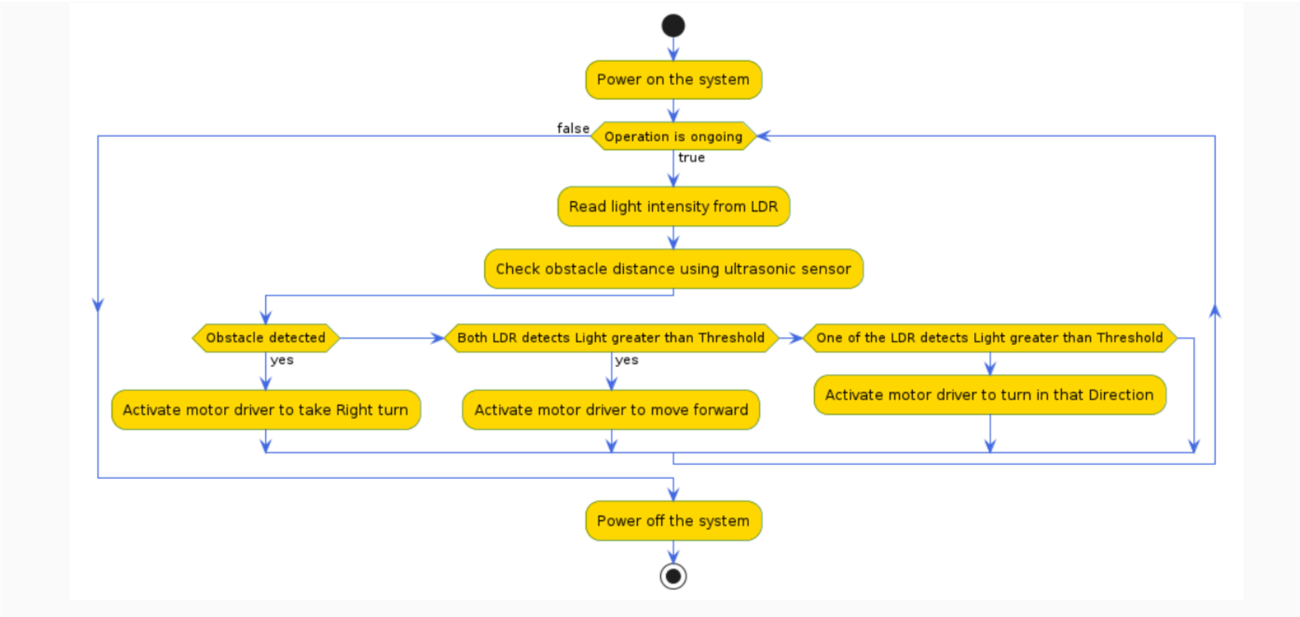
Circuit Diagram

The detailed and labeled circuit diagram represents the schematic for our project.

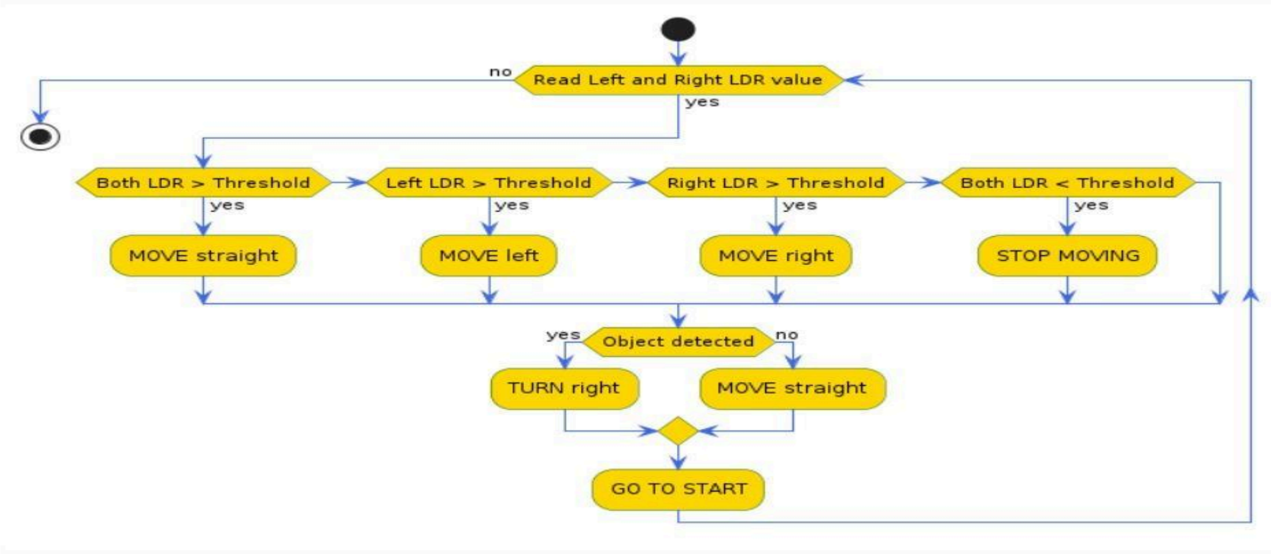


Hardware FLowchart

The flowchart illustrates the hardware interaction in our project.



