OBSTACLE AVOIDING CAR - AN ARDUINO BASED PROTOTYPE WHICH RUNS AUTONOMOUSLY AVOIDING OBSTACLES IN FRONT OF IT

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project/internship titled **"**Obstacle Avoiding Car- An Arduino based prototype which runs autonomously avoiding obstacles in front of it.**"**, submitted by Jahidul Islam Akash, Shahadat Hossain, Jamsedul Islam, ID No: 171-15-8786, 171-15-8938, 171-15-8889 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 03 June 2021

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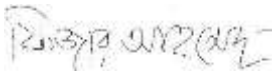

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Declaration

We, hereby declare that this project neither as a whole nor as a part there of has been copied out from any source. It is further declared that we have developed this project and the accompanied report entirely on the basis of our personal efforts made under the sincere guidance of our supervisor. No portion of the work presented in this report has been submittedin the support of any other degree or qualification of this or any other University or Institute of learning, if found we shall stand responsible.

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Abstract

The goal of this research was to create a vehicle that could repeat a human-driven trajectory.The system would be equipped with sensors that would identify impediments andallow it to react based on their location.In order to measure the deformation of the suspensions and the wheel speed, many more sensors were required.

It was also investigated employing a GPS, a gyroscope, and an accelerometer to compare the information they provided with the orders issued by the CPU, as well as a light sensor (LDR) to assist in selecting whether or not to use the camera and the computer vision algorithm.It might consider parking in the closest available spot if there isn't much light. It was also suggested that a spotlight be used.In addition, a pressure sensor was said to be installed inside the seat to detect whether or not someone was sitting on it.The car would come to a halt if no one was seated.Some concepts, however, were deemed secondary and were kept for a later version of the vehicle.

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CHAPTER 1

Introduction

1.1 Introduction

From science fiction autonomous cars have now gone uphill to reality. This technology appears to have appeared out of nowhere, but in reality the path to self-driving cars has been a long and tedious one. The history of self-driving cars went through several milestones. After the invention of man driven motor vehicles, it did not take too long for the inventors to think upon self-driven vehicles. “In the year 1925, the inventor Francis Houdina invented radio-controlled car, which he drove through the streets of Manhattan without any human steering the wheel. The radio-controlled vehicle can start its engine, shift gears, and turn on its horn”[2]. In year 1969, John McCarthy who is the In an essay titled "The Future of Artificial Intelligence," oneof the founding fathers of artificial intelligence demonstrated something that is likely to be relevant to today's autonomous vehicles. “Computer-Controlled Cars.” McCarthy refers to an “automatic chauffeur,” capable of navigating a public road via a “television camera input that uses the same visual input available to the human driver”[2]. In early 90s, Carnegie Mellon researcher Dean Pomerleau wrote a PhD thesis, describing how neural networks could allowa self-driving vehicle to take in raw images from the road and output steering controls in real time[2]. Pomerleau wasn't the only one working on self-driving automobiles, but hisapproach of using neural networks outperforms other methods of manually dividing photos into "road" and "non-road" categories. Waymo, which is also known as “Google Self-driving car” collects tons of data and feed the data to deep learning algorithm from labeling and processing. Waymo, nowadays is being used as an online cab service like Uber in different states of the US [2]. The basic model for a self –driving car is shown in figure 1.1 [3]:

