OBSTACLE AVOIDANCE ROBOT

By

MECHATRONICS ENGINEERING

COLLEGE OF ENGINEERING (COLENG)

BELLS UNIVERSITY OF TECHNOLOGY-NEW HORIZON

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Robotics 1

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Declaration

We group 10 mechatronics team members hereby declare that this is our own original work of the project design reflecting the knowledge we have acquired from research on our project about “**Design and Simulation of Obstacle Avoidance Robot using Arduino**”. We therefore declare that the information in this report is original and has never been submitted to any other institution,University or college for any award other than Bell's University of Technology,Mechatronics Department,COLENG.

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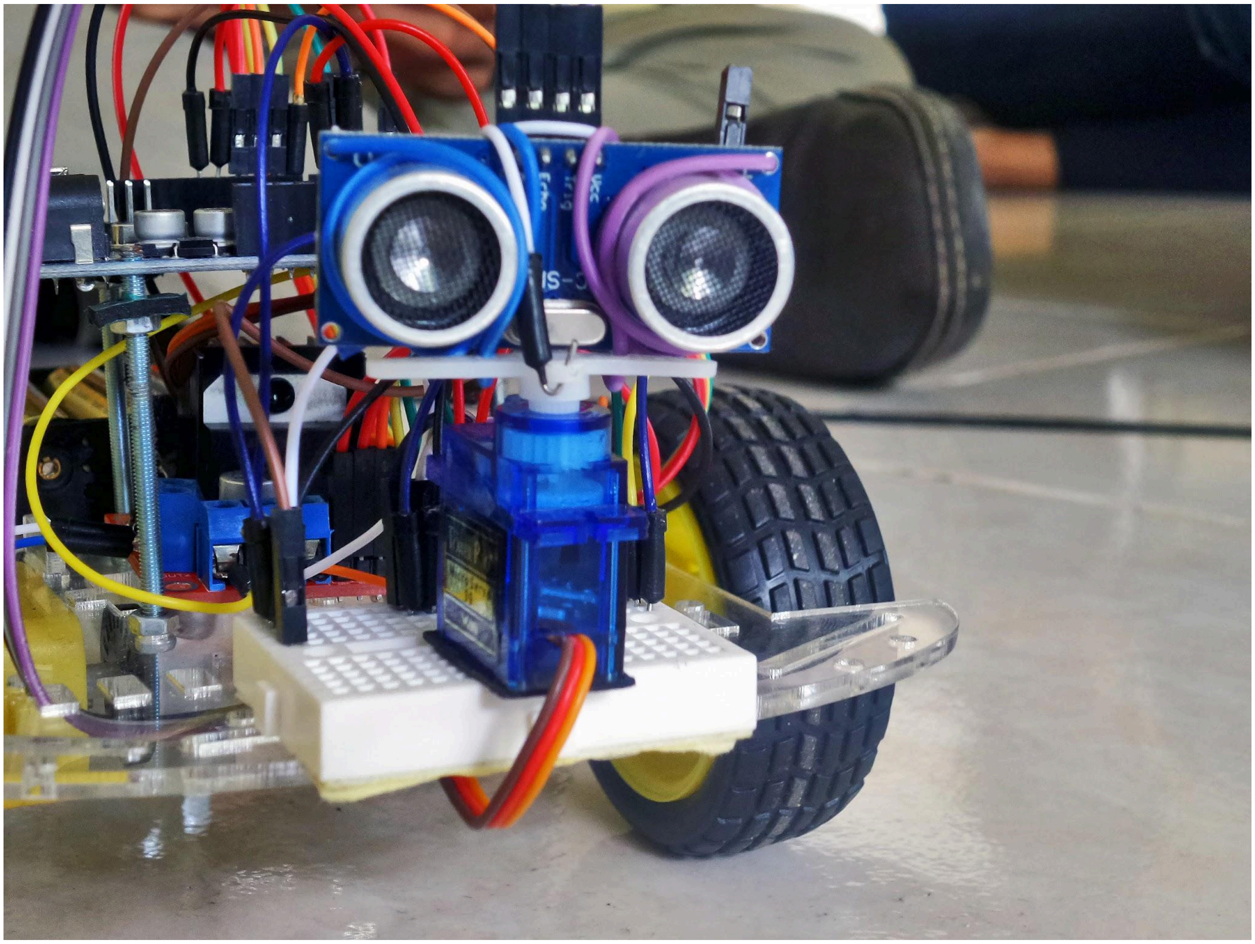


Design And Simulation Of Obstacle Obstacle Avoidance Robot

Mechatronics Project Group 10

200 level first semester robotics project proposal to be submitted in New Horizon Bells University

APPROVAL

I have read and hereby recommended this Mechatronics Group 10 project design entitled “Design and Simulation of Obstacle Avoidance Robot Using Arduino” acceptance of Bells University Of Technology in the fulfilment of project requirement.

…………………………………………………..

MR. AYUBA IBRAHIM

Lecturer.

ACKNOWLEDGMENT

We would like to thank our Robotics lecturer Mr. Ayuba Muhammed for his valuable guidance and unwavering support by providing step-by-step instructions and detailed explanations which helped make the complex process much more manageable and enlightening. His mentorship not only provided clarity but also inspired confidence in us to successfully complete this project. We truly appreciate his patience,support and willingness to share his wealth of knowledge.

ABSTRACT

Obstacle avoidance robots are one of the most important aspects of mobile robotics. Without it, robot movement would be very restrictive and fragile. This project proposes a robotic vehicle that has an intelligence built in it such that it directs itself whenever an obstacle comes in its path. So to protect the robot from any physical damages. This can be designed to build an obstacle avoidance robotic vehicle using ultrasonic sensors for its object detection. Arduino Uno is used to achieve the desired operation. An ultrasonic sensor is used to detect any obstacle and send a signal to the microcontroller(Arduino Uno). Depending on the input signal received,the micro-controller redirects the robot to move in an alternate direction by actuating the motors which are interfaced to it through a motor driver.

A robot could be thought of rudimentarily as analogous to how a human or an animal responds to environmental stimuli. For example, we humans perceive the environment through the five senses (e.g. sight). We might then ‘decide’ the following action based on these incoming signals and, finally, execute the action through our limbs. For example, you might see (sense) a familiar face in the crowd and think it would be good to grab their attention and then act on this thought by waving your hand.

Development of an obstacle avoiding robot model is required as a fundamental step towards a bigger goal, for example development of an autonomous vehicle. An obstacle avoiding robot uses a proximity sensor module, besides other parts. In this case, this robot uses a proximity sensor. The robot is controlled by a program that is embedded into a microcontroller. The logic produced by the microcontroller is further processed by an interface module. The interface module translates the microcontroller's logic into voltage and current that can practically drive the two motors.

CHAPTER ONE

1.0 INTRODUCTION

Obstacle avoidance robots are autonomous systems designed to navigate and operate in dynamic environments by avoiding collision with obstacles. These robots are equipped with sensors and programmed algorithms that enable them to detect,analyze, and respond to obstacles in their path, ensuring smooth and safe movement. The development of obstacle avoidance robots is a critical step in advancing robotics, as it combines elements of **mechatronics,control systems, and artificial intelligence**.

The primary objective of an obstacle avoidance robot is to achieve efficient navigation without human intervention,making it useful in a wide range of applications,including industrial automation,transportation,search and rescue missions,and home automation. The robot's functionality depends on its ability to sense the environment using sensors such as ultrasonic,infrared,or LIDAR,process the data through a microcontroller or processor,and execute appropriate actions like turning,stopping,or altering its path.

In today's world ROBOTICS is a fast growing and interesting field. It is the simplest way for the latest technology modification. Nowadays communication is part of the advancement of technology, so we decided to work on ROBOTICS field, and design something which will make human life simpler in today 's aspect. Thus we are supporting this cause. An obstacle avoiding robot is an intelligent device, which can automatically sense and overcome obstacles on its path. Obstacle Avoidance is a robotic discipline with the objective of moving vehicles on the basis of the sensorial information. The use of these methods in front of classic methods (path planning) is a natural alternative when the scenario is dynamic with unpredictable behaviour. In these cases, the surroundings do not remain invariable, and thus the sensory information is used to detect the changes consequently adapting moving. It will automatically scan the surroundings for further paths.

This project is the basic stage of any automatic robot.This ROBOT has sufficient intelligence to cover the maximum area of provided space. It has an ultrasonic sensor which is used to sense the obstacles coming in between the path of ROBOT. It will move in a particular direction and avoid the obstacle which is coming in its path. We have used two D.C motors to give motion to the ROBOT. The construction of the ROBOT circuit is easy and small .The electronics parts used in the ROBOT circuits are easily available and cheap too.

By exploring this project,we aim to gain experience in robotic design, sensor integration, and algorithm development, contributing to the broader field of autonomous systems and intelligence machines.

Background Of Study

The idea of obstacle avoidance robots emerged from the need to create autonomous systems that can navigate through complex environments safely and efficiently.Electronics have found their place into the development and the initiation of the first electronic autonomous robots produced in Bristol England by William Grey Walter in the year 1984, also the first digital and programmable robot was invented and named Unimate in the year 1954 by George Devol. SumitGarethiya in his dissertation “the first ever system to detect an obstacle was developed by Delco System operations, Goleta of California in 1988”. The Study was mainly a safe way to spot obstacles on the road then inform the motorist.

In 1949, neurobiologist William Grey Walter developed two rudimentary robots named Elmer and Elsie, which were equipped with light and bump sensors to navigate around obstacles. These robots are considered the first biologically inspired and behavior-based robots. In the 1960s, Stanford University introduced Shakey, the first mobile robot that could perceive its surroundings and reason about its actions. Shakey was equipped with whisker-like bump sensors, a TV camera, an infrared rangefinder, and an antenna for communication. The development of various sensors, such as Ultrasonic, LiDAR, radar, sonar, and cameras, allowed robots to detect obstacles and calculate distances in real-time. These sensors enable robots to sense their environment, make decisions, and act accordingly to avoid collisions. Algorithms like A* (A-star), Dijkstra's algorithm, and Rapidly-exploring Random Trees (RRT) were developed to calculate collision-free paths for robots. These algorithms help robots find the quickest route to their destination while avoiding obstacles. With the advent of artificial intelligence (AI) and machine learning, robots can now learn to adapt to changing environments and make more complex decisions. This has expanded the possibilities for obstacle avoidance and autonomous navigation.

Developing a robot that can avoid other objects over or below the required size is the prime objective. It makes dexterous coordinated movements. It moves without direct human intervention. So, in an industry, this robot can automatically navigate through an object in any direction using various sensors such as Ultrasonic sensors,Infrared sensors, and bump sensors. In this project we will be making use of ultrasonic sensors and it is widely used due to their low cost and high accuracy.

In the world today, robotics is a fast growing innovation. With the evolving of different technology in various fields of science, human life has become more convenient and relaxed with the advancement of technology that brought about a robot.. Robotics are used in places that are dangerous for humans to reach directly, these robots are used in those places by gathering information from the environment to avoid obstacles. Robots are used in factories/industries to prevent workers from being hurt.

Various advances have been made in the world of technology and robotics, a few of those advancements have been observed in artificial intelligence, security in general and so on but the concern here deals with an obstacle avoidance robot that incorporates knowledge from computer science, robotics, system analysis, algorithm, and electro mechanics, mechatronics, software development, engineering and programming an autonomous robot. This study major on the ability of the vehicle to detect and move past obstacles using components that enable these functions.

Nowadays many industries e.g (legos robotic) are making use of robots because of the level of efficiency, performance and dependability which is of great help to human life. The design of obstacle avoidance robots needs the integration of many components like the ultrasonic sensor, microcontroller, diodes, motor drivers IC, DC Motors etc according to their task.

This study proposes an autonomous robot that has the ability to control its direction when an obstacle comes in its path. Thiscar is constructed with a microcontroller . An ultrasonic sensor is used to sense any obstacle ahead of the robot and forward the signal to the microcontroller. The input signal received would determine the way the microcontroller interpret it and control the robot to move in an alternative direction by triggering the motors which are done through a motor driver.The main task of the robot is to go in a straight direction and whenever it senses an obstacle in its way, it doges the obstacle and this is done with the use of an ultrasonic sensor, it then continues in its own path. Obstacle avoidance is the primary obligation of this self-driven robot. The robot gets its information from its immediate environment with the help of the sensor fixed robot, there are various sensing devices like, infrared sensor, ultrasonic sensor, cameras etc. We would be making use of an ultrasonic sensor for this project and it would be attached in front of the robot and multi vibrator, which is fixed at its base. Ultrasonic sensor is more appropriate for obstacle detection because of its high ranging capability. The Ultrasonic sensor is made up of two parts which are the emitter and the detector. The emitter which produces a 40KHz sound wave and detector which detects 40KHz sound waves and emits frequency signals, when an obstacle is detected these signals are reflected back which is considered as input to the microcontroller. The microcontroller controls in different directions either left, right or front based on the signal received from the ultrasonic sensor.

