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SCHOOL OF ELECTRONICS ENGINEERING (SENSE)

COURSE CODE: ECE3001

MICROCONTROLLER AND ITS APPLICATIONS

SMART ROVER

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AIM

In this project, we aim to develop an intelligent rover that detects obstacles along its path and sends the data back to the user. The user will control the movement of the rover based on the data received and navigate as per.

INTRODUCTION

The road is not a safe place for a lot of people. Accidents are prone in many parts of the country and even the world. With the help of this project, we have tried to tackle this issue to safeguard the damage to the life and property of many in a minimal way. Moreover, there are certain places that mankind cannot reach and uses a lot of tools such as a rover to control and simulate the environment. But it is very difficult to control something which is situated very distantly from the user.

To tackle these situations, we have made a project in a miniature form to demonstrate the use of 3-D LiDAR in such scenarios.

Calamities such as the rover getting smashed into something and getting into an accident are minimised using this. This will highly reduce the repair costs and even the use of surplus resources for the same. To use the same in a vast scenario, we can add these to the vehicles which can avoid accidents and safeguard life and property in a major manner.

A system is only accurate and practical as long as it has a good grasp on its environment or surroundings. Being able to autonomously navigate a vehicle without running into pedestrians, navigate a workspace without becoming an obstacle itself, cleaning our floors while not falling a stairwell, all require spatial data.

LITERATURE REVIEW

[1] Tajim Md. Niamat Ullah Akhund Remote Sensing IoT based Android Controlled Robot

This robot will communicate remote data to an IoT cloud database. This robot is android-controlled. Android phone's Bluetooth can control the robot's movement. The robot will receive instructions over Bluetooth and process them with Arduino. Then it moves the robot in all directions using motor driver L298N by following android phone instructions.
The robot will gather temperature and humidity data from that location using sensor DHT11 and transfer it through Wi-Fi to a cloud database using node MCU ESP8266. The distant location may be watched from anywhere in the world using an internet server to display the data. Low-cost system.

[2] Midhat Jdeed; Sergii Zhevzhyk; Florian Steinkellner; Wilfried Elmenreich Spiderino - A low-cost robot for swarm research and educational purposes

The article provides a proposal for a cheap research robot based on the toy Hexbug Spider's diminutive size1. A 3D-printed adapter with two sections that have room for sensors, a bigger battery, and a printed circuit board (PCB) with an Arduino microcontroller, Wi-Fi module,

and motor controller replaces the robot head in the simple modification. Arduino Studio was used for both the robotics assembly process and the programming. The described prototype, which costs about 70 euros, is appropriate for swarm robotic experimentation and teaching.

[3] Pranam R * 1, Dr. Maheswaran C. P. SMART SURVEILLANCE ROVER

With surveillance being a very important application in defence systems, an advanced robotic system is required for efficient monitoring. The proposed system is built around Node MCU with a camera, temperature and humidity sensor, and gas detector. It will capture images and live stream videos of remote areas along with temperature, humidity, and gas data being collected and displayed at the user end

[4] Shubham Choudhury; Sahil Sawant; Laukik Bidwalkar; Mayuresh Marathe; Siuli Das Design and Implementation of Autonomous Rover for Wildfire Extinguishing

This paper presents the advancement of a Self-sufficient Putting out fires Meanderer that is outfitted with the fundamental battling gear that has the ability to watch from a dangerous area by means of a GPS with the point of initial recognition of fire catch. At a point when the fire source is distinguished, the fire will be quickly stifled utilising the fire-quenching framework that is built on its foundation. To find out the shortest path, the A* Algorithms are reported in this paper. The undertakings for the Rover once it explores out of the watching course incorporate the impediment evasion utilising Ultrasonic sensors, situating for progressively exact areas of fire catch utilising rear fire sensors, and dousing the fire.

[5] Satish Kumar Ojha; Vishal Singh; Priyank Sharma; Swaraj Dash Navigating a terrain using Raspberry-Pi and node MCU

The project has two robotic systems namely the `Base Station' and `Rover'. The `Base Station' is already docked on the planet, and the `Rover' is the unmanned mission sent to the planet. This also involves wireless communication between the two systems. This automated robotic technology will not only help in reducing the risk of human lives associated with manned space missions but will also cut down the total cost of such space missions.