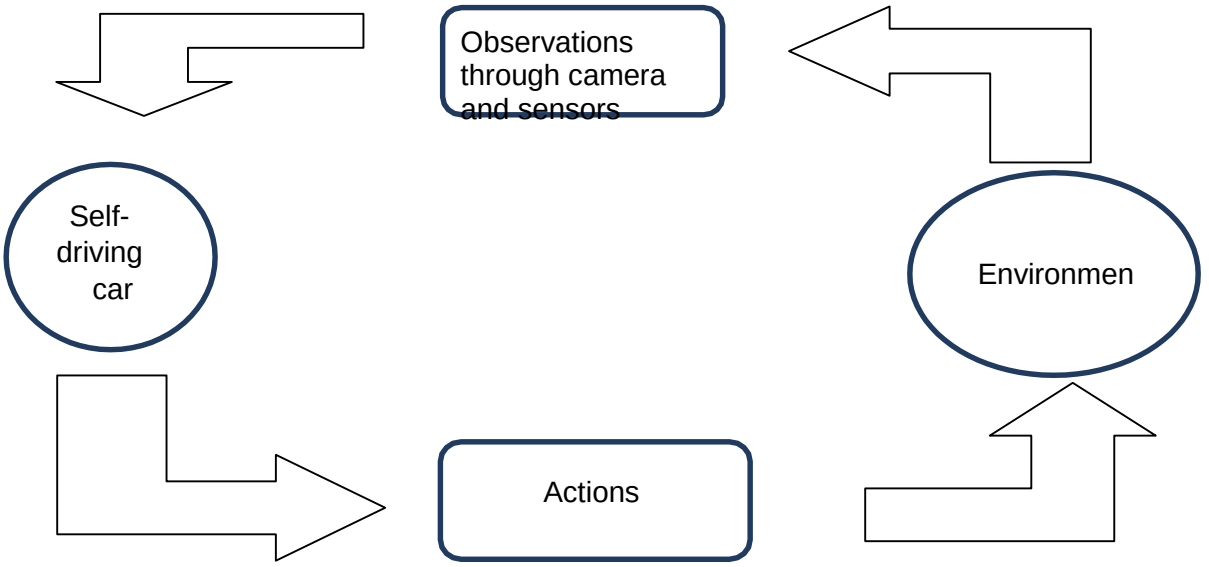


Figure 1.1: Basic model for self-driving cars [3]

The basic concept behind self-driving car is to sense its environment and take actions accordingly as shown in fig 1.1. The car collects data of its environment through a single or multiple cameras along with different sensors. This data is then processed through advanced computer vision and other algorithms to generate action required to maneuver the car according to the environment [3].

For example, in case of Waymo, machine learning plays an important role. With the collaboration of Google AI researchers, Waymo is integrated with AutoML which enables the autonomous car to optimize models for different scenarios at a great velocity. AutoML has a graphical user interface to train, assess, improve, and arrange models based on the data [4].

GM cruise comes second to cover most number of miles autonomously [5]. It is regarded as one of the world's most advanced self-driving vehicles, capable of carefully connecting people to the places, things, and experiences that they value. With federal, state and regulations Safety plan and functioning requirements in obedience are kept in focus. Cruise self-driving carhas a balanced array of sensors so that the car may automatically map out the intricate city streets with a 360-degree view of the environment around it.Each automobile is equipped with ten cameras that shoot at a rate of ten frames per second. [5]. That is how this car is able to see more of its surrounding environment and therefore, can respond more quickly and safely.

At Nissan, advancement in artificial intelligence is making the autonomous Vehicles that are more intelligent, responsive, and capable of making their own decisions.Nissan is working on a vehicle that will soon be capable of self-driving on a single lane road.The multi-lane road will be the next step. then self-driving in the city, and Finally, completely autonomous driving in all conditions is a reality. Nissan self-driving cars are designed to get smarter with time. Seamless Autonomous Mobility is a system developed from NASA technology to help autonomous cars deal with unexpected, the vehicle sends live data to a mobility manager who instantly teaches it what to do then it shares what it learned with other cars in the system so they get smarter too [6]. Once this knowledge is absorbed into the system, vehicles can start using it to solve completely new challenge.

What level of safety should a self-driving automobile have?As firms like Waymo, Uber, and others test self-driving cars on public roads, this subject is becoming increasingly crucial.Vehicles kill 1.3 million people every year around the world [7].Human mistake is to blame for many of these deaths.. If a self-driving car can help in this, it would be a great achievement. In contrast, the self-driving vehicles do not drink, they do not text and they do not fall asleep at the wheel, thus reducing deaths and injuries. Statistics illustrated in figure 1.2 [6] show the likeness of people around world towards self-driving vehicles.

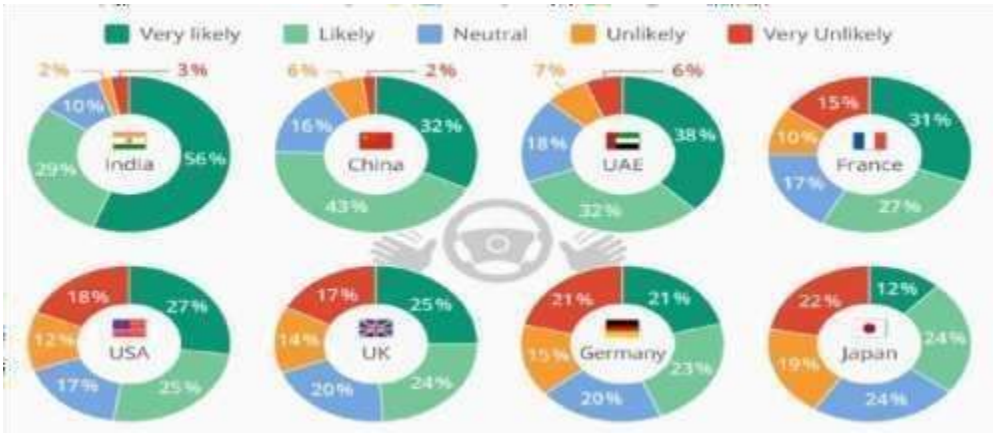


Figure 1.2: Survey chart [6]

Twenty percent of people living in America are suffering with disabilities [13]. because of transportation barriers 11 million medical appointments missed every year which leads to greater health care expenses later on, but this new technology of self-driving cars can be a promising solution to this problem [13]. Self-driving cars lead to 19 billion dollars in annual health care savings [13]. Two million more people with disabilities could become employed

with the help of reliable transport. Self-driving cars could save around 1.3 trillion dollars through fuel and accident avoidance [7]. A lot of traffic is caused by human error. Self-driving car can eliminate human error that causes traffic jams. Self-driving cars can be programmed to space out between cars automatically as illustrated in figure 1.3 [2], thereby eliminating the problem of congested traffic. Cars using adaptive cruise control infer the effect of a braking event smoother than those vehicles without the activated technology [5].