The study is to design a robot that will move in accordance to the code programmed on it, it would move in a straight direction and if it senses any obstacle in its way it would check for a free space and avoid the obstacle.The obstacle avoidance robot would be useful in the various places like the industrial area where less supervision is need and prevent the risk of human been getting hurt in the process of working.

Problem Statement

In the past, the rate of accidents on a typical Nigeria road has increased as many years passed by and it is still rising. The major cause of these accident cases is as a result of lack of awareness of obstacles(bumps), whether it is a coming vehicle or a pedestrian or even a domestic animal on the road and in some cases brake failure.

The study is an attempt towards developing a robotic car that would be able to detect and avoid obstacles(bumps) in the robot's path using a sensor to achieve the target point in an optimized manner. With the use of an obstacle avoidance technology in the car, it will automatically alert the driver (or even the car itself) of the obstacle ahead with a possible means of avoiding the obstacle depending on the advancement of the technology, thus, effectively reducing the rate of mortality on the road.

When the robot gets to an environment that it is not used to, it will stop scanning through its environment, thereby processing it to recognize any obstacle. With the use of state of the art equipment, the robot can avoid obstacles and finds a secured path thereby causing reduction in accidents and non-avoidance of obstacles. Once the robotic car performs a task, it will store the task which will then make it perform better when another task is given which would be based on the updated percept (a combination of the current percept with the information that exists in its knowledge base with an internal state).

Navigating safely in dynamic and cluttered environments is a significant challenge for autonomous mobile robots. Traditional navigation systems often struggle to effectively detect and avoid obstacles, resulting in potential collisions and inefficiencies. These issues limit the practical applications of robots in real-world scenarios, such as search and rescue operations, industrial automation, and household tasks. This study aims to develop a robust obstacle avoidance robot that can dynamically detect and navigate around obstacles in real-time, enhancing its operational safety and efficiency in various environments.

Objectives of the study

Main objectives:

The main objective of this project is to design an obstacle avoidance robot using various forms of technology components such as ultrasonic sensor,Arduino uno,LCD display,D.C motor.

Specific objectives:

1. To evaluate literature related to the fields of engineering, mechatronics, and software development in the design, construction, and programming of an autonomous robot.
2. To design a robot capable of obstacle detection in a controlled environment.
3. To interface the robot with a real-time system that will enable it to perform assigned tasks.
4. To achieve optimal performance from the robot and distinct quality in contrast to other obstacle avoidance robots known.

Research questions:

1. How can multiple sensors be integrated to improve obstacle detection accuracy?
2. How can the graphical user interface (GUI) be enhanced to provide more detailed and interactive feedback to users?
3. How can power management be optimized for extended operation in autonomous robots?
4. How can machine learning be used to enhance the decision-making process of autonomous robots?

Significance of study

Obstacle avoidance is very useful in real life. The robot is to detect an obstacle that comes its way. Obstacles include chairs, desks, bottles, walls or any object standing in the robot's path. The robot correspondingly changes its direction to avoid any collisions according to the pre-existed programme on the microcontroller that can only be performed when it receives a signal from the environment through the sensor mounted in front of the robot as the name implies obstacle avoidance robot. This robot will be able to produce the basic performance with the use of the code programmed on it so as to sense the obstacle then decode the information coming from the sensor and then perform the right task either by moving forward or scanning through its environment for an obstacle in its way. When the entire system is combined together, the car will achieve a great functionality of avoidance.

Scope of the study

Context scope

The study will cover the implementation of obstacle avoidance robot using Arduino Uno. This research is centred around designing an autonomous obstacle avoidance robot that would be able to sense any obstacle in its paths, with the use of the ultrasonic sensor and then make 90˚or 180 ˚turn to look for a free space to avoid the obstacle and resume its normal direction which is control by the microcontroller. The research work would be limited to obstacle avoidance using robotics.

Geographical scope

The geographical scope of this study is centered around environments where obstacle avoidance robots can be effectively deployed. This includes various indoor and outdoor settings, each presenting unique challenges and opportunities for testing and application. For example,in a warehouse,it can avoid shelves, pallets, and dynamic obstacles like human workers and other moving equipment. While outdoors, it can operate in unpredictable and hazardous environments to assist in search and rescue missions, avoiding debris and unstable structures.

Time scope

This project is based on methodological data, thus it is estimated to take a maximum of 7-11 months. This timeline ensures a thorough and systematic approach to developing an effective obstacle avoidance robot.

CHAPTER TWO
LITERATURE REVIEW

Introduction

We reviewed different obstacle avoidance robot mechanisms that have been built by a lot of students and practitioners that are in existence. For an autonomous mobile robot performing a navigation-based task in a vague environment,to detect and to avoid encountered obstacles is an important issue and a key function for the body's safety as well as for the task's continuity. Obstacle avoidance in a real world environment that appears so easy to humans is a rather difficult task for autonomous mobile robots and is still a well-researched topic in robotics. In many previous works, a wide range of sensors and various methods for detecting and avoiding obstacles for mobile robots have been proposed. Good references related to the developed sensor systems and proposed detection and avoidance algorithms can be found. Based on these developed sensor systems, various approaches related to this work can be grouped.The primary goal is to enable robots to navigate their environments while avoiding collisions. This involves sensors like **ultrasonic sensors**, **infrared sensors**, **cameras**, and **bump sensors**, which detect the presence of obstacles. But in this project we will be making use of **ultrasonic sensors**

Ultrasonic sensor

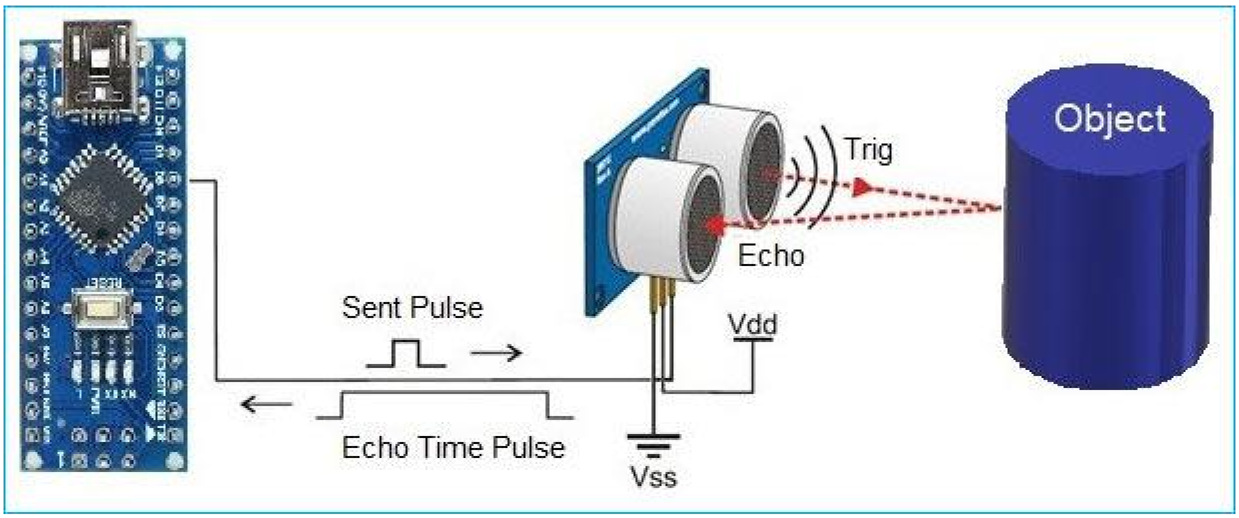
Before going into building this obstacle avoidance robot, it is important to understand how the ultrasonic sensor works because these sensors will have an important role in detecting obstacles. Ultrasonic sensors have been available for the past many decades and these devices continue to hold huge space in the sensing market because of their specifications, affordability, and flexibility. As the automation industry has been progressing, the employment of ultrasonic sensors in multiple domains such as drones, EV vehicles is emerging. In the year 1914, **Fessenden** developed the first modern transducer employed in sonar where it can be able to find the items in water but not the direction of items. And then in 1915 Langevin introduced the contemporary model of ultrasonic which resolved the problem of Fessenden. **ultrasonic sensor definition**, how it works, its specifications, its integration with Arduino, and its advantages are explained clearly in this article.

The basic principle behind the working of an ultrasonic sensor is to note down the time taken by the sensor to transmit ultrasonic beams and receive the ultrasonic beams after hitting the surface. Then further the distance is calculated using the formula. In this project, the widely available **HC-SR04 Ultrasonic Sensor** is used. To use this sensor, a similar approach will be followed as explained above. Ultrasonic sensors are electronic devices that calculate the target's distance by emission of ultrasonic sound waves and convert those waves into electrical signals. The speed of emitted ultrasonic waves traveling speed is faster than the audible sound. There are mainly two essential elements which are the transmitter and receiver. Using the piezoelectric crystals, the transmitter generates sound, and from there it travels to the target and gets back to the receiver component. The sensor calculates the time it took for the sound wave to return and determines the distance to the object using the formula:

$$D = \frac{T \times C}{2}$$

where D is the distance, T is the time taken, and C is the speed of sound.

Ultrasonic sensor working principle is similar to sonar or radar which evaluates the target/object attributes by understanding the received echoes from sound/radio waves correspondingly. These sensors produce high-frequency sound waves and analyze the echo which is received from the sensor. The sensors measure the time interval between transmitted and received echoes so that the distance to the target is known.



Pins in ultrasonic sensor

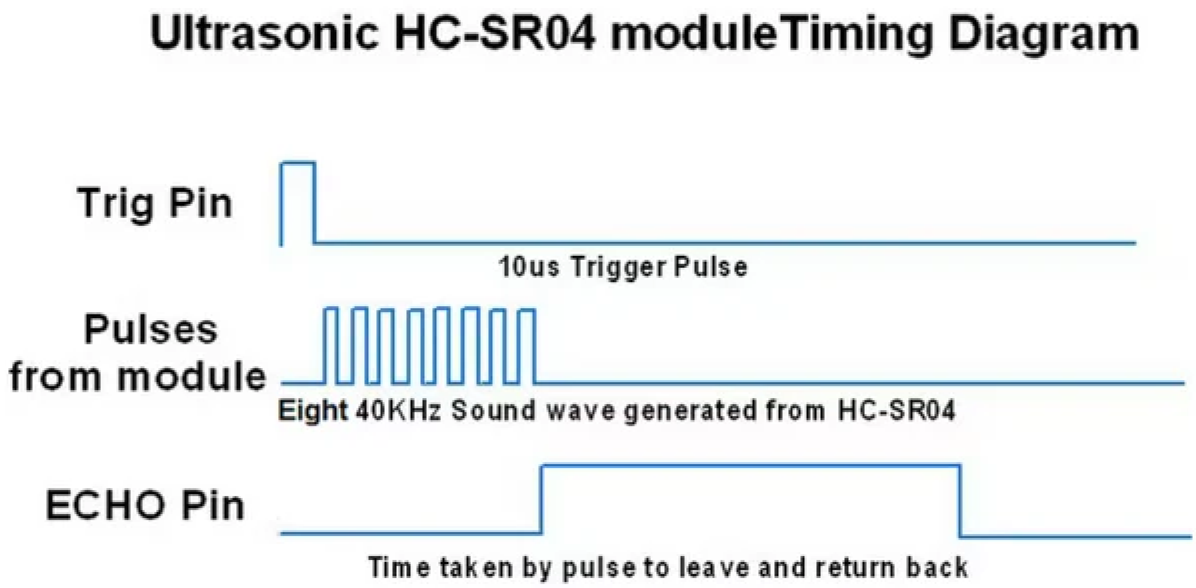
- Vcc - Power supply +5V
- Gnd - Common ground
- Trigger Pin - to start the sensor
- Echo pin - to receive the signal

The principle of obstacle avoidance robot

The fundamental working principle of an ultrasonic sensor is to measure the time it takes for the signal sent by a transmitter and sent back or propagated back to the receiver. It is evident from the name ultrasonic sensor that it operates on the ultrasonic frequencies. Ultrasonic frequencies ranges are beyond our audible sound to humans and these frequencies are greater than 20 kilo Hertz. Ultrasonic sensors are versatile in sensor technology and are used significantly in many industrial applications. There are various types of objects that can be detected such as solids, liquids, granules and powder. They detect transparent objects or shiny objects, as well as objects for which the color changes.