BLOCK DIAGRAM

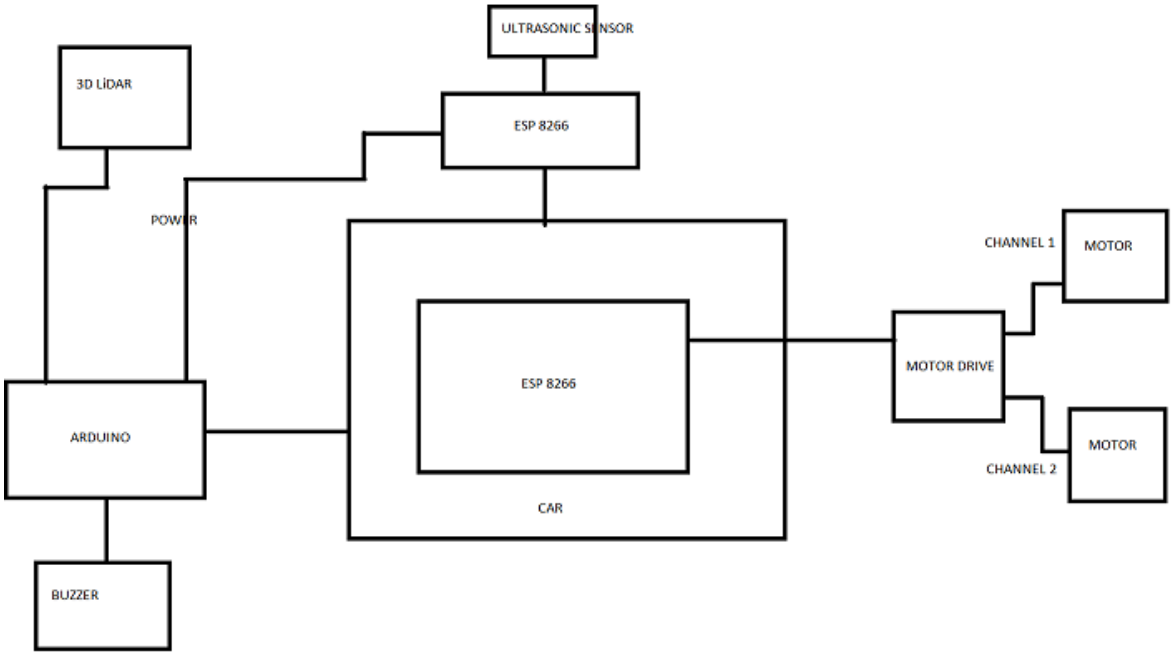


Fig. 1. Block diagram of the working of the smart rover

Fig. [1] depicts the block diagram that shows the working of the project. The various components of the block diagram are described below.

1. **Arduino -** Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - a light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, or publishing something online.

2. **ESP 8622 -** The ESP8266 is a low-cost Wi-Fi microchip, with built-in TCP/IP networking software, and microcontroller capability. The ESP board is used to send data from the ultrasonic sensor to a locally hosted webpage.

3. **3D LiDAR -** LiDAR is an acronym for “Light Detection and Ranging.” It is sometimes called “laser scanning” or “3D scanning.” The technology uses eye-safe laser beams to create a 3D representation of the surveyed environment. LiDAR is an active remote sensing technology that makes use of the 'time of flight' principle. It rapidly fires laser pulses at the target object and an inbuilt sensor measures the reflected light. The time taken for this round trip is measured. In general, 160000 pulses are emitted per second. Each one metre pixel gets fifteen pulses per second. This makes LiDAR a fast and direct method of 3D spatial mapping. The different components in a LiDAR are:

    - A laser source - to emit laser beams
    - A detector - usually a sensor that can detect the returning reflected pulse
    - A specialised GPS receiver - this gives the location of the system with the LiDAR sensor

- Optical lenses and other supporting elements

The various factors that help in describing or determining the accuracy of spatial maps are as follows:

- Azimuth rate - The rate at which azimuth angle changes is called Azimuth rate. Azimuth angle is a constraint measured in the horizontal or perpendicular plane based on the application type. It is essential to maintain fixed vectors in the body-frame coordinate system.
- Line count
- Sampling Frequency
- Sample Average

4. **Ultrasonic Sensor -** An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves and converts the reflected sound into an electrical signal. A sound wave of frequency higher than human audible range is sent out from the sensor. The transducer part of it is rESPonsible for sending and receiving the sound wave

5. **Motors and Motor Driver -** A motor driver takes the low-current signal from the controller circuit and amps it up into a high-current signal, to correctly drive the motor. It basically controls a high-current signal using a low-current signal. There are different types of motor drivers available in the market, in the form of ICs.