Figure 1.3: Self-driving environment by Volkswagen [2]

There are many ways that self-driving cars can improve our lives. There also exist some downsides. The vehicle industry may suffer as a result.Automobile manufacturers will produce fewer models and cars as a result of self-driving automobiles, resulting in fewer jobs and less choice for consumers.Because self-driving cars rely entirely on computers, they are more exposed to hackers and other cyber-threats. And the worst of all threat is the unemployment.

1.2 Motivation

In this project, a Obstacle Avoiding Car car is developed using computer vision and deep learning techniques. Obstacle Avoiding car made in this project is able to navigate the track by making prediction using the trained data set. Obstacle Avoiding Vehicles are cars or trucks in which human drivers are never necessary to take control in order for the vehicle to operate properly.They're also known as "driverless" automobiles since they use sensors and software to operate, navigate, and drive the vehicle. The preprocessing is done to identify the lane line on track on which car has to move. Initially, tracks are deployed on the ground in order to gather the data in a form of videos using OpenCV with webcam interface.

Some major factors of Autonomous vehicle are,

- Prevention of carcrashes.
- Environmentallyfriendly.
- Better access and mode of transportation.
- Traffic efficiency.
- Societal cost-savings

the Arduino processes the wrappers embedded in its code according to the string received from the classifier and the car moves according to the prediction. The trained model predicts in which direction to move and can also respond to traffic sign, such as a stop sign. This is a motorized car in which additional modifications such as steering angle control, motor driver control and high resolution camera interfacing has been done. this report ,here is 6 different chapter.In the first chapter of this report, we have discussed the introduction of Self driving car. And we also discuss in this chapter the motivation and objective and what will be the expected outcome ofour work. In the next chapter, we have discussed the related research work done by other people and the comparative studies we have done so far, and also discuss the challenges and scope ofthe problem we are solving here. In the next chapter we have discussed the methodology and requirement specification, the components we have used and how they work, the power circuit diagram we have used for this research purpose, and the threshold values of different sensors and components. In the next chapter, we have discussed different requirements and factors we have to look after to complete the aquarium system and what are the ideal values we should follow, and how our device will work and generate the result. In chapter 5 we have discussed the impact of the environment and the sustainability of our work. In the last chapter, we have discussed the future scopes and conclusions of our research work.

1.3 Objective

Obstacle-avoidance vehicles use a variety of sensors, including radar, lidar, sonar, GPS, odometry, and inertial measurement units, to sense their environment.Advanced control systems analyze sensory data to determine the best navigation courses.

- To development of a Obstacle Avoiding car using a toy car that will mainly navigate using computer vision and deep learning techniques .
- To usage of Convolutional Neural Network to identify a stop sign.
- To greatly improved safety: 94 percent of road accidents are caused by human error.
- To increase interconnection between modes of transportation.
- To reduced congestion: Congestion will cost the state of New South Wales $6.9 billion in 2017.
- To reduced pollution: Transport energy usage can be reduced by up to 90%.
- To greater mobility options: Users who are elderly, young, or crippled.

1.4 Expected Outcomes

Automobile technology has progressed significantly over the years, and as you may be aware, autonomous vehicles will be the next big thing.Autonomous automobiles, often known as self-driving cars, are vehicles that drive themselves using modern technology.

They don't require the input or supervision of a human driver.Although dozens of these vehicles have already been developed by some of the world's top automakers, it looks that we will have to wait a long time before we see self-driving automobiles everywhere.In the case, here are four ways self-driving cars will change our lives.

Cleaner Air

According to a new study conducted by Ohio University, adopting self-driving cars willlower harmful pollutants by up to 60%.This is due to the fact that the majority of emissions come from automobiles delayed in traffic.As a result, the air we breath in our cities will be fresh, helping to safeguard the environment.

Reduced Deaths From Car Crashes

Finally, driverless vehicles are predicted to vastly increase road safety.The majority of deadly road accidents, according to Florida car accident attorneys, are caused by driver mistake.When

fully implemented, these self-driving vehicles are expected to reduce traffic fatalities by up to 90%.