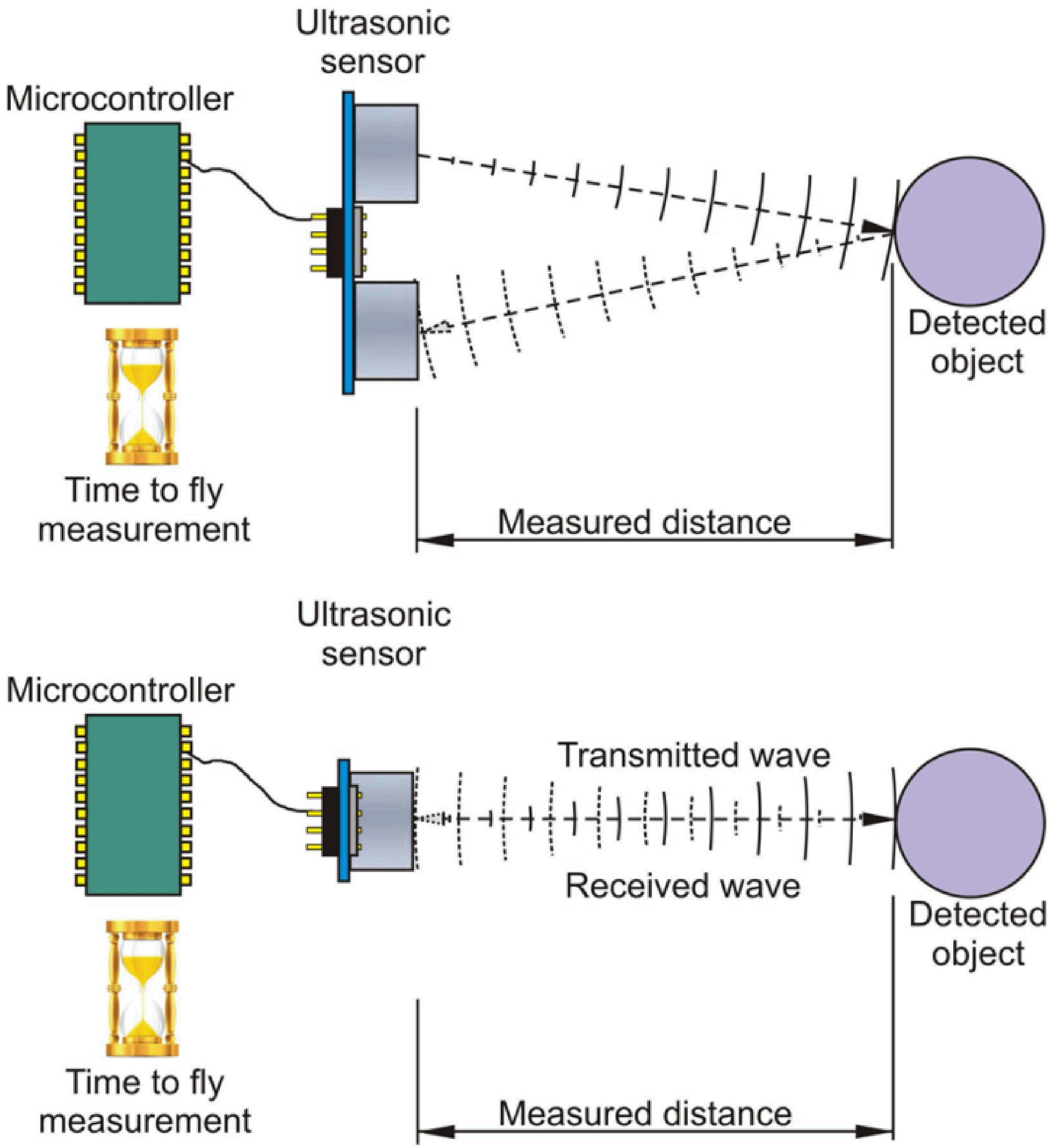
- **Obstacle Detection**: The robot continuously scans its surroundings using sensors to detect obstacles. Each sensor can detect different types of obstacles depending on its technology.
- **Data Processing**: The data from sensors is sent to the microcontroller. The microcontroller processes this data to understand the robot's environment, typically creating a map or a grid of the surrounding area.
- **Decision Making**: Based on the processed data, the robot decides the best path to take to avoid obstacles. This can involve simple rules like "if an obstacle is detected within 10 cm, turn right" or complex algorithms like path planning using A* or Dijkstra's algorithm.
- **Movement Control**: The microcontroller sends commands to the motors and actuators to move the robot in the desired direction. The robot typically moves in small steps, constantly re-evaluating its path based on new sensor data.

    While some sensors have seperate sound emitters and receivers,the two functions can be combined into a single device by using an ultrasonic element that alternates between sending and receiving signals in a continuous loop. The transmitter of the module transmits an ultrasonic sound. This sound will be reflected if an object is present in front of the ultrasonic sensor. The reflected sound is received by the receiver present in the same module. An ultrasonic sensor signal is propagated by a wave at an angle of 30 degrees.



How does an ultrasonic sensor work?

Ultrasonic sensor is an electronic instrument which measures the distance to a targeted object by the emission of ultrasonic sound waves and converting the reflected sound into the electrical signals. A separate sound emitter and receivers used by some kind of sensors, it is viable to combine both the functions into a single device by using an ultrasonic element to switch between sending the signals and receiving the signals in a continuous cycle. The transmitter module transmits an ultrasonic sound. If an object is present in-front of the ultrasonic sensor, then this transmitted ultrasonic sound will be propagated or reflected back.
The sound reflected will be received by the receiver of the same module. Ultrasonic signal is reproduced by a wave at an angle of 30 degrees. To achieve the maximum accuracy, external objects which come under this measurement angle will interfere to determine the distance to the object targeted.



RELATED WORK DONE

Automatic driving technology, as a transformative technology in the transportation industry, has attracted extensive attention and research. It has many potential benefits, including improving road safety (Jafarzadeh Ghoushchi et al., 2023), enhancing traffic efficiency (Garg and Bouroche, 2023), and increasing mobility. However, achieving reliable automatic driving systems still faces numerous challenges.

Firstly, autonomous vehicles need to accurately perceive and understand complex road environments (Guo et al., 2023). This includes accurate perception and recognition of other vehicles, pedestrians, traffic signals, road signs, and geometric structures. Accurate environmental perception forms the foundation for making informed decisions in autonomous driving systems. However, this method may be affected by environmental changes, such as adverse weather conditions, insufficient light, or sensor failures. In these situations, the perception system may not be able to obtain sufficiently accurate information, leading to the system making incorrect decisions. In addition, accurate perception and recognition require highly complex algorithms and sensors, which may lead to increased system costs and deployment complexity.

Secondly, autonomous driving systems require efficient decision-making capabilities. They need to make rapid and accurate decisions based on the perceived environmental information, such as obstacle avoidance, path planning, and traffic participation. This is crucial for ensuring safe and efficient vehicle operation in complex traffic environments.

Additionally, precise control capabilities (Chotikunnan and Piti Theeraphab, 2023) are necessary for autonomous driving systems to achieve accurate vehicle maneuvering. This includes controlling vehicle acceleration, braking, steering, and precise control of vehicle power systems and braking systems. However, in practical applications, achieving precise control may be influenced by multiple factors. For example, changes in road conditions, background traffic conditions, and unforeseeable events can all interfere with precise control. This may result in the control system needing to adjust in real-time to adapt to changing situations, but the system may not be able to provide optimal response in all situations, and sensors may also have delays and noise.

In this context, researchers and practitioners have been actively exploring various algorithm models and technological methods to address the challenges related to perception, decision-making, and control in autonomous driving systems. They aim to develop more accurate, efficient, and reliable algorithm models to enhance the performance and reliability of autonomous driving systems. These research efforts are aimed at promoting the development of automatic driving technology and providing better solutions for practical application scenarios.

In this regard, perception forms the foundation of autonomous driving systems and involves accurate perception and recognition of road environments, obstacles, and traffic signs. In perception research, numerous theoretical and experimental research findings have been achieved. In literature (Zhang et al., 2023), researchers have utilized various sensors (Liu et al., 2021) such as cameras, lidar, etc., for environment perception and obstacle detection. CNN have been widely applied for object detection and lane detection tasks, enabling accurate and efficient perception by extracting meaningful features from sensor data. However, despite CNN's excellent performance in object detection and lane detection, there are still some limitations and drawbacks. For example, in dealing with complex situations such as occlusion, changes in lighting, and different perspectives, it may be affected. The quality of sensor data and changes in environmental conditions may make it difficult for CNN to accurately identify obstacles or lane lines; Its demand for a large amount of annotated data may limit its generalization ability beyond specific scenarios or datasets. Without sufficient diversity data for training, CNN may not perform well in various complex environments.

Decision-making (Wang F.-Y. et al., 2023) is crucial in autonomous driving systems, where decisions need to be made based on the perceived environmental information, such as obstacle avoidance, path planning, and traffic participation. In decision-making research, various decision-making algorithms and models have been developed. RL algorithms have been widely applied, enabling vehicles to learn optimal decision-making strategies through interactions with the environment, such as motion planning, lane changing, and negotiation at intersections. However, in decision-making research, the RL algorithm may require a large amount of training data and time to achieve good performance. In complex traffic environments and uncertain road conditions, a large number of experiments and interactions are required to adjust and optimize decision strategies, which may limit the practical application of the algorithm.

Moreover, other research areas have received significant attention and application in the field of autonomous driving. Sensor fusion techniques have been employed to integrate information from multiple sensors (Shao et al., 2023a), improving the reliability and accuracy of perception. Path planning algorithms aim to find optimal driving paths, considering road conditions, traffic situations, and vehicle capabilities, enabling efficient and safe vehicle operation in complex traffic environments.

For example, in the robotic system that integrates perception and decision-making, the perception module, and decision-making module play an important role (Xu W. et al., 2023), including visual sensors, lidar, radar, inertial measurement units, etc. These sensors are capable of acquiring multimodal information about the vehicle's surroundings, such as data such as images, point clouds, and distances. By processing and analyzing these data, the perception module can extract key environmental features, such as roads, vehicles, pedestrians and obstacles, and classify, locate and track them. The decision-making module is responsible for making intelligent decisions based on the information provided by the perception module. In literature (Black et al., 2023), the controller converts the path generated by the planner into specific vehicle control instructions, and controls parameters such as the speed, steering and acceleration of the vehicle. Compared with traditional robotic systems, our method has obvious advantages in the fusion of perception and decision-making. First, the method in this paper adopts an end-to-end architecture, which integrates perception and decision-making tasks into one model, avoiding the information transfer and alignment problems between perception and decision-making in traditional systems, and making the whole system more compact and efficient. Secondly, the method in this paper introduces an attention mechanism, which enables the vehicle to pay more attention to important environmental features and obstacles, improving the accuracy of perception and the robustness of decision-making. In terms of dynamic environment perception for robots, this is a key problem in solving the perception and decision-making of autonomous vehicles in complex and dynamic environments. In such an environment, vehicles need to be able to accurately perceive and track moving objects and obstacles in order to make timely decisions and plan driving paths. In our approach, these dynamic environment perception techniques can be combined to improve the perception and decision-making capabilities of autonomous vehicles.

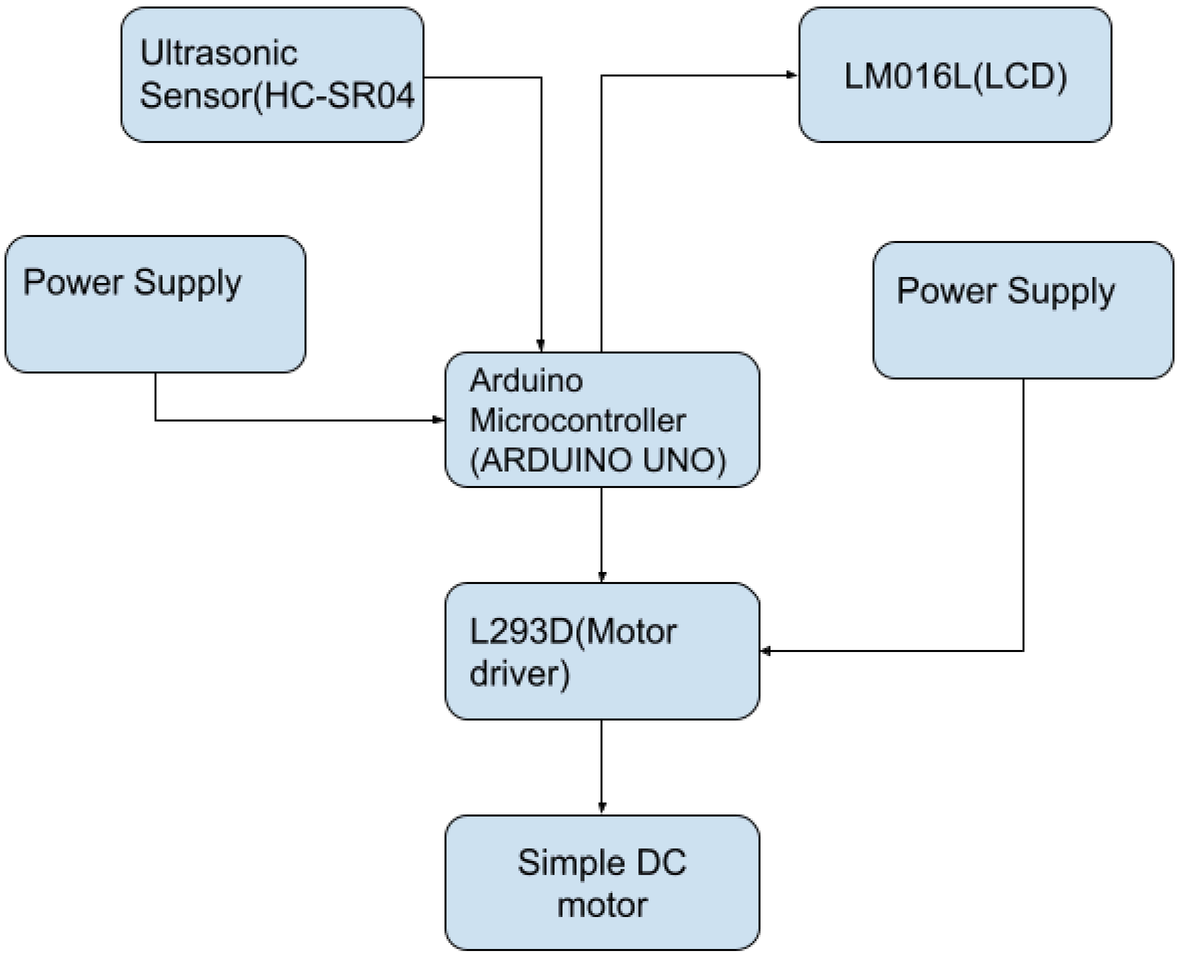
To sum up, with the rapid development of deep learning (Zhang M. et al., 2022; Zhang Y.-H. et al., 2022), a large number of theoretical, experimental and applied researches have been carried out in the field of automatic driving, which provides valuable theoretical basis and technical support for the development and application of automatic driving systems. However, there may still be the following research gaps: comparison of multimodal information fusion methods; Selection of different end-to-end architectures; The application of classic algorithms in the field of robotics; Traffic behavior modeling; Human machine interaction and driver behavior prediction; Adaptability to urban and non urban environments; Diversity of experimental evaluations; Actual deployment and application cases, etc.