Further, the working mechanism of the system is explained under the next topic.

WORKING MECHANISM

- An ultrasonic sensor is placed in front of the rover. As the rover keeps moving in its path, as soon as the ultrasonic sensor senses an obstacle in the range of region (distance and angle) specified by us, the sensor sends the data to the ESP board, which in turn sends the data to a locally hosted webpage. A screenshot of the webpage has been given in Fig [3].

- Each input and motor output is refreshed on a 5 second interval loop basis.

- Once the user has access to the webpage, they have access to a continuous flow of ultrasonic data converted to the form of multi-directional object distances with which they can monitor the objects present in the surroundings of the rover. This enables a sense of spatial awareness even during low light conditions or even when the rover is out of the user’s line of sight.

- An app controlled by the user is used to manoeuvre the rover wherever there is a free path.

- The LiDAR creates a 3-dimensional spatial map of its surroundings. If any obstacle is found within the specified range (distance and angle), the buzzer will activate. This range of distance and angle can be changed and customised according to user needs. A picture of said spatial map created by LiDAR is given in Fig [2].

- Using the data obtained from the ultrasonic sensor and the LiDAR, the user can then use the app to move the robot in its path. A basic app was developed, containing controls like forward, backward, left, right and stop. A screenshot of the app has been attached as Fig [4].

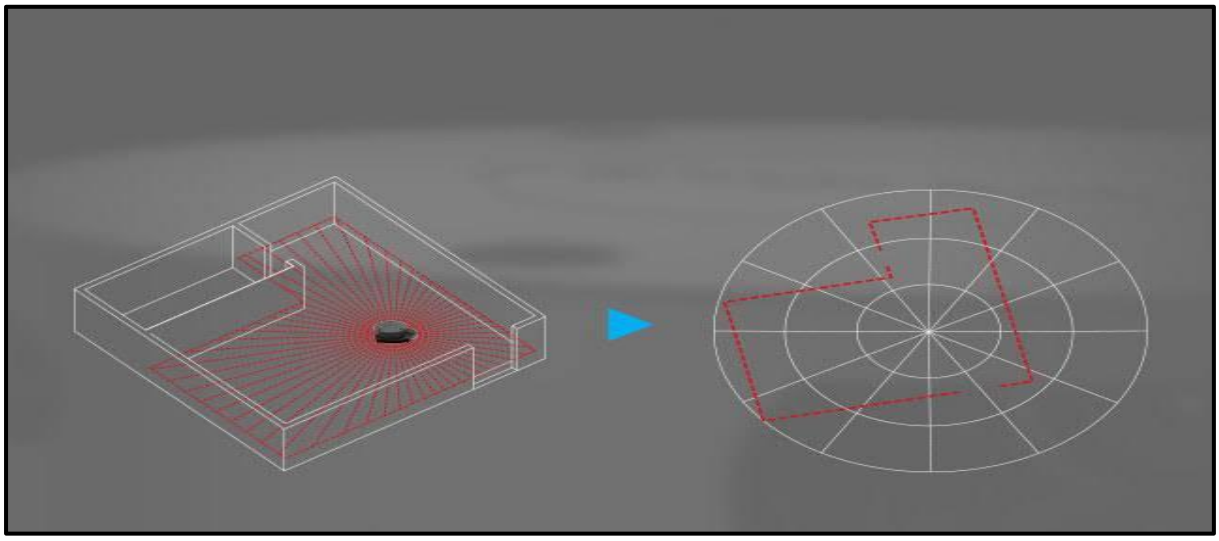
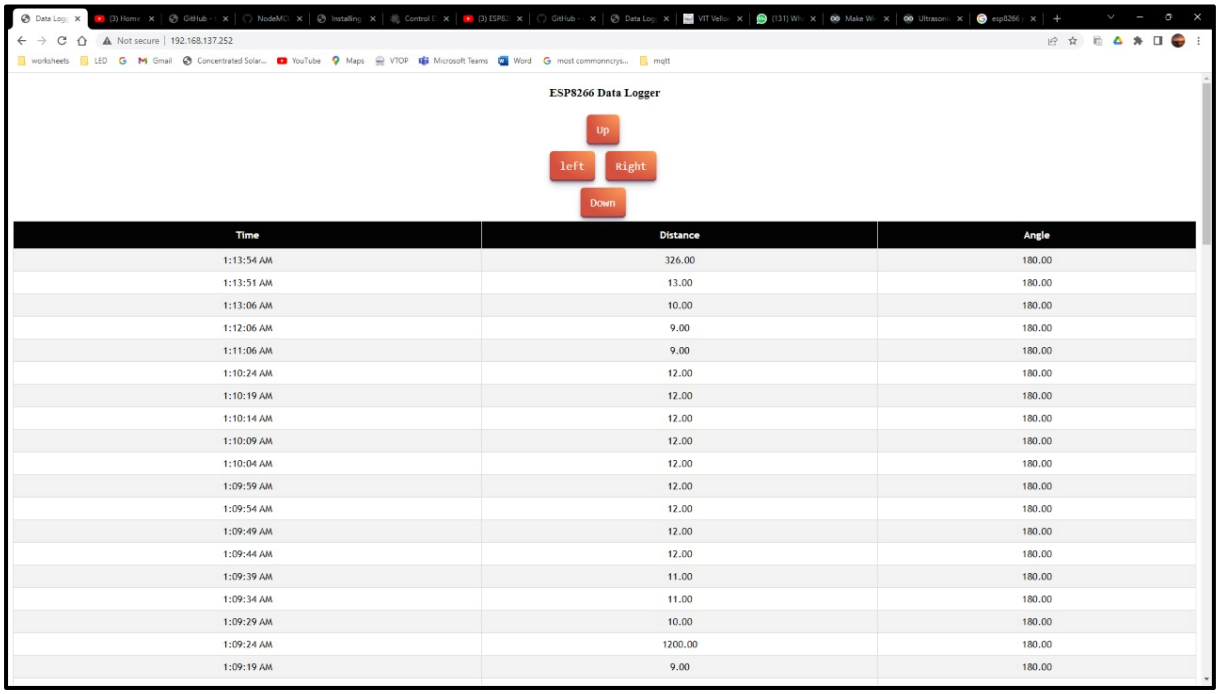