1.5 Report Layout

In this report ,here is 6 different chapter.In the first chapter of this report, we have discussed the introduction of Obstacle Avoiding car. And we also discuss in this chapter the motivation and objective and what will be the expected outcome of our work. In the next chapter, we have discussed the related research work done by other people and the comparative studies we have done so far, and also discuss the challenges and scope of the problem we are solving here. In the next chapter we have discussed the methodology and requirement specification, the components we have used and how they work, the power circuit diagram we have used for this research purpose, and the threshold values of different sensors and components. In the next chapter, we have discussed different requirements and factors we have to look after to complete the aquarium system and what are the ideal values we should follow, and how our device willwork and generate the result. In chapter 5 we have discussed the impact of the environment and the sustainability of our work. In the last chapter, we have discussed the future scopes and conclusions of our research work.

CHAPTER 2

Background

2.1 Terminologies

Consider a bus capable of transporting people without the assistance of a human driver.Imagine a taxi that you can summon using an app on your smartphone and that takes you to your location as quickly and affordably as possible.Consider vehicles that are solely dedicated to agriculture and do not require rest. Imagine vehicles traveling alone, mapping every location they pass through, not just on Earth, but on any rock in the cosmos.Imagine that your own automobile drives for you and that you don't have to worry about anything, and that it drives better than you ever could.Consider the possibilities in a world where automobiles are driven by themselves.We are nearing a future in which our aged and disabled loved ones will be able to preserve their freedom, in which time spent commuting will be spent doing what you want to do, and in which the annual death toll from traffic accidents, which currently stands at over 2 million, will be drastically reduced, Because human error is responsible for 94% of all accidents,They are also focused on clean and silent automobiles that will not contaminate their environment in any way, which will also benefit us significantly.[14]

The autonomous cars aren't all created equal, and they don't all use the same sensors or algorithms, but they all need to sense accurately and make quick decisions if they want to compete with humans. To do so, they'll need powerful computers mounted onboard in addition to the sensors, because the computing load to complete this task is extremely high, regardless of the methods used. Tesla Autopilot is a suite of sophisticated driver-assistance features that includes lane centering, traffic-aware cruise control, self-parking, automatic lane changes, semi-autonomous navigation on limited-access highways, and the ability to call the vehicle from a garage or parking spot.In all of these aspects, the driver is responsible, and the vehicle must be constantly monitored. The features, according to the business, decrease accidents caused by driver error and exhaustion from long-distance driving.Consumer Reports scored Tesla Autopilot "a distant second" in the "Capabilities and Performance" and "Ease of Use" categories in October 2020..[14]

2.2 Related Works

Related work was done before is Tesla Autopilot Car. The Tesla Autopilot is a collection of advanced driver-assistance technology that includes lane centering, traffic-conscious cruise control, self-parking, automatic lane change, semi-autonomous navigation on limited access highways, and the option to recall cars from a garage or parking space. In all of these aspects, the driver is in charge, and the vehicle must be constantly monitored. The features, according to the business, decrease accidents caused by driver error and exhaustion from long-distance driving.Consumer Reports scored Tesla Autopilot "a distant second" (after Cadillac's Super Cruise) in the "Capabilities and Performance" and "Ease of Use" categories in October 2020. [15]

Fig(2.1)-Tesla Autopilot Car[15]

The company's stated purpose is to offer full self-driving (FSD) as an upgrade to the standard Autopilot features at a later date, noting that legal, regulatory, and technical challenges must be overcome to achieve this aim.Most analysts predict Tesla vehicles will lack the requisite hardware for complete self-driving by April 2020. In March 2020, Navigant Research ranked Tesla last in the autonomous driving sector for both strategy and performance.Tesla gave a small number of testers in the United States a "beta" version of their FSD software in October 2020.Tesla's idea to engage unskilled users to evaluate the beta software was lambasted by several industry analysts as risky and irresponsible.[15]

2.3 Comparative Analysis

Tesla is well-known autopilot car car,which is already developed and running. The company's stated purpose is to deliver full self-driving at a later date, noting that legal, regulatory, and technical challenges must be overcome to attain this aim. The Tesla Autopilot is a collection of advanced driver-assistance technology that includes lane centering, traffic-conscious cruise control, self-parking, automatic lane change, semi-autonomous navigation on limited access highways, and the option to recall cars from a garage or parking space. And After the work done the car which we working on will work successfully as well. This car is not only able to carry passenger .It also can carry medicine for emergency patient when there is no driver.It can also be use in war . It can supply foodstaffs,arms amd every equipment which need in war .In this case it will be very effective because during the war the car will distribute all equipment and food to the fighter no need to drive it.

Some features of our Self driving car,

1. Supplying foodstuffs and medical equipment for emergency patient and hospital.
2. Supplying war equipment and foodstuffs during the war.
3. Super fast service .
4. During pandemic situation it will be very effective.