Control Logic flowchart



DATA - VISUALIZATION

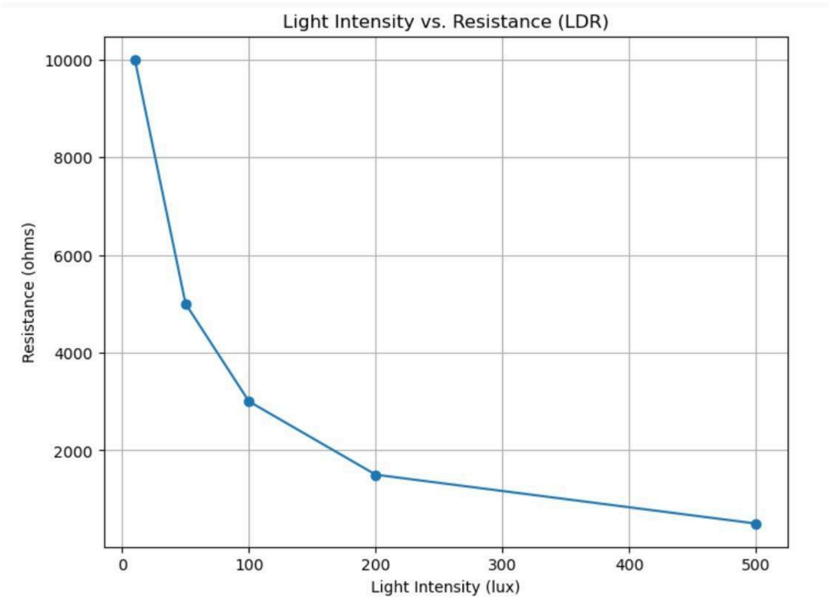
The light-dependent resistor (LDR) measures the intensity of light falling on it, represented as voltage values, correlating with environmental brightness. The Ultrasonic sensor collects distance data by emitting ultrasonic waves and measuring their return time, converting this to distance information.

The data collected by the sensors is stored in the memory of the Arduino Uno microcontroller, which has limited memory and can hold a certain amount of data based on size and available memory.

Data collection duration is throughout the robot's operation. By combining LDR and ultrasonic sensor data, the robot makes informed movement decisions, taking paths with better lighting and avoiding obstacles.

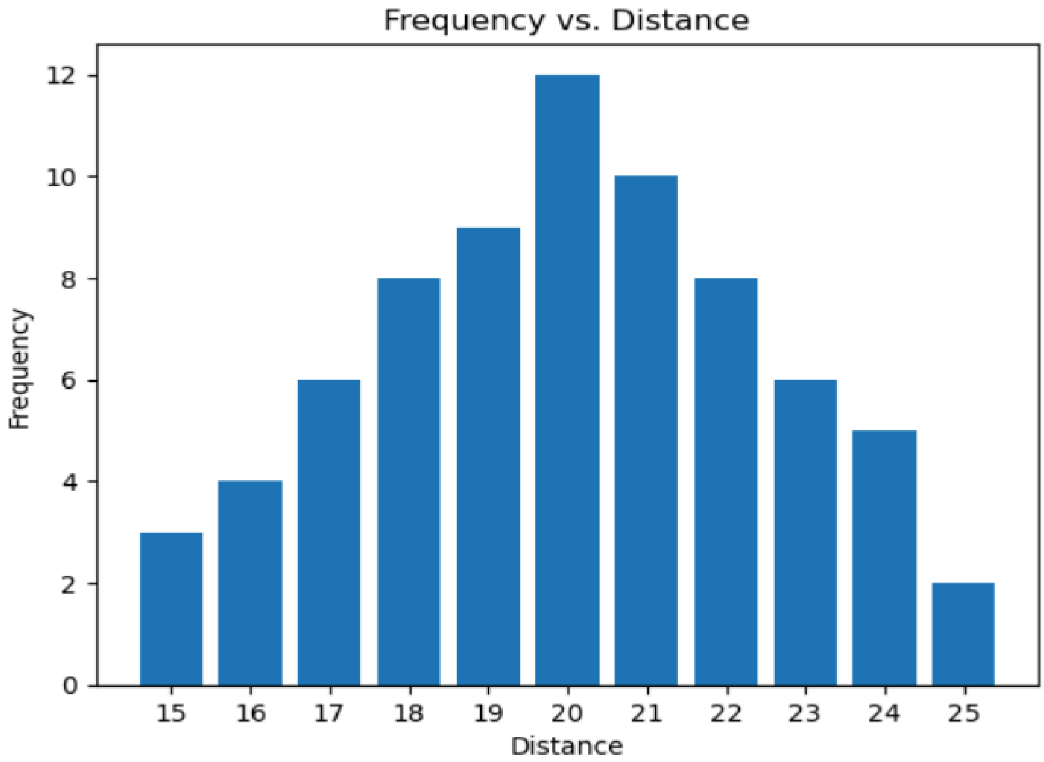
Light Intensity vs. Resistance

The graph depicts the inverse correlation between light intensity and LDR resistance. As light intensity increases, resistance decreases, and vice versa, following a logarithmic pattern indicating significant resistance changes with small light intensity fluctuations, particularly at lower light levels.



Object Detected Distance vs. Frequency

The graph shows the frequency of object detection by the Ultrasonic sensor at various distances. The sensor frequently detects objects at a 20 cm distance, influenced by factors like the Servo Motor's position, indicating the importance of careful sensor reading consideration in project development.



DISCUSSION / CONCLUSION

Problems Encountered and Solutions

Several challenges were faced, including incorrect or loose hardware connections, which were resolved by soldering connections. Issues with control logic were addressed through testing and adjustments.

Application in Various Fields

The project has diverse applications, including industrial automated inventory management and surveillance, agricultural monitoring and crop management, healthcare support for limited mobility patients, and rescue operations in dangerous or inaccessible areas.

Future Work

Improvements can increase robot efficiency, such as integrating advanced sensor technology like LIDAR for detailed mapping and precise object detection, and implementing machine learning algorithms for optimal navigation, especially in challenging terrains.

Video link: Demonstration of the project

https://drive.google.com/file/d/1BiSeA8uhqci24x_V_ptq6qCaBFBtY62p/view?usp=sharing

Github Link: code link

https://github.com/shivenyadavs/Light-Following-Robot