Fig. 2. LiDAR unit mapping its surrounding



Time	Distance	Angle
1:13:54 AM	326.00	180.00
1:13:51 AM	13.00	180.00
1:13:06 AM	10.00	180.00
1:12:06 AM	9.00	180.00
1:11:06 AM	9.00	180.00
1:10:24 AM	12.00	180.00
1:10:19 AM	12.00	180.00
1:10:14 AM	12.00	180.00
1:10:09 AM	12.00	180.00
1:10:04 AM	12.00	180.00
1:09:59 AM	12.00	180.00
1:09:54 AM	12.00	180.00
1:09:49 AM	12.00	180.00
1:09:44 AM	12.00	180.00
1:09:39 AM	11.00	180.00
1:09:34 AM	11.00	180.00
1:09:29 AM	10.00	180.00
1:09:24 AM	1200.00	180.00
1:09:19 AM	9.00	180.00

Fig. 3. Screenshot from the webpage, displaying data from the ultrasonic sensor

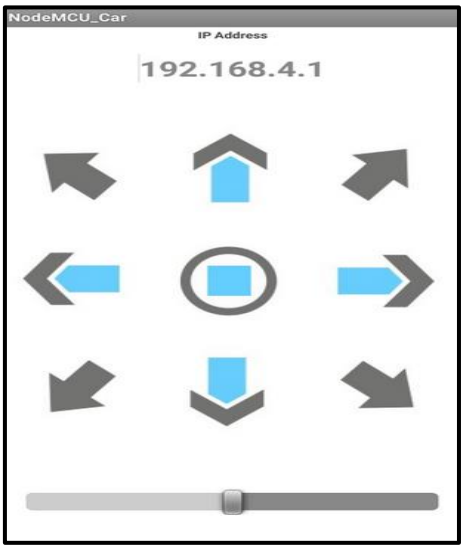


Fig. 4. Screenshot of the app that is used to control the rover

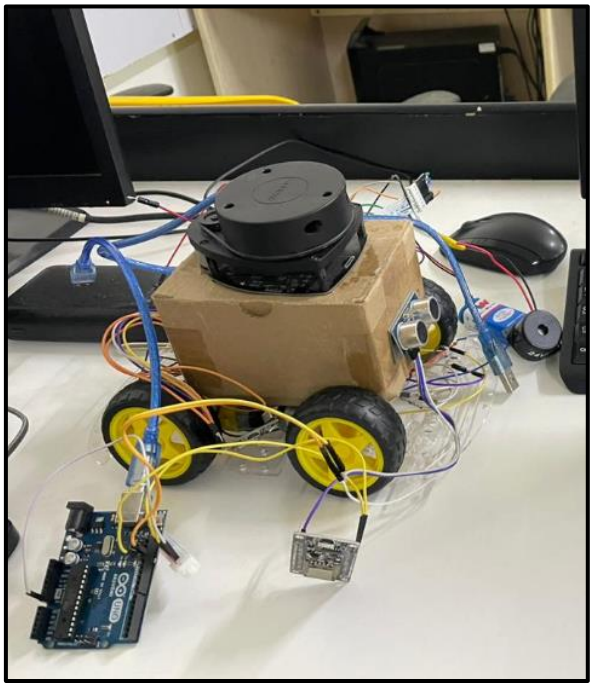


Fig. 5. A picture of the hardware implementation of the rover

FLOWCHART OF THE CODE

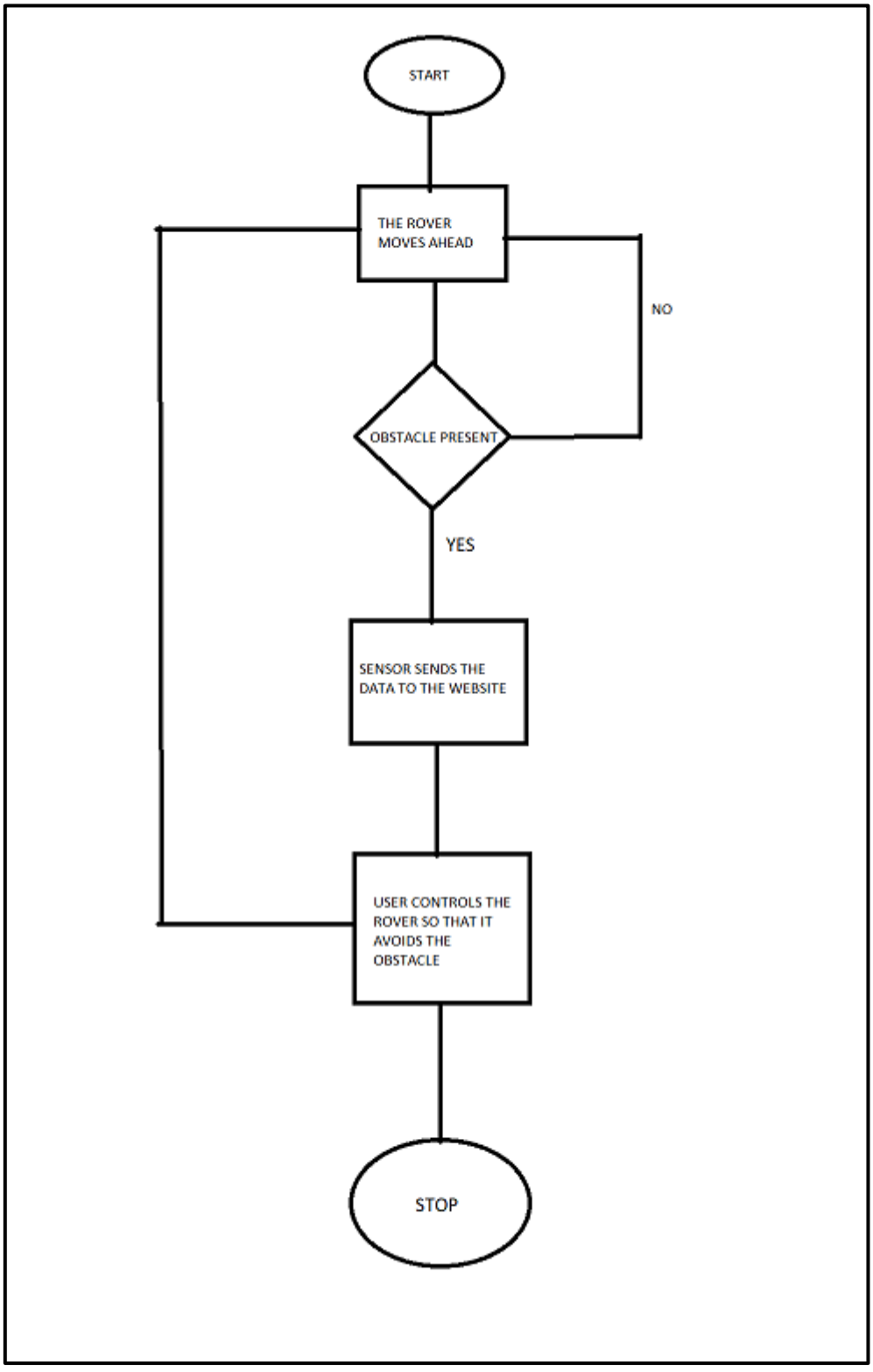


Fig. 6. A flowchart representing the working of the code

ADVANTAGES OF THE ROVER

- The rover can be used to detect the obstacles where human intervention is not possible or where surroundings are not safe for human beings. For example, it can be used by the military to detect unwanted obstacles in the environment.
- The website's user interface is easy to understand and navigate. It is also pretty easy to understand and analyse the data sent by the ultrasonic sensor. Thus, anybody can read the data and control the rover. Furthermore, the buzzer, along with the data from the LiDAR, acts as a precautionary method. They would alert the user even if the user fails to notice any obstacles.
- As the whole system works off its own Wi-Fi, it can work very well in remote areas without any issues, as long as we are in range of the rover. This helps us widen the applications of the project to more fields.