Aside of these features it also can carry passenger .You just need to select the destination then the car is drive its own .This system will be cost saving ,fast service ,traffic efficiency and environment friendly.

2.4 Challenges

During this pandemic situation we are not able to find all the components and can not work properly .In our research work we tried find all the sensors and components according to our work .But we are trying our level best to complete it as soon as possible and we are working on it.We have made most part of our system, some components we want to add with our project but those are not available. We also faced some difficulties while doing the project. We can not go to market when needed and can not collect data properly.

But the main challenges to make this project complete is money problem .For complete this project we need huge amount of money .We don't have enough money to upgrade it quickly .So that the working process is slow.But we are working on it and trying to upgrade it day by day.

2.5 Scope of the problem

- Automated power source lackings
- It can not reach the destination without user input
- Some feature not be upgradable now for some limitation
- Components is costly so budget is problem

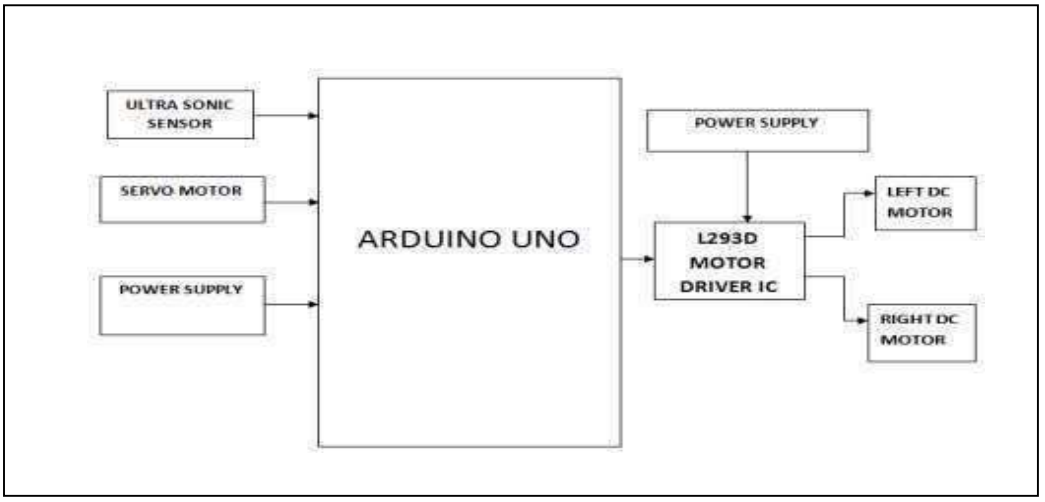
CHAPTER 3

Requirement Specification

3.1 Methodology

This is a prototype car named obstacle avoiding car made with Arduino Uno Microcontroller. The car can automatically detects any object in front of it and stops. Any obstruction ahead of it is detected by an ultrasonic sensor, which delivers a command to the microcontroller. Many other components is used to achieve the goal.

Block Diagram:



Fig(3.1): Block Diagram of Robot

3.2 Requirements

This items will required for this specific project

- **Required Components:**

1. Arduino Uno :

The Arduino Uno is a microcontroller board that uses the Atmega 328p microcontroller from the microchip. This board has a microcontroller that can be used to separate and control things in the genuine world..

Figure 3.2.:Arduino Uno

2. Motor Driver Shield :

L293D Motor Driver Shield is a full-included engine safeguard

It can drive:

- 4 bi-directional DC engines with 8-bit speed selection(0-255)
- stepper engines with single, twofold, interleaved, or miniature venturing loops.
- servo engines.

Figure 3.3 :Motor driver shield

3. Bluetooth Module :

The HC-05 is an interesting module that may be used to add two-way (full-duplex) wireless capabilities to your projects. This module can be utilized to impart between two microcontrollers, like an Arduino, or with any Bluetooth-empowered gadget,such as a phone or laptop.4V to 6V (often +5V) operating voltage .

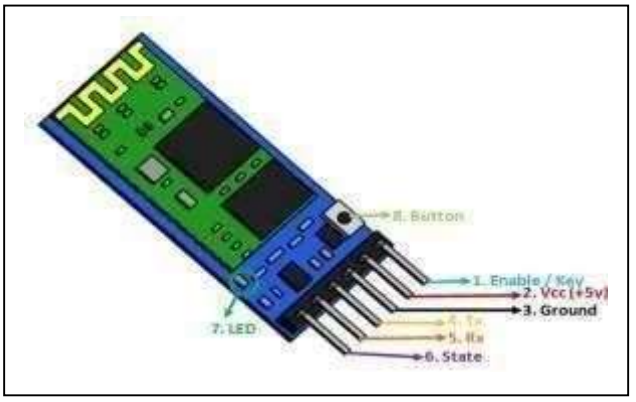


Figure 3.4 :Bluetooth Module

4. Infrared Sensor:

An infrared sensor is a type of electrical contrast that distinguishes and measures the infrared radiation around it. A creates a light transmitting diode and a collector dynamic infrared sensor. and don't produce it from a LED.

