An-Najah National University

Faculty of Engineering & Information Technology
Department of Computer Engineering

Hardware Graduation Project

Cave Rover

Authors:
Mustafa Sokar , Amr abo amr

Supervisor:
Dr.Luai Malhis

Date: January, 2023

Disclaimer

This report was written by students (Mustafa Sokar and Amr abo Amr) at the Computer Engineering Department, Faculty of Engineering, An- Najah National University. Therefore, has not been corrected or modified as a consequence of assessment and it may contain language as well as content errors. The ideas and opinions stated, as well as any views or suggestions, are purely those of the students. An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

Contents

1 Abstract **6**

2 Introduction **7**

2.1 Background 7

2.2 Problems 7

2.3 Objectives 7

3 Constraints and Earlier Coursework **8**

3.1 Constraints 8

3.2 Earlier Course work 9

4 Literature Review **10**

5 Methodology 11

5.1 Equipment and components 11

5.1.1 Arduino Mega 11

5.1.2 ESP32-CAM 12

5.1.3 Temperature and Humidity Sensor 13

5.1.4 MQ-2 Gas Sensor 13

5.1.5 Esp8266 NodeMCU 14

5.1.6 Ultrasonic Sensor 14

5.1.7 L298N 15

5.1.8 DC Motor 15

5.1.9 Robot car chassis 16

5.1.10 Single Cell Batteries 17

5.1.11 Power bank 18

5.1.12 MG996R Servo Motor 18

5.1.13 SG90 Micro Servo Motor 19

5.2 Component Implementation 20
5.2.1 DC Motors, Drivers 20
5.2.2 Power Supply 21

5.3 ESP32-CAM Implementation 22

5.4 Robot Arm 23

6 Result and Discussion 24

7 Conclusion and Future Works 25
7.1 Conclusion 25
7.2 Future Work 25

8 References 26

Chapter 1

Abstract

Human life is very important, it’s too risky to let people enter dangerous and unknown places that might be out of oxygen, too tight, or may have some dangerous animals inside them.
This Cave Rover robot will take a risk and will do the mission instead of the person, Cave hover is a manually and also it could drive automatically controlled robot by Wi-Fi equipped with a camera for steaming, there are also some sensors to read information from the place (oxygen percentage, temperature, humidity, metal detection …) displaying them on the control Board and this robot could take a sample from the place using its arm.

Chapter 2

Introduction

2.1 Background

In our world there are a lot of dangerous areas or some unknown places E.g. caves, tight areas, abandoned buildings and even terriers of animals. Human life is critical in these cases so we want something to discover these places before allowing people to enter them.

2.2 Problem

As we don't know what we will face in this areas the main problem that we want a strong robot, fast , and easy to control , also it must has all features needed to deal with this mission to take a good vision of the place we want to discover.

2.3 Objective

As we mentioned before , the human life is so important , this is the main propose for carrying out this work , we hope to design a good prototype of the cave rover that will help people in case that they need to enter dangerous places or they want to take something inside it.

Chapter 3

Constraints and Earlier Coursework

3.1 Constraints

3.1.1 Car chassis

The car chassis in our project is made from plastic it's not that strong for the robot work nature ,we need an Aluminum or some strong and light weight material chassis.

3.1.2 Streaming quality

The streaming is a main feature in our project as it is our ayes inside the place we want to discover ,but The quality of our camera(ESP 32) wasn't perfect it sometimes lagged and give low quality video .
So we provide an Auto driving mode to avoid obstacles when we couldn't see them on camera , also we show the users the reads of ultrasonic sensors to help them.

3.1.3 Saving the path

The motors of the car is DC motors it was a challenge to save the path using DC motors as it not accurate as stepper or servo motors .
We decided to save direction ,speed and time in the EEPROM of the arduino mega ,that's help to save a good copy of the path that we drived.

3.2 Earlier Coursework

- **Electrical Circuits:**

  This course helped us develop the skills we needed in our ability to analyze and understand different type of circuits we worked with resistors and lot of important component in this course which we each used in order to bring our idea into life.

- **Microcontroller Lap:**

  This course was useful for us in terms of understanding how to handle the Arduino Chip and testing our code on it.

- **Web programming course:**

  Among what we learned in this course is how to create web pages using HTML,CSS and JavaScript.

- **Wireless Communication:**

  With our project having the need to send data from ESP32-CAM to Arduino over Wi-Fi, the wireless course helped us understand the protocols and the processes that we should do in order to establish a well and functional wireless connection between different types of hardware parts in our project.

- **Critical Thinking:**

  This course helped learn the skills and the applications that we need in order to prepare and create the paper that you are reading at the moment and gave us a good understanding on how a professional and scientific paper should look like

Chapter 4

Literature Review

Cave Rover aim to save human life, the robot will take the risk and will do the mission instead of the human. There are many robotic car manufacturer companies. For example:

PackBot: German Army receives 127 new robots.
Small ground robots for reconnaissance and object disposal.
As we see from picture below the robot has an arm to carry objects
Also it has a camera for streaming .The robot controlled wirelessly as we did in our project, and the most important point that this robot did is saving the solders (human) lives.
The things that distinguish our project , We'll summarize all the features and add some new features ,we designed the project in a simple way and less expensive.