- The rover, if equipped with proper end-effectors, can be used for applications like physical sample collection, chemical sample collection, etc where human exposure to the materials could be dangerous to health.
- An unmanned rover could be used in various different fields. It can be used as a mechanised night guard. In such cases, the robot should be programmed to act proactively in case emergencies arise.
- The rover can be equipped with sensors that can detect human beings. This can then be used in search and rescue operations in rough terrains. It can also be made to provide basic first aid tools if survivors are found.
- Usually, the LiDARs that are being sold in the market do not come with proper instruction manuals. This project could serve as a proper starting point for anyone who wants to start working with a LiDAR.

DISADVANTAGES OF THE ROVER

- Since LiDAR data is sent serially, the interface cannot send control data over the same platform while it is receiving it. This was a limitation that was discovered while the project was being made.
- The app that has been made to control the rover is developed for Android phones. It doesn't work for IOS smartphones. This makes the app non-accessible to a large group of people.
- The 3-D LiDAR that is used in this project is very expensive and thus would not be accessible to everyone. We can replace it with a cheaper 2-D LiDAR but it will decrease the efficiency of the product.

- The entire unit must be powered by an external battery unit to ensure that enough power delivery to each component is achieved.
- This makes the unit very heavy and thus brings in the need for more powerful motors and in turn driving systems
- A five second loop time for the motor system may not be ideal in many cases.
- The ultrasonic sensor unit also updates once in five seconds to the site.