CHAPTER THREE

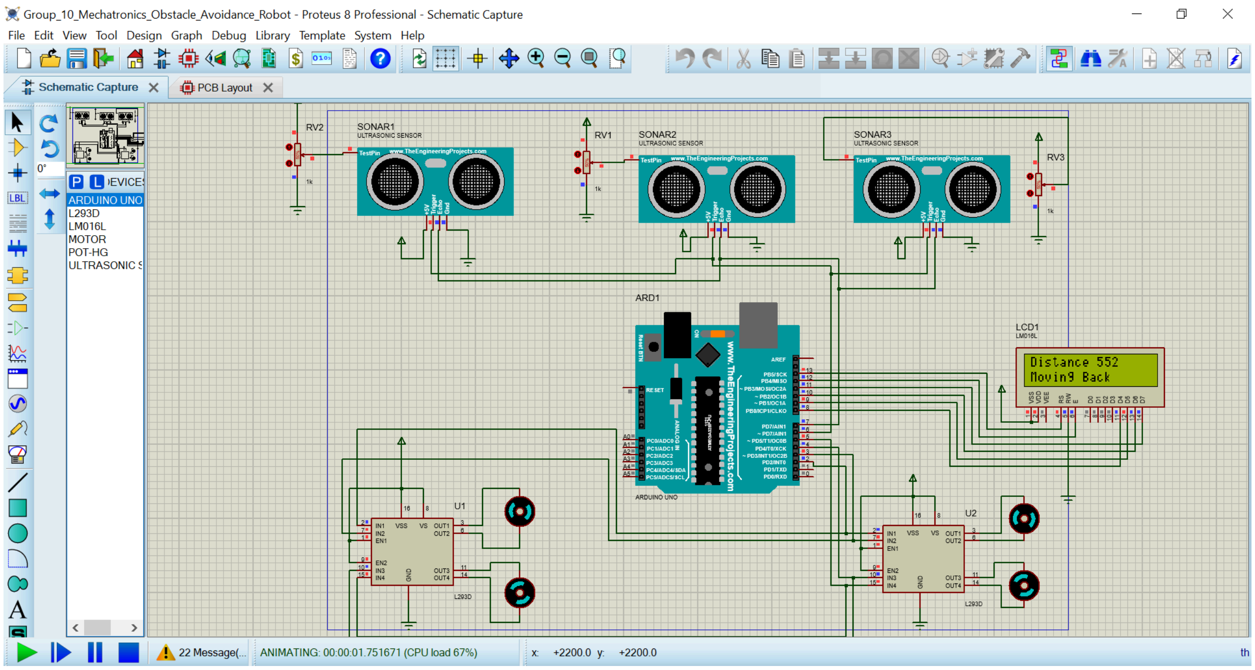
METHODOLOGY

Obstacle avoidance robots use sensors to detect obstacles and then use algorithms to calculate the best path to avoid them. The robot then uses this information to move around the obstacles. In this project, the vehicle uses the ultrasonic sensor to detect objects. Initially the system starts with one sensor i.e. ultrasonic, but as cars have some blind spots in its left and right direction that is why two additional sensors were added to overcome the blind spot and limit its chances of collisions. Robot is designed in such a way that it detects the obstacle inside a particular range. Suppose there is something inside the range, then that is referenced as an obstacle the smart vehicle avoids and changes its direction. At the forepart on the left and right sides the sensors (ultrasonic) are embedded. They produce an ultrasonic- pulse after every 300ms Whose echo comes back from the nearby obstacle after collision. We make use of the lapse of time between the ultrasonic pulse and its reflection, the UNO computes the separation from the obstacles from where the reflection is arriving at the speed of 340m/s. Whenever the sensors recognize the presence of obstruction within the threshold distance, the car diverts its path. Apart from general movements, the car is arranged to manage the typical scenario where all the ultrasonic-sensors have obstruction inside the particular distance. In that case, the robotic car must turn back about 10ms then validate the separation from obstacles through sensors (left and right). Cars must differentiate the separation and turns according to the greater distance.

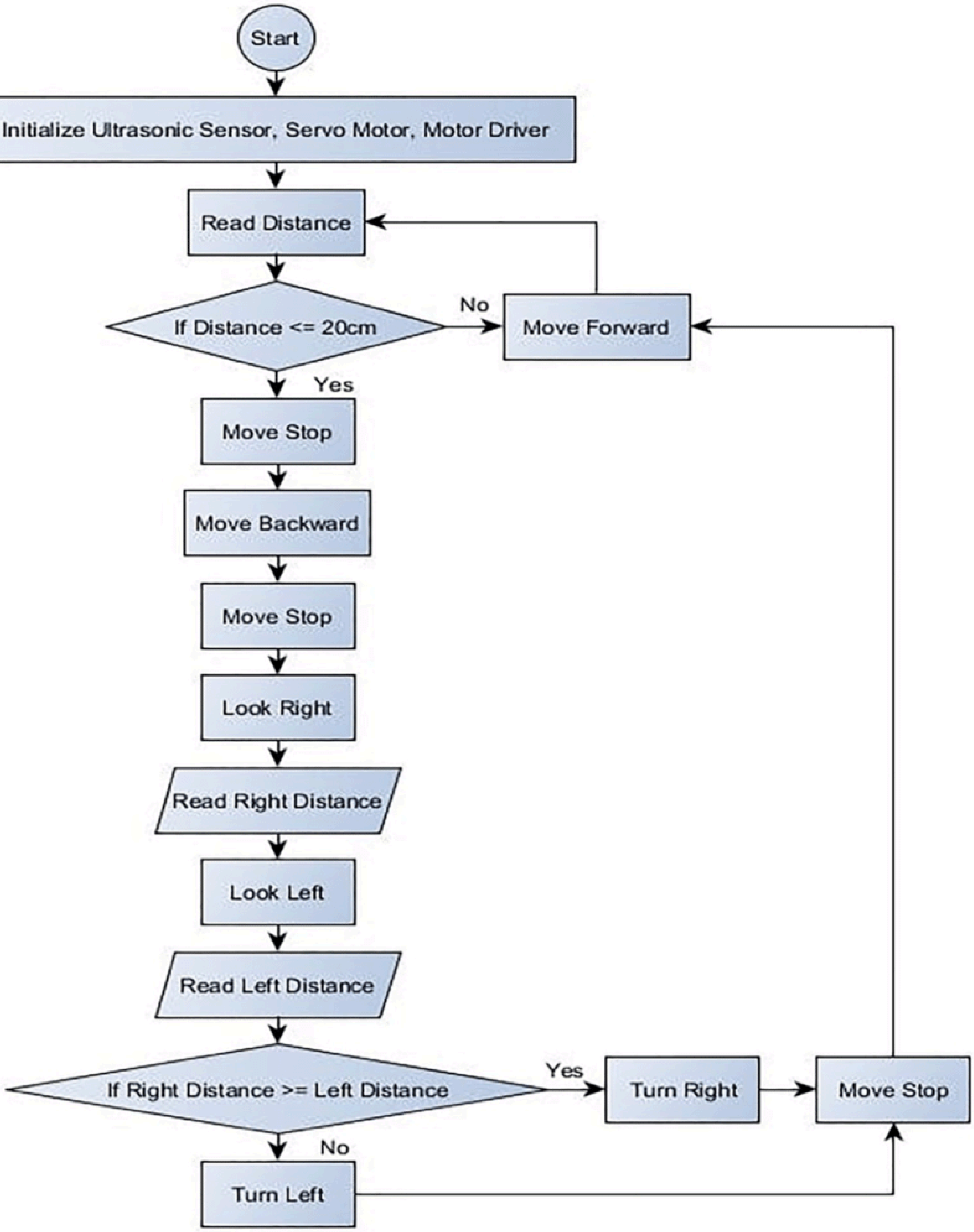
Block Diagram Of Obstacle Avoidance Robot



CIRCUIT DESIGN OF OBSTACLE AVOIDANCE ROBOT



FLOW CHART OF OBSTACLE AVOIDANCE ROBOT



As shown in the above flow chart, the robot is powered on and initializes its sensors and motors. The robot continuously collects data from its sensors (e.g., ultrasonic sensors) to detect obstacles. The robot processes the sensor data to determine if there is an obstacle in its path and if no obstacle, the robot continues to move forward and if the robot detects an object, it stops and decides on an alternative path. The robot determines the best direction to avoid the obstacle (e.g., turn left, turn right, or reverse). The robot executes the chosen maneuver to avoid the obstacle and after avoiding the obstacle, the robot resumes its original path. The process repeats continuously as the robot navigates its environment.

SYSTEM COMPONENTS

Arduino Uno

The **Arduino Uno** is an open-source microcontroller board developed by Arduino.cc, based on the Microchip ATmega328P microcontroller. It was initially released in 2010 and has since become one of the most popular and widely used microcontroller boards.

The Arduino Uno is equipped with 14 digital input/output pins (six of which can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It can be powered via a USB connection or an external power supply, such as a 9-volt battery.

The board is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. The ATmega328P microcontroller on the board comes pre programmed with a bootloader that allows uploading new code to it without the need for an external hardware programmer

Digital Pins

- **Pins 0-13**: General-purpose digital I/O pins.
- **PWM Pins**: Pins 3, 5, 6, 9, 10, and 11 support Pulse Width Modulation (PWM) output.

Analog Pins

- **Pins A0-A5**: Analog input pins that can also be used as digital I/O pins.