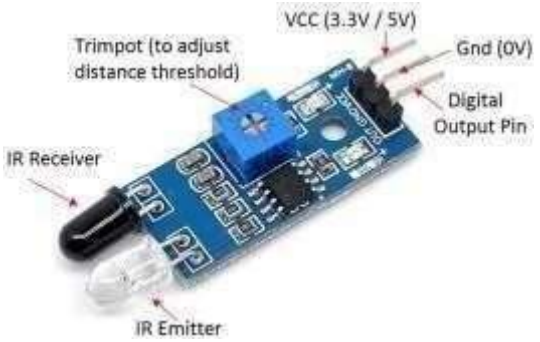


Figure 3.5 Infrared Sensor

5. Ultrasonic Sensor :

An ultrasonic sensor is a digital device that uses ultrasonic sound waves to detect gaps between a target object and converts the disturbed sound into electrical signals. Ultrasonic waves travel faster than the heard sound waves of travel. The sensor measures the time among sound emissions through the object with a view to calculate the gap among the sensor and the object. to its touch with the receiver. The components for this calculation is D = ½ T * C

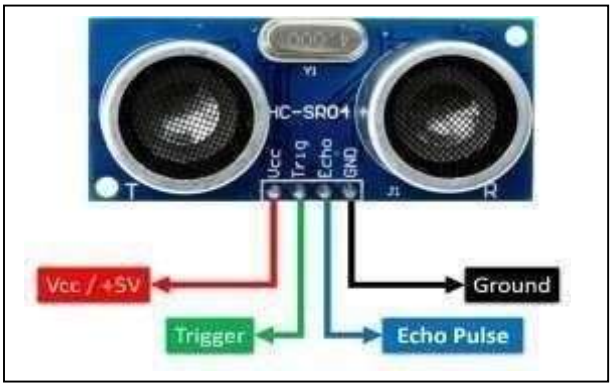


Figure 3.6 : Ultrasonic Sensor

6. Servo Motor :

A servomotor is a rotary or linear actuator which can manipulate angular or linear role, velocity, and acceleration with precision.It is made made out of the suitable motor and a role comments sensor.It additionally necessitates a complicated controller, that is often a separate module created completely for servomotors.

Figure 3.7 : Servo Motor

7. Solar panel :

Solar panels are made of sun (or photovoltaic) cells that may be used to generate electricity thru the photovoltaic effect.On the floor of sun panels, those cells are prepared in a grid-like arrangement.Crystallized silicon solar cells are used in the majority of solar panels.

Figure 3.8 : Solar Panel

8. DC Gear motors :

The combinational form of gears and motor When a gear head is added to a motor, the speed is reduced but the torque output is increased.

Figure 3.9 : DC Gear Motor

9. Jumping wires :

A jump cable is an electrical wire, or a set of them in a cable, with a connector or pin at each end that is used to connect the components of a breadboard or other prototype or test circuit internally or with other equipment or components, without welding.