- The drawback of not being to send and receive a continuous stream of serial data continuously brings in the need for an additional ESP module.
- The LiDAR unit cannot be processed to its full extent by the ESP due to lack of graphical and driver support.

FUTURE SCOPE

- We can generate cost maps using pre-made algorithms to make the rover navigate its surroundings.
- Industrial grade LiDARs often exist without much technical support or instruction manuals. Newcomers can use the project code to get started and implement the LiDAR systems with ease.
- By adding actuators and end effectors, we can program the rover to pick up, carry or place hazardous material or get the job done easier in tight spaces.
- A smart rover as such can be used for remote exploration. In that case, it should be equipped with the appropriate sensors that will be able to collect the necessary data (like temperature, humidity, and so on). It will collect all the necessary data which can then be used by human analysts.

CONCLUSION

The rover is developed to identify an obstacle which interferes with its path. It thus uses an ultrasonic sensor coupled with an ESP board to collect distance and angular data from an obstacle and sends this to a website for the user. Along with this, the Arduino and LiDAR combined together help form a bubble of detection with alarms the user if any foreign body crosses in it. The range of this bubble can be tweaked as per the user's requirement. LiDAR offers a precise and accurate 360-degree view with rotating laser beams to prevent collision with objects and other cars. In addition, we have also augmented an ultrasonic sensor, which improves the rover. Thus, by incorporating 3D LiDAR systems into regular work systems which require a good sense of spatial awareness, we can streamline many day-to-day tasks.