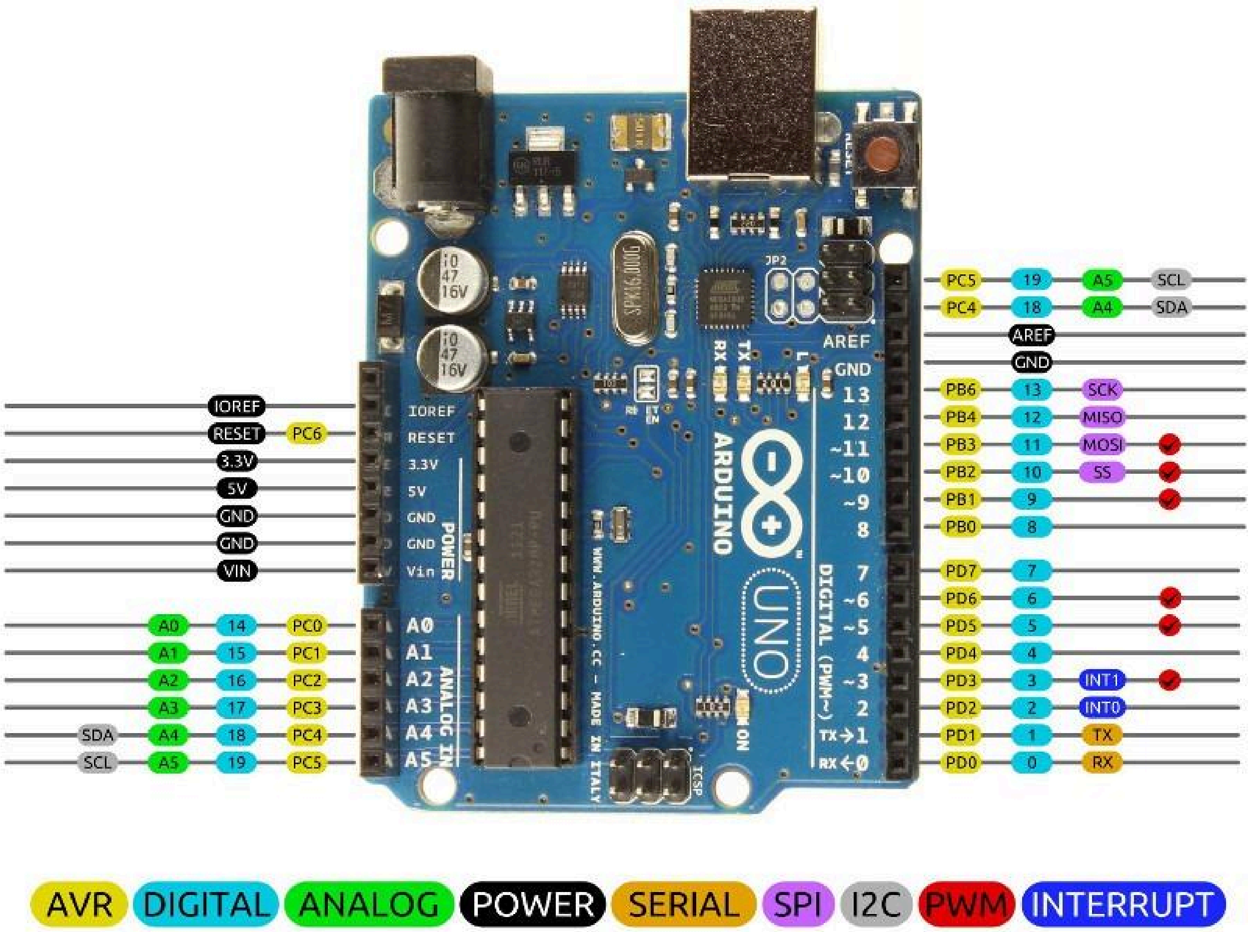
Power Pins

- **Vin**: External power source input.
- **5V**: Regulated 5V output.
- **3.3V**: Regulated 3.3V output.
- **GND**: Ground pins.

Communication Ports

- **Serial (UART)**: Pins 0 (RX) and 1 (TX) for serial communication.
- **I2C**: Pins A4 (SDA) and A5 (SCL) for I2C communication.
- **SPI**: Pins 10 (SS), 11 (MOSI), 12 (MISO), and 13 (SCK) for SPI communication.

Arduino Uno R3 Pinout



Ultrasonic Sensor

Ultrasonic Sensors are electronic devices that calculate the target's distance by emission of ultrasonic sound waves and convert those waves into electrical signals. The speed of emitted ultrasonic waves traveling speed is faster than the audible sound. We discuss what ultrasonic sensors are and how they emit ultrasonic sound and receive feedback . There are mainly two essential elements which are the transmitter and receiver. Using the piezoelectric crystals, the transmitter generates sound, and from there it travels to the target and gets back to the receiver component.
To know the distance between the target and the sensor, the sensor calculates the amount of time required for sound emission to travel from transmitter to receiver. The calculation is done as follows:

D = 1/2 T * C

Where 'T' corresponds to time measured in seconds

'C' corresponds to sound speed = 343 measured in mts/sec

What is Ultrasonic Sensor : Working & Its Applications

March 29, 2022 By WatElectronics

Ultrasonic sensors have been available for the past many decades and these devices continue to hold huge space in the sensing market because of their specifications, affordability, and flexibility. As the automation industry has been progressing, the employment of ultrasonic sensors in multiple domains such as drones, EV vehicles is emerging. In the year 1914, **Fessenden** developed the first modern transducer employed in sonar where it can be able to find the items in water but not the direction of items. And then in 1915 Langevin introduced the contemporary model of ultrasonic which resolved the problem of Fessenden. **ultrasonic sensor definition**, how it works, its specifications, its integration with Arduino, and its advantages are explained clearly in this article.

What is an Ultrasonic Sensor?

Ultrasonic sensors are electronic devices that calculate the target's distance by emission of ultrasonic sound waves and convert those waves into electrical signals. The speed of emitted ultrasonic waves traveling speed is faster than the audible sound.

There are mainly two essential elements which are the transmitter and receiver. Using the piezoelectric crystals, the transmitter generates sound, and from there it travels to the target and gets back to the receiver component.

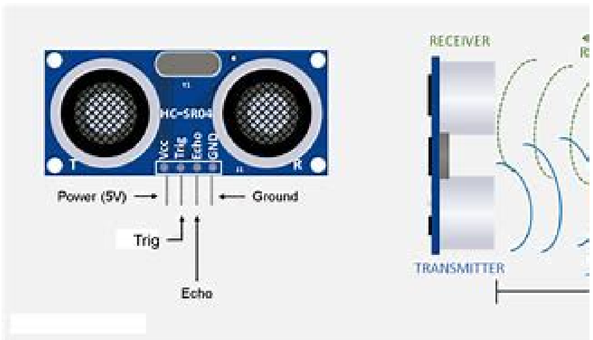
To know the distance between the target and the sensor, the sensor calculates the amount of time required for sound emission to travel from transmitter to receiver. The calculation is done as follows:

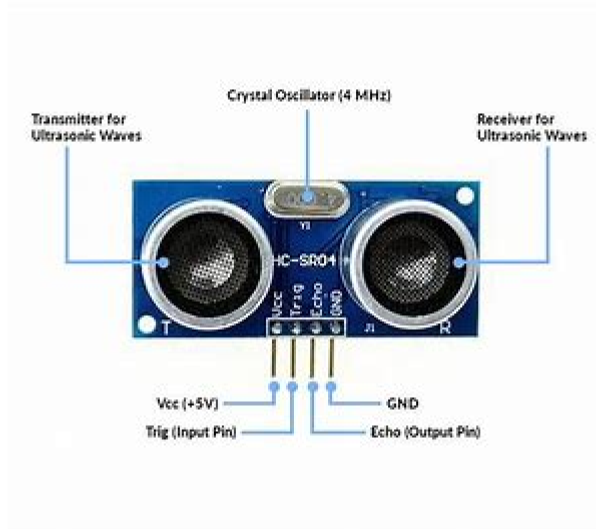
D = 1/2 T * C

Where 'T' corresponds to time measured in seconds

'C' corresponds to sound speed = 343 measured in mts/sec

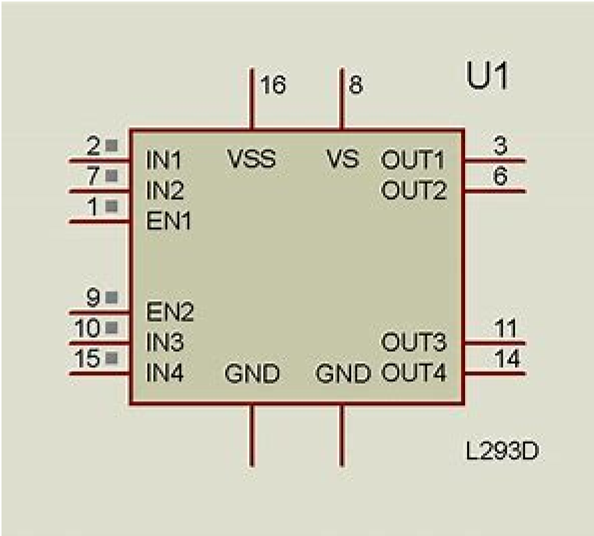
Ultrasonic sensor working principle is similar to sonar or radar which evaluates the target/object attributes by understanding the received echoes from sound/radio waves correspondingly. These sensors produce high-frequency sound waves and analyze the echo which is received from the sensor. The sensors measure the time interval between transmitted and received echoes so that the distance to the target is known.





Motor Driver(L293D)

L293d IC is known as a motor driver. It is a low voltage operating device like other ICs. The other ICs could have the same functions like L293d but they cannot provide the high voltage to the motor. L293d provides the continuous bidirectional Direct Current to the Motor. The Polarity of current can change at any time without affecting the whole IC or any other device in the circuit. L293d has an internal H-bridge installed for two motors. The L293D contains two H-Bridge circuits, allowing it to control two DC motors independently. It has 14-16 pins, including input pins for controlling the motors, output pins connected to the motors, and enable pins to activate the H-Bridge circuits. In Proteus, we simulated the L293D to control the direction and speed of DC motors by connecting it to a microcontroller (e.g, Arduino) and other components like sensors and power supplies.

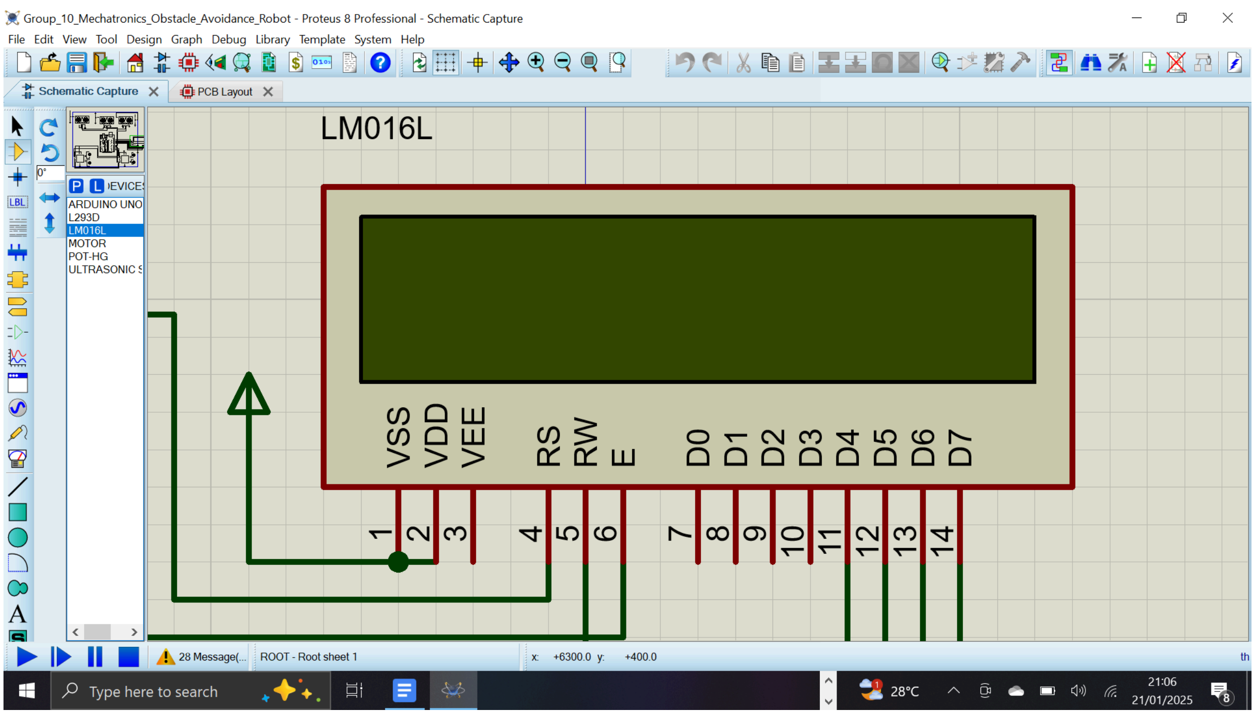


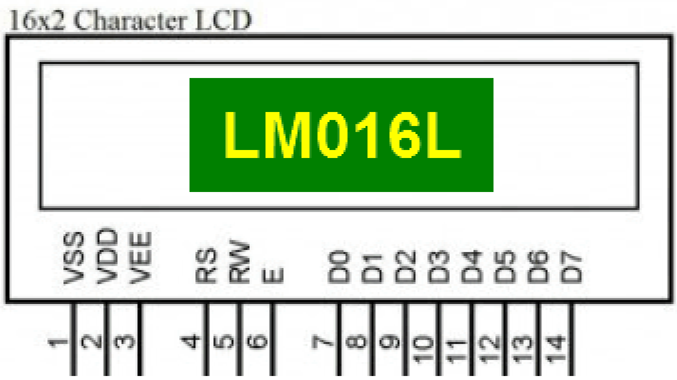
PIN SUMMARY OF L293D

1. Enable 1-2 (Pin 1): Activates the left side of the IC when set to HIGH.
2. Input 1 (Pin 2): Controls the direction of Motor 1.
3. Output 1 (Pin 3): Connected to one terminal of Motor 1.
4. Ground (Pin 4): Connected to the ground of the circuit.
5. Ground (Pin 5): Connected to the ground of the circuit.
6. Output 2 (Pin 6): Connected to the other terminal of Motor 1.
7. Input 2 (Pin 7): Controls the direction of Motor 1.
8. Vcc2 (Pin 8): Motor supply voltage (4.5V to 36V).
9. Enable 3-4 (Pin 9): Activates the right side of the IC when set to HIGH.
10. Input 3 (Pin 10): Controls the direction of Motor 2.
11. Output 3 (Pin 11): Connected to one terminal of Motor 2.
12. Ground (Pin 12): Connected to the ground of the circuit.
13. Ground (Pin 13): Connected to the ground of the circuit.
14. Output 4 (Pin 14): Connected to the other terminal of Motor 2.
15. Input 4 (Pin 15): Controls the direction of Motor 2.
16. Vcc1 (Pin 16): Logic supply voltage (typically 5V).