Figure 3.10 : Jumping Wires

3.3 Flow chart

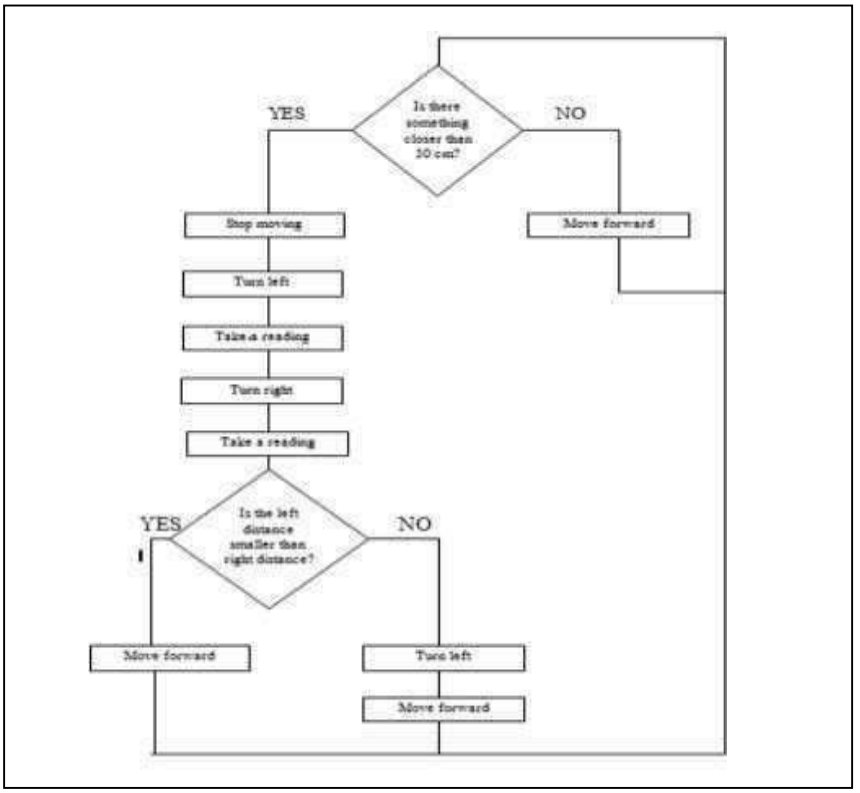


Figure 3.11 : Flow Chart

3.4 Circuit Diagram:

After assembling the all components together the desired project works very fine and correctly

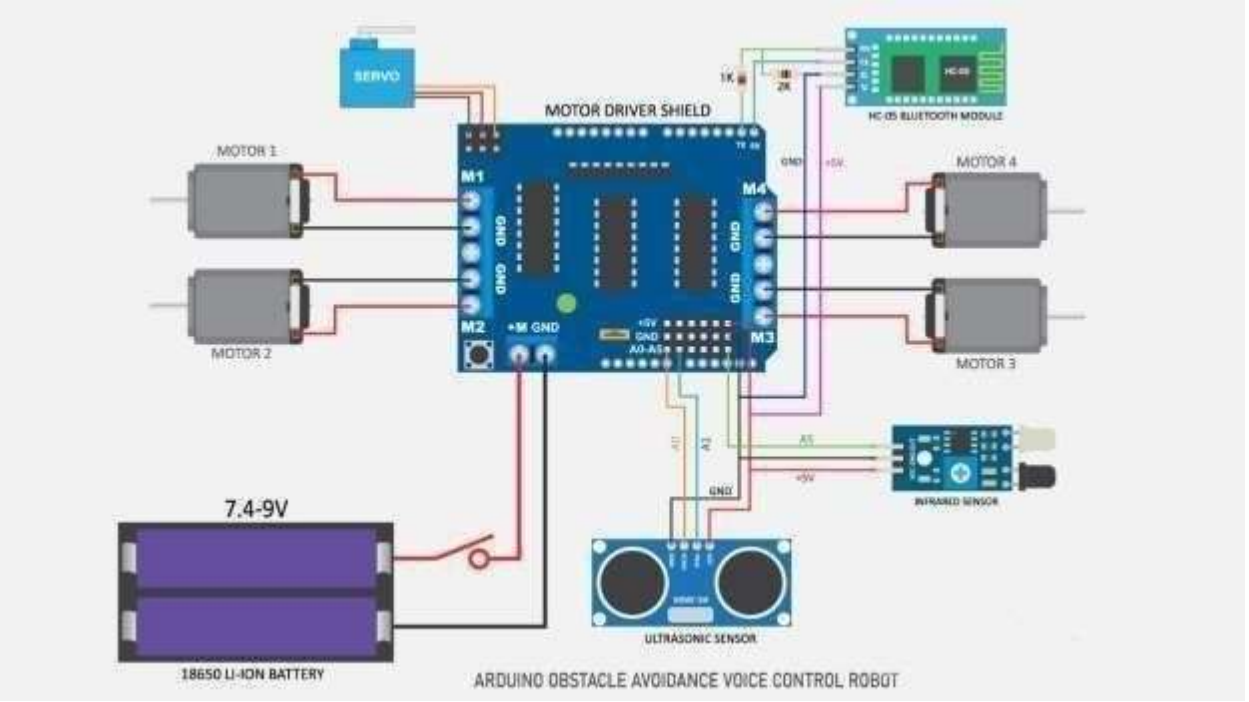


Figure 3.12:Circuit Digram

CHAPTER 4

Design Specification

4.1 Front End Design

An obstacle-avoiding vehicle is a system that can sense its surroundings and travel without the assistance of humans. Some of the sensors that an autonomous vehicle can use are distance, radar, camera, internal sensor and laser for GPS determination. The requirement for so many different sensors arises from the fact that it is impossible to have a reliable understanding of the vehicle's position based on a single measurement.While the GPS and inertial sensor will approximate the vehicle's position, the laser, radar, and camera will provide informationabout the environment, such as how the environment looks in 3D and where impediments are. The basic design of this Obstacle avoidance car is given below .Where we use these components,

- Motor driver shield
- Bluetooth Module
- Infrared Sensor
- Ultrasonic Sensor
- Servo motor
- Solar panel
- DC gear panel
- Jumping wires
- Arduino motor