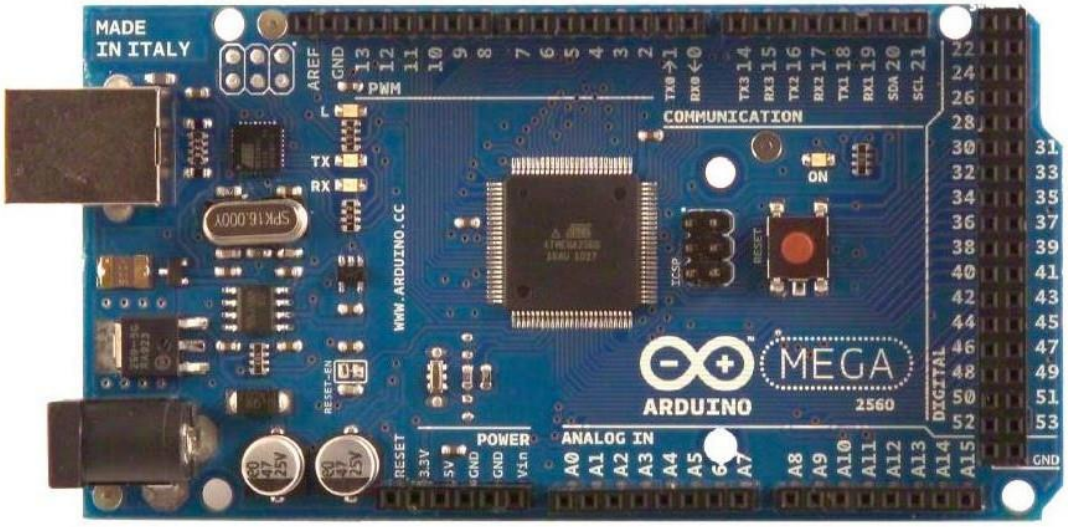
Chapter 5

Methodology

5.1 Equipment and Components

5.1.1 Arduino Mega

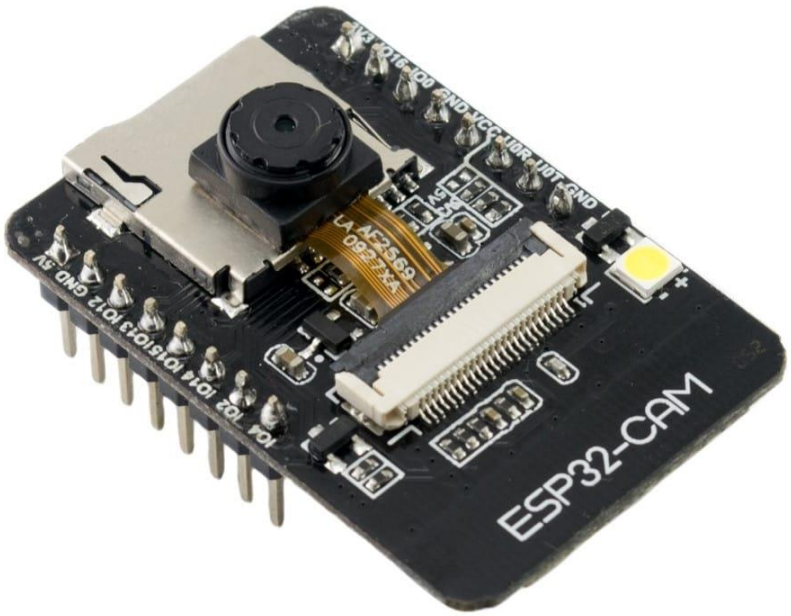
One of the most important components of our project the Arduino is a micro-controller board based on the ATmega2560. It has 54 digital input/output pins, 16 analog inputs, 4 UARTs, It contains everything needed to support the micro-controller.



It was used in our project to connect the drivers and motors together and we connect the sensors with it. We also connected it to the ESP32-CAM to receive the commands from ESP32 .

5.1.2 ESP32-CAM

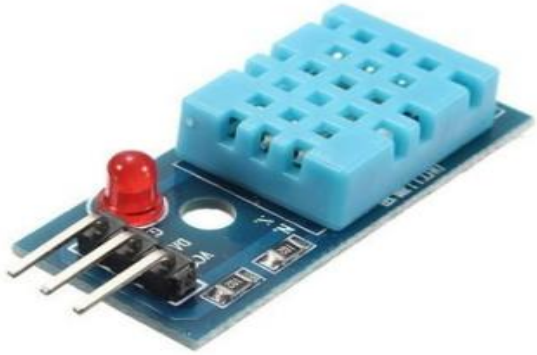
The ESP32-CAM is a very small camera module. It contains several GPIOs to connect peripherals, it also features a micro SD card slot that can be useful to store images taken with the camera.



We use it to control the robot using a web server that displays a video streaming of what the robot “sees”. We can control our robot remotely even if it’s out of our sight and control robot arm by sending control commands from mobile or desktop over Wi-Fi.

5.1.3 Temperature and Humidity Sensor

We used the temperature and Humidity sensor to measure the water vapor in the air and the temperature of the environment inside the cave. The sensor sends the measures to arduino.



We connected the sensor to the Arduino in order to get power from it and send the analog signal to it.

5.1.4 MQ-2 Gas Sensor

We used the Gas sensor to detect hazardous or flammable gas or smoke. The MQ-2 Gas detection sensor module has four pins VCC, GND, Aout, and Dout that can be used to get the needful information out of the sensor, The pin out of the MQ-2 Gas detection sensor is given below:

We connected the sensor to the Arduino in order to get power fromit and send the analog signal to it.

5.1.5 Esp8266 NodeMCU