Liquid Crystal Display(LM016L)

The LM016L is a type of LCD (Liquid Crystal Display) module which features a 16-character by 2-line display, which means it can show up to 16 characters per line and has two lines. It uses the HD44780 controller, which is a common controller for LCD modules and allows for easy interfacing with microcontrollers. Among the 16 pins LM016L ,there include power supply pins, data pins, and control pins. You can connect these pins to the corresponding pins on your microcontroller (even in the Proteus simulation).





PIN SUMMARY OF LM016L

1. Vss: Ground (0V)

2. VDD: Power supply (+5V)

3. Vo: Contrast adjustment (connected to a potentiometer)

4. RS: Register Select (0 = Instruction register, 1 = Data register)

5. R/W: Read/Write (0 = Write, 1 = Read)

6. E: Enable signal (starts data read/write)

7. DB0: Data bus line 0 (least significant bit)

8. DB1: Data bus line 1

9. DB2: Data bus line 2

10. DB3: Data bus line 3

11. DB4: Data bus line 4

12. DB5: Data bus line 5

13. DB6: Data bus line 6

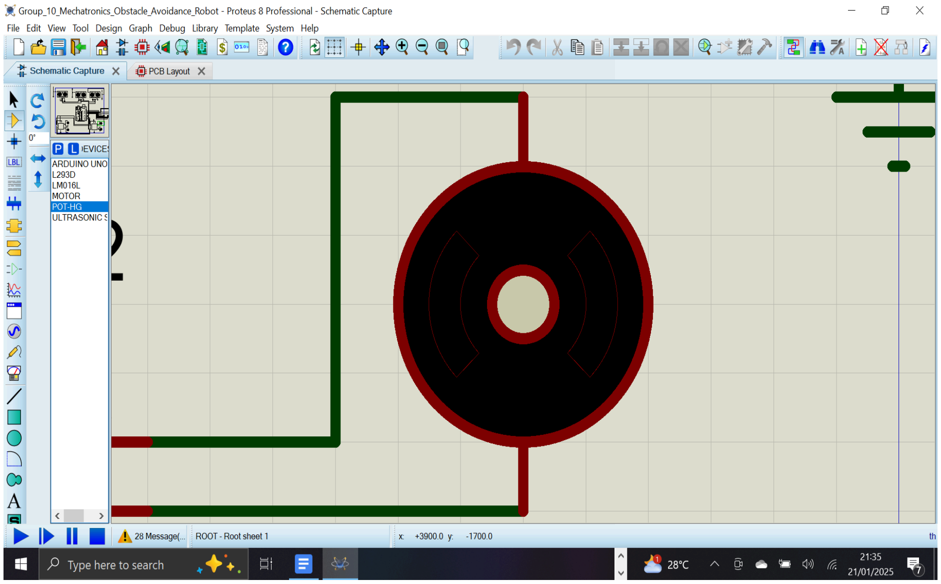
14 DB7: Data bus line 7 (most significant bit)

15. A: LED backlight anode (+5V)

16. K: LED backlight cathode (Ground)

D.C Motor

The DC motor provides the necessary torque to rotate the wheels, allowing the robot to move forward, backward, and turn. By controlling the speed and direction of the DC motor, you can precisely maneuver the robot. This is typically done using a motor driver (like the L293D) and a microcontroller (like Arduino). When the robot detects an obstacle, the microcontroller sends signals to the motor driver to adjust the motor's speed and direction. This enables the robot to navigate around the obstacle and continue on its path.

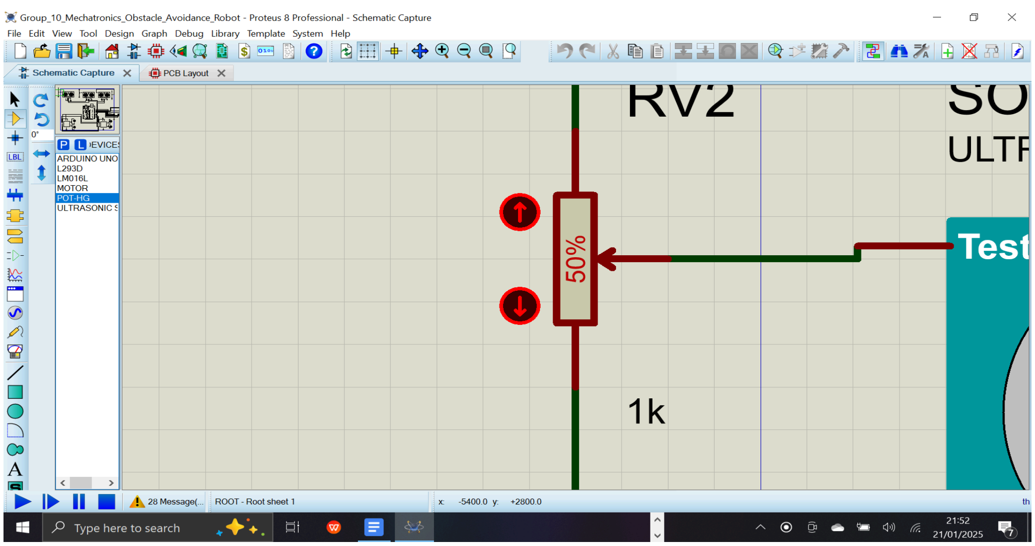


POT-HG(Potentiometer or Variable Resistor)

POT-HG, often regarded as a potentiometer or variable resistor, is used in this project to adjust the sensitivity of sensors, such as ultrasonic sensors. This helps in fine-tuning the distance at which the robot detects. The potentiometer (POT-HG) is used to adjust the distance at which the robot detects obstacles. By varying the resistance of the potentiometer, you can change the threshold distance for obstacle detection. This allows you to fine-tune the robot's sensitivity to obstacles and optimize its navigation behavior. For example, if you increase the resistance of the potentiometer, the robot might detect obstacles at a greater distance, giving it more time to react and avoid them. Conversely, if you decrease the resistance, the robot might detect obstacles at a shorter distance, making it more responsive to nearby objects.

Using the potentiometer in this way helps you test and calibrate the robot's obstacle avoidance system during the simulation.


B10K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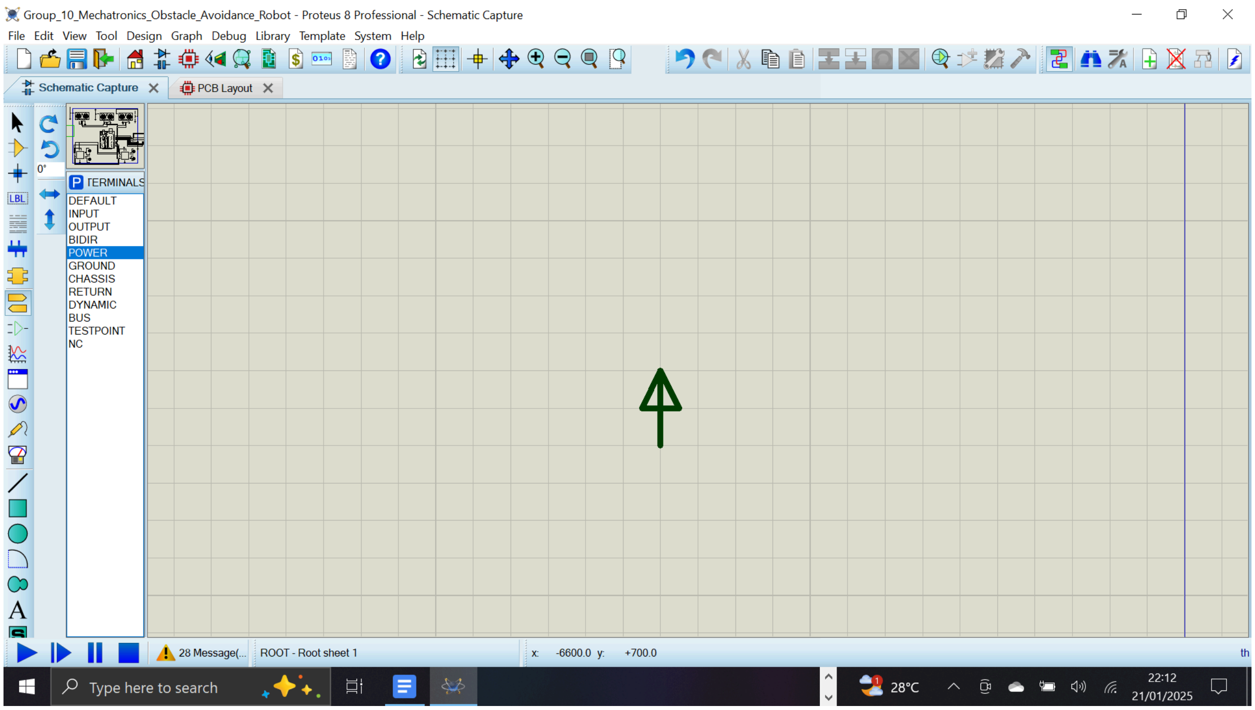
Power Supply(Terminal)

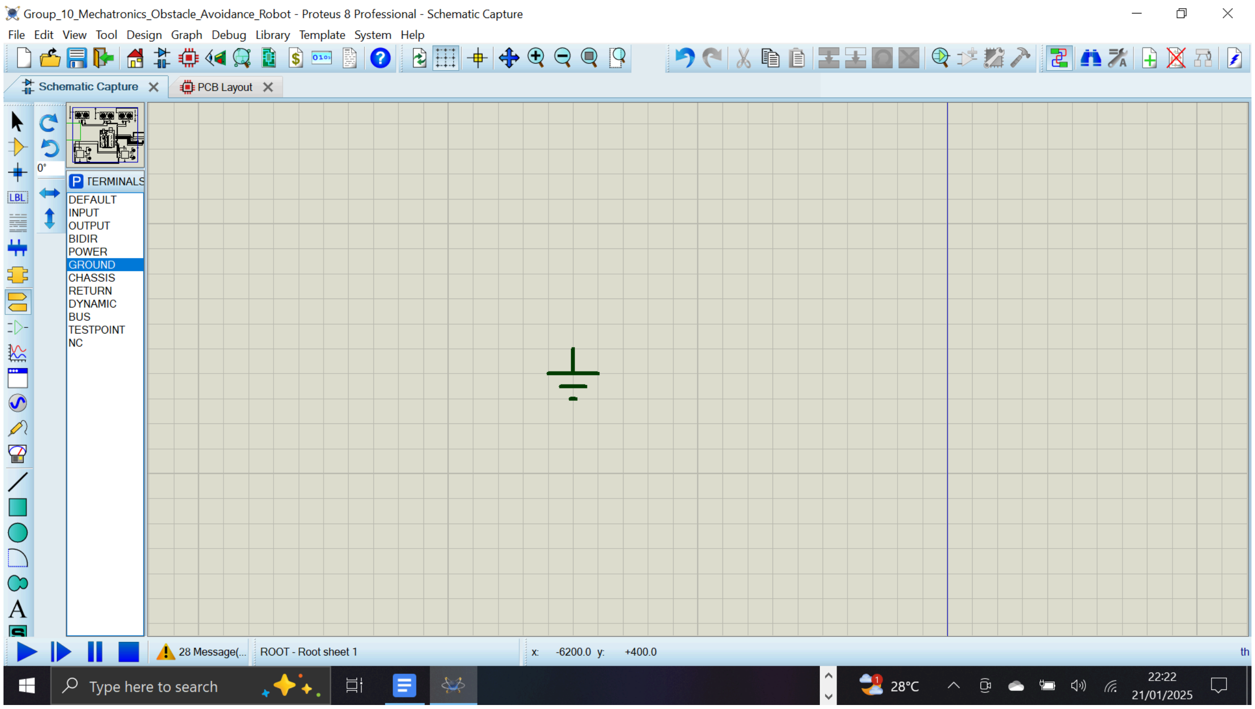
The power(Voltage supply) provides the necessary voltage and current to all the components in the circuit, including the microcontroller, sensors, motor driver, and motors. It ensure that all components receive a stable and consistent power supply, which is essential for reliable operation. In proteus we used the power from the terminal mode. We placed these power terminals in our design to ensure that all components receive the necessary voltage connections without cluttering the schematic with wires.