4.2 Back End Design

The algorithm that autonomous automobiles must follow normally works like this: first, it develops an internal map of its environment and locates itself as precisely as possible within it, then it searches for impediments that must be avoided, and last, it plans the path it must take. These processes are carried out on a continuous basis, many times each second.To begin, a laser rangefinder or a camera (or cameras) are used to map the area, as previously stated.By shooting laser beams and measuring the distance using the time it takes for the light to return, the laser sensor builds a 3D model of its environment that is accurate up to 100 meters away. Here's an example of how the car's entourage may look if sensors were used.

```
void loop() {
  int distance = sonar.ping_cm();
  //int IR1 = digitalRead(IR);
  //Serial.println(IR1);

if(Serial.available()>0) {
  voice="";
  delay(2);
  voice = Serial.readString();
  delay(2);
  Serial.println(voice);


if (voice == "turn left") {
  left();
}else if (voice == "left") {
  left();
}else if(voice == "turn right") {
  right();
}else if(voice == "right") {
  right();
}

}
while(voice == "move forward") {
  forward();
}
while(voice == "move backward") {
  backward();
}
```

Fig(4.1):Basic Arduino code

This loop control this device ,how it move ,when need to turn backward,turn left ,turn right and move forward.And how its avoid obstacle.

4.3 Implementation requirements

Required things to implement this device is,

- All components like motor,Sensor,panel etc…
- Arduino
- Machine learning code
- Usable device
- Programming knowledge
- Some component may not be used but need to develop.

4.4 Output of this device

- This car will drive itself
- It will remove any obstacle in front of it.
- It took power from the solar system by solar panel
- It can be controlled over voice
- Aside of carrying passenger it can also carry medical equipment war equipment and food stuffs etc.

CHAPTER 5

Impact on Society, Environment and Sustainability

5.1 Impact on Society

People are becoming increasingly interested in supporting transportation systems that allow them to travel anywhere they need to go as quickly as possible, without being hampered by their economic circumstances or disability, and that are both environmentally friendly and safe for other people.Driving automation is a significant topic to watch in this competition, because they will know the optimum path, there will be fewer accidents and less time spent within them.They will also provide persons with disabilities more autonomy because they will no longer need to drive them.As a result of their appearance, a whole other culture may arise. One in which everyone can walk freely and no one (or almost no one) dies on the roads One in which moving is incredibly inexpensive and time spent commuting is spent doing other things we might enjoy.

5.2 Impact on Environment

Metal vehicles have always had a significant environmental cost due to the material extraction necessary and the high energy expenditure necessary to shape them.When we consider the electronic components, batteries, and all of the plastics in a car, we can see that the cost of production is fairly expensive in terms of environmental impact. However, another significant cost is the vehicle's energy supply.The pollution produced by autonomous vehicles in the present and near future will be considerably decreased because they are all electric.Even though producing the electricity they need to move pollutes the environment, it is always thought to be less harmful to do so in a single location rather than spreading it out. which is usual cars do. Apart from the fact that they are usually (but not always) electric, there is little doubt that the smoother we drive and the shorter the journey we take, the less we consume and, as a result, the less pollution we produce.The goal of autonomous vehicles is that they can drive better than humans.If they didn't, developing this technology would be pointless. Driving better entails not just being safer, but also driving more smoothly and taking the quickest routes.When smart cities are built, the roads, as well as other vehicles and signals, will connect with autonomous cars, reducing traffic congestion by alerting them to any problems that occur in their way.Autonomous cars, like other vehicles, will emit less pollution.

5.2 Sustainability Plan

As you have already told about that we have some limitation during this pandemicsituation to get all the necessary sensors and components, but we have plans to collect all the components as soon as possible.Many features has been added and we have plan to add some special features in it like it can be control over voice and another very important feature is solar panelin which the car will be auto charged by solar sytem.And for add these feature and upgrade it ,we have some limitation budget problem and availability of components. And in our future plan we have some plans create this automated system more improved and with some more features to get an efficient system and device.

CHAPTER 6

Conclusion And Future Scope

5.1 Discussion and Conclusion

In this project, a toy car has been used for making a Obstacle avoiding car. The basic concept behind a Obstacle avoiding car is to sense its environment and take actions accordingly. The steering angle of the car was measured using a potentiometer mounted on the steering wheel. Movement in the steering wheel caused change in the potentiometer voltage which was then digitized for subsequent processing.By the Infrared Sensor car sense the environment and surroundings then it will take action whether need to move left or right. And some features is missing for some limitation .And it will be upgraded in future .

5.2 Scope for Further Developments

As we said before that there are so many option so many features to upgrade this project in future .And we also have some limitation to upgrade it .A lots of features like solar panel system voice control more capability etc. Further improvements can be made in this project by using GPU based high speed processing system and a high definition camera. In addition, computer vision techniques such as camera calibration, structure from motion, etc can have very profound impact on the accuracy of navigation.

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