In summary, the power terminals are essential for powering an entire circuit and ensuring its proper operation during the simulation. It has an arrow head symbol



Ground Terminal

The ground terminal provides a return path for the electrical current, completing the circuit. Without a proper ground connection, the circuit won't function correctly. Ground serves as a reference point for all voltage measurements in the circuit. It ensures that all components operate at the correct voltage levels relative to ground. It helps maintain consistent and reliable operation of the circuit, preventing issues like noise and voltage fluctuations.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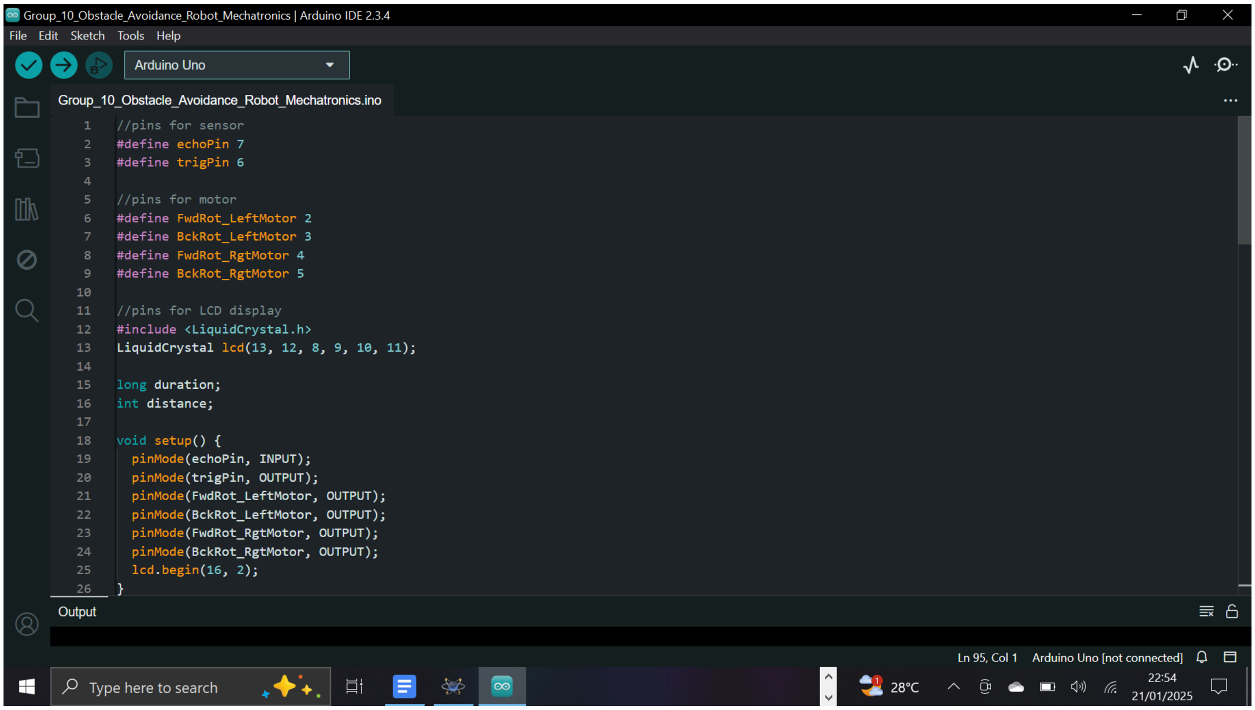
Pseudocode of the program

```
BEGIN

//Declare pins
DEFINE echoPin AS 7
DEFINE trigPin AS 6

DEFINE FwdRot_LeftMotor AS 2
DEFINE BckRot_LeftMotor AS 3
DEFINE FwdRot_RgtMotor AS 4
DEFINE BckRot_RgtMotor AS 5

DECLARE LiquidCrystal lcd(13, 12, 8, 9, 10, 11)

DECLARE duration AS LONG
DECLARE distance AS INTEGER

FUNCTION setup()
  SET pinMode(echoPin, INPUT)
  SET pinMode(trigPin, OUTPUT)
  SET pinMode(FwdRot_LeftMotor, OUTPUT)
  SET pinMode(BckRot_LeftMotor, OUTPUT)
  SET pinMode(FwdRot_RgtMotor, OUTPUT)
  SET pinMode(BckRot_RgtMotor, OUTPUT)
  lcd.BEGIN(16, 2)
END FUNCTION

FUNCTION loop()
  SET digitalWrite(trigPin, LOW)
  WAIT 2 microseconds

  SET digitalWrite(trigPin, HIGH)
  WAIT 10 microseconds
  SET digitalWrite(trigPin, LOW)

  SET duration TO pulseIn(echoPin, HIGH)
  SET distance TO duration * 0.034 / 2

  lcd.SETCURSOR(0, 0)
  lcd.PRINT("Distance")
  lcd.SETCURSOR(9, 0)
  lcd.PRINT(distance)
```

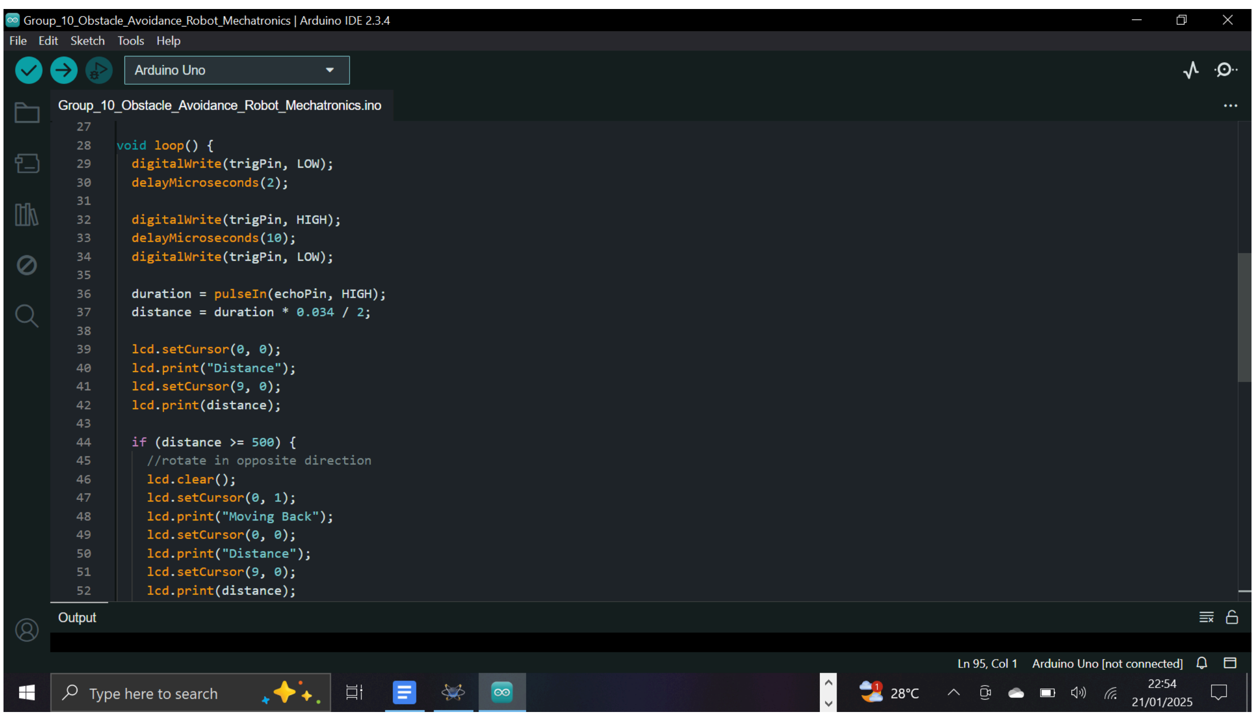
```
IF distance >= 500 THEN
  lcd.CLEAR()
  lcd.SETCURSOR(0, 1)
  lcd.PRINT("Moving Back")
  lcd.SETCURSOR(0, 0)
  lcd.PRINT("Distance")
  lcd.SETCURSOR(9, 0)
  lcd.PRINT(distance)

  SET digitalWrite(BckRot_LeftMotor, HIGH)
  SET digitalWrite(BckRot_RgtMotor, HIGH)

  SET digitalWrite(FwdRot_LeftMotor, LOW)
  SET digitalWrite(FwdRot_RgtMotor, LOW)

  WAIT 1000 milliseconds
  lcd.CLEAR()
  lcd.SETCURSOR(0, 1)
  lcd.PRINT("Moving Left")
  lcd.SETCURSOR(0, 0)
  lcd.PRINT("Distance")
  lcd.SETCURSOR(9, 0)
  lcd.PRINT(distance)

  // Move left
  SET digitalWrite(BckRot_LeftMotor, HIGH)
  SET digitalWrite(BckRot_RgtMotor, LOW)

  SET digitalWrite(FwdRot_LeftMotor, LOW)
  SET digitalWrite(FwdRot_RgtMotor, HIGH)
  WAIT 500 milliseconds

ELSE
  lcd.CLEAR()
  lcd.SETCURSOR(0, 1)
  lcd.PRINT("Moving Forward")
  lcd.SETCURSOR(0, 0)
  lcd.PRINT("Distance")
  lcd.SETCURSOR(9, 0)
  lcd.PRINT(distance)

  SET digitalWrite(BckRot_LeftMotor, LOW)
  SET digitalWrite(BckRot_RgtMotor, LOW)
```

```
    SET digitalWrite(FwdRot_LeftMotor, HIGH)
    SET digitalWrite(FwdRot_RgtMotor, HIGH)
    WAIT 1000 milliseconds

  END IF
END FUNCTION

END
```

CODE



```
//pins for sensor
#define echoPin 7
#define trigPin 6

//pins for motor
#define FwdRot_LeftMotor 2
#define BckRot_LeftMotor 3
#define FwdRot_RgtMotor 4
#define BckRot_RgtMotor 5

//pins for LCD display
#include <LiquidCrystal.h>
LiquidCrystal lcd(13, 12, 8, 9, 10, 11);

long duration;
int distance;

void setup() {
  pinMode(echoPin, INPUT);
  pinMode(trigPin, OUTPUT);
  pinMode(FwdRot_LeftMotor, OUTPUT);
  pinMode(BckRot_LeftMotor, OUTPUT);
  pinMode(FwdRot_RgtMotor, OUTPUT);
  pinMode(BckRot_RgtMotor, OUTPUT);
  lcd.begin(16, 2);
}
```



```

void loop() {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);

  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  duration = pulseIn(echoPin, HIGH);
  distance = duration * 0.034 / 2;

  lcd.setCursor(0, 0);
  lcd.print("Distance");
  lcd.setCursor(9, 0);
  lcd.print(distance);

  if (distance >= 500) {
    //rotate in opposite direction
    lcd.clear();
    lcd.setCursor(0, 1);
    lcd.print("Moving Back");
    lcd.setCursor(0, 0);
    lcd.print("Distance");
    lcd.setCursor(9, 0);
    lcd.print(distance);
```

Group_10_Obstacle_Avoidance_Robot_Mechatronics | Arduino IDE 2.3.4

File Edit Sketch Tools Help

Arduino Uno

Group_10_Obstacle_Avoidance_Robot_Mechatronics.ino

```
    lcd.print(distance);

    digitalWrite(BckRot_LeftMotor, HIGH);
    digitalWrite(BckRot_RgtMotor, HIGH);

    digitalWrite(FwdRot_LeftMotor, LOW);
    digitalWrite(FwdRot_RgtMotor, LOW);

    delay(1000);
    lcd.clear();
    lcd.setCursor(0, 1);
    lcd.print("Moving Left");
    lcd.setCursor(0, 0);
    lcd.print("Distance");
    lcd.setCursor(9, 0);
    lcd.print(distance);

    //move left/right direction
    digitalWrite(BckRot_LeftMotor, HIGH);
    digitalWrite(BckRot_RgtMotor, LOW);

    digitalWrite(FwdRot_LeftMotor, LOW);
    digitalWrite(FwdRot_RgtMotor, HIGH);
    delay(500);
  }
```

Output

Ln 95, Col 1 Arduino Uno [not connected]

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Group_10_Obstacle_Avoidance_Robot_Mechatronics | Arduino IDE 2.3.4

File Edit Sketch Tools Help

Arduino Uno

Group_10_Obstacle_Avoidance_Robot_Mechatronics.ino

```
    digitalWrite(BckRot_RgtMotor, LOW);

    digitalWrite(FwdRot_LeftMotor, LOW);
    digitalWrite(FwdRot_RgtMotor, HIGH);
    delay(500);
  }
    else {
    //moving forward
    lcd.clear();
    lcd.setCursor(0, 1);
    lcd.print("Moving Forward");
    lcd.setCursor(0, 0);
    lcd.print("Distance");
    lcd.setCursor(9, 0);
    lcd.print(distance);

    digitalWrite(BckRot_LeftMotor, LOW);
    digitalWrite(BckRot_RgtMotor, LOW);

    digitalWrite(FwdRot_LeftMotor, HIGH);
    digitalWrite(FwdRot_RgtMotor, HIGH);
    delay(1000);
  }
}

```

Output

Ln 95, Col 1 Arduino Uno [not connected]

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WORKING OF THE SYSTEM

Initialization:

- Set up the pins for the ultrasonic sensor, motors, and LCD.
- Initialize the LCD to display data.

Main Loop:

- The program continuously runs in a loop to monitor the distance to obstacles and control the motors accordingly.

Distance Measurement:

- The ultrasonic sensor (trigger and echo pins) is activated to measure the distance to an object.
- The duration of the ultrasonic wave traveling to and from the object is recorded.
- Distance is calculated using the formula: Distance = duration * 0.034 / 2, where 0.034 is the speed of sound in cm/us, and the division by 2 accounts for the travel to the object and back.

Display Distance:

- The calculated distance is shown on the LCD.

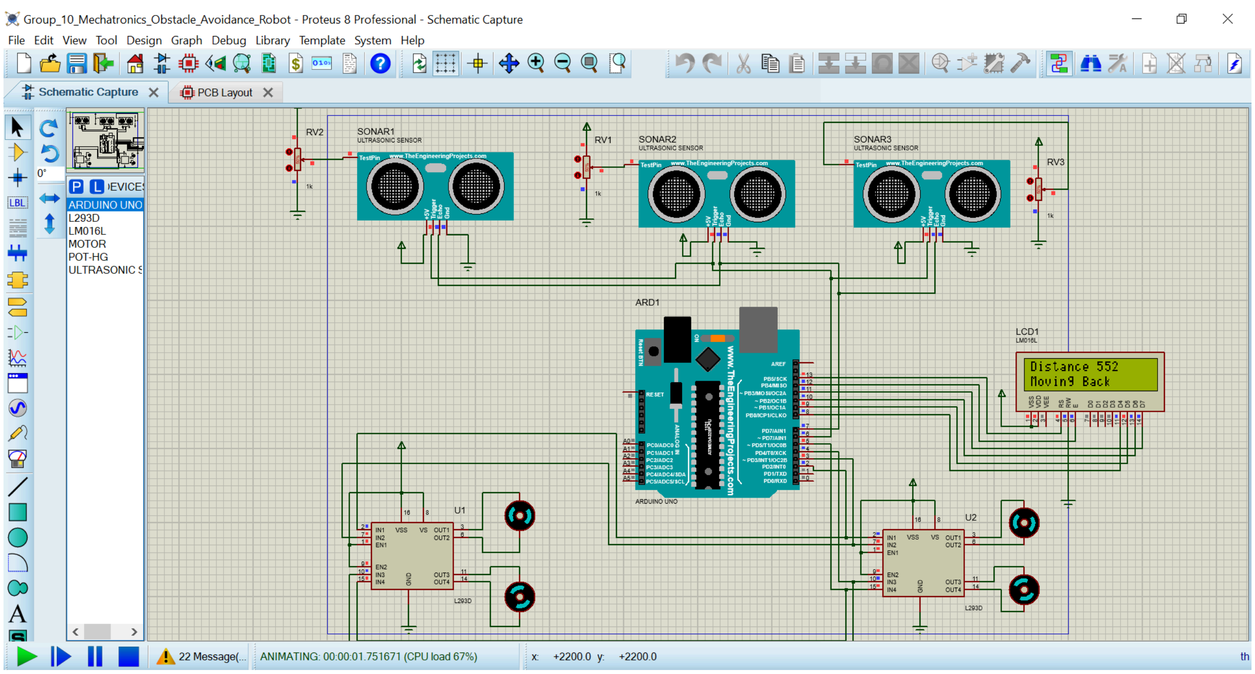
Obstacle Avoidance Logic:

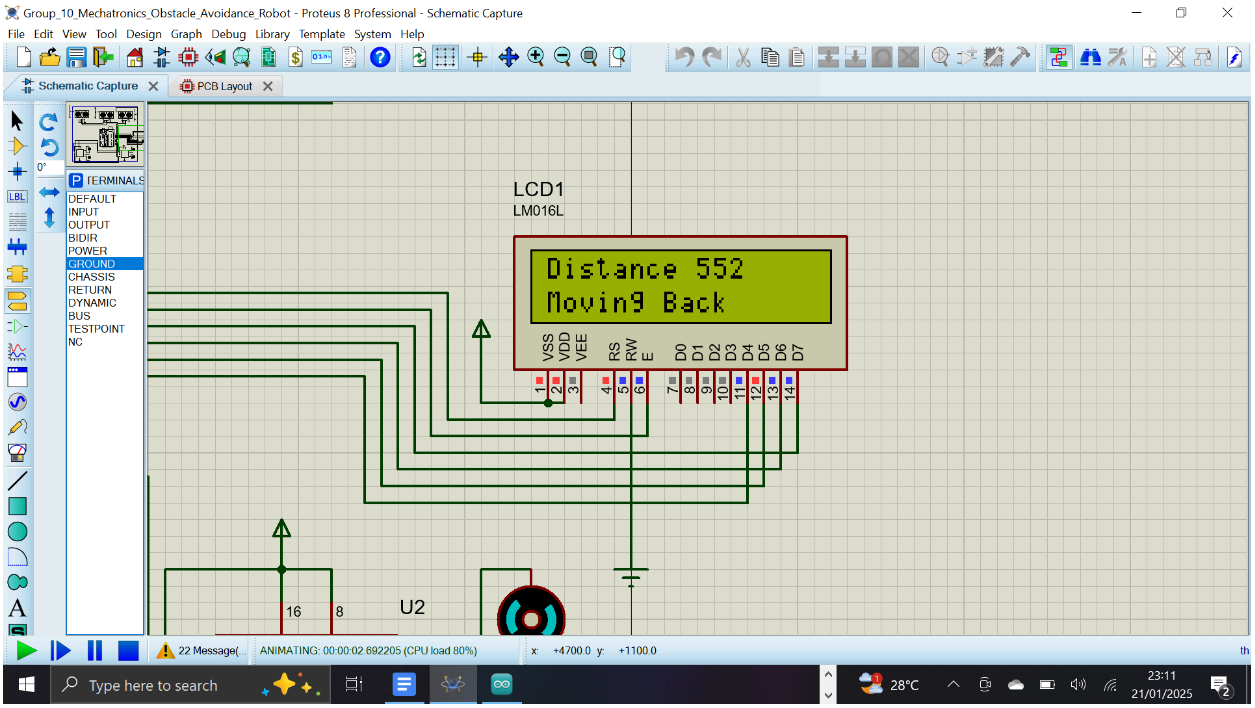
- If the distance is greater than or equal to 500 cm:
    - The robot decides there's enough space and continues moving forward.
    - Display "Moving Forward" on the LCD.
    - Motors are controlled to move the robot forward.
- If the distance is less than 500 cm:
    - The robot detects an obstacle and initiates avoidance maneuvers.
    - Display "Moving Back" on the LCD.
    - Motors are controlled to move the robot backward to create space.
    - After a delay, display "Moving Left" on the LCD and move the robot to the left to avoid the obstacle.

CHAPTER FOUR

RESULT OF THE SYSTEM

When the obstacle avoidance robot system runs, The LCD will continuously show the current distance to the nearest obstacle. If the distance is greater than or equal to 500cm, LCD shows “Moving Forward”then both forward rotation motors will be activated, making the robot move forward. If distance is less than 500 cm, LCD Shows "Moving Back" first, then "Moving Left".The robot will then initially move backward. After retreating, it will turn to the left to avoid the obstacle.The system continuously measures distance and updates motor actions and LCD display in real-time, avoiding obstacles dynamically as it navigates through its environment.

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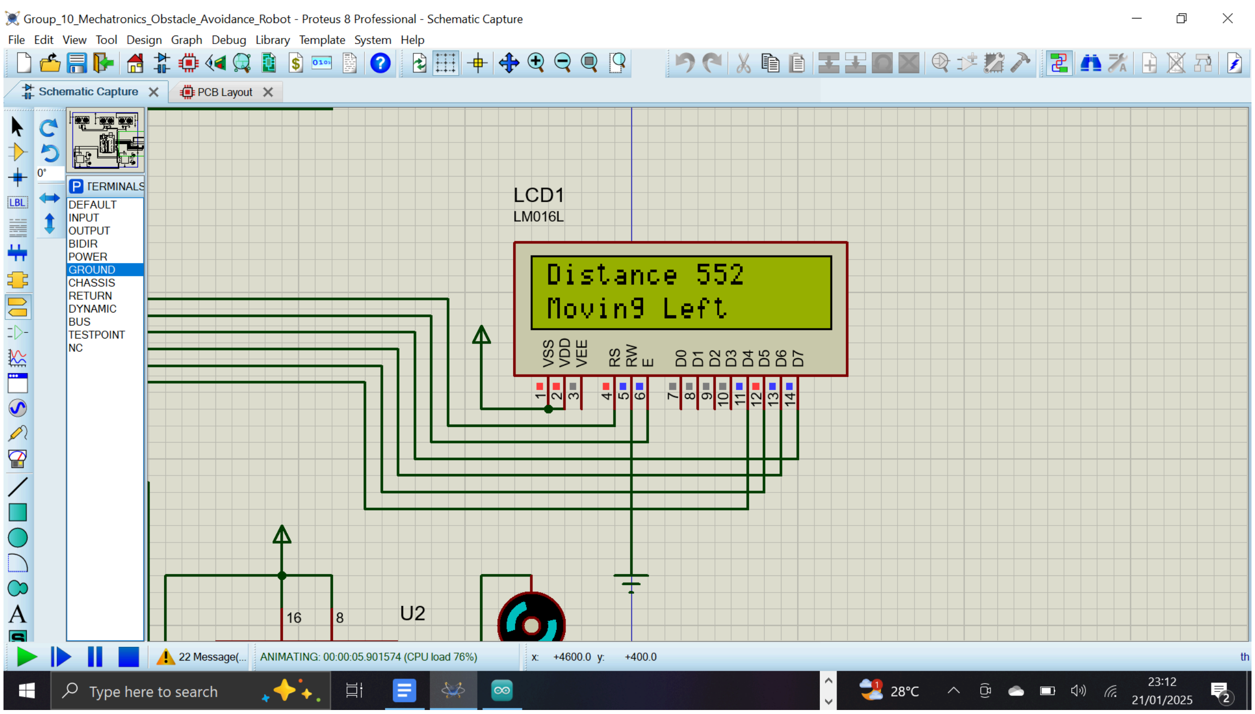
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NC
LCD1
LM016L
Distance 552
Moving Left
VSS VDD VEE RS RW E D0 D1 D2 D3 D4 D5 D6 D7
U2
22 Message(...
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CHAPTER FIVE

CONCLUSION

This design presents the simulation of an Obstacle Avoidance Robot where the ultrasonic sensors efficiently measure distances, enabling the robot to detect obstacles ahead and respond accordingly. By continuously adjusting its movements (forward, backward, left), the robot navigates its environment while avoiding collisions, showcasing intelligent behavior. The LCD display provides clear, real-time feedback on the robot's distance from obstacles and its current state (e.g., moving forward, backward, and Left).This simulation offers valuable insights into the integration of hardware (sensors and motors) with software logic to achieve autonomous robotic behavior. It's a solid foundation for further exploration into more complex robotics projects.

This project underscores the importance of sensor data processing, motor control algorithms, and real-time user feedback in developing smart robotic systems.

Recommendation

With the rise in AI(Artificial intelligence) and ML(Machine Learning),this system can further be optimized by Integrating machine learning to enhance decision-making, such as recognizing different types of obstacles and adapting behaviors accordingly.

References

1.https://www.researchgate.net/publication/322640373_Design_and_fabrication_of_an_object_avoider_robot_with_predefined_object_grippe_gripper

2.(PDF) DEVELOPMENT OF AN OBSTACLE AVOIDING ROBOT https://www.researchgate.net/publication/295519484_DEVELOPMENT_OF_AN_OBSTACLE_AVOIDING_ROBOT

3.Behavior-Based Robotics" by Ronald C. Arkin

4. https://www.slideshare.net/slideshow/final-report-obstacle-avoiding-roboat/94563467

5. OBSTACLE AVOIDANCE ROBOTIC CAR ~ Project Topics and Materials

6. Arduino Based Obstacle Avoiding Robot Project with Code and Circuit Diagram

7. What is Ultrasonic Sensor: Working Principle & Applications – Robocraze

8. Ultrasonic Sensor : Working Principle and Applications https://www.learnelectronicsindia.com/post/ultrasonic-sensor

9. Frontiers | Research on obstacle avoidance optimization and path planning of autonomous vehicles based on attention mechanism combined with multimodal information decision-making thoughts of robots

10. Arduino Uno - Wikipedia

11. L293D Motor Driver IC introduction, pinouts and how to use https://microcontrollerslab.com/l293d-motor-driver-ic-introduction-pinouts-example/

12. LCD 16×2 (LM016L) « Innovation of Engineers https://embeddedcenter.wordpress.com/ece-study-centre/display-module/lcd-16x2-lm016l/

13. Virtual Engineer - YouTube https://www.youtube.com/@VirtualEngineer_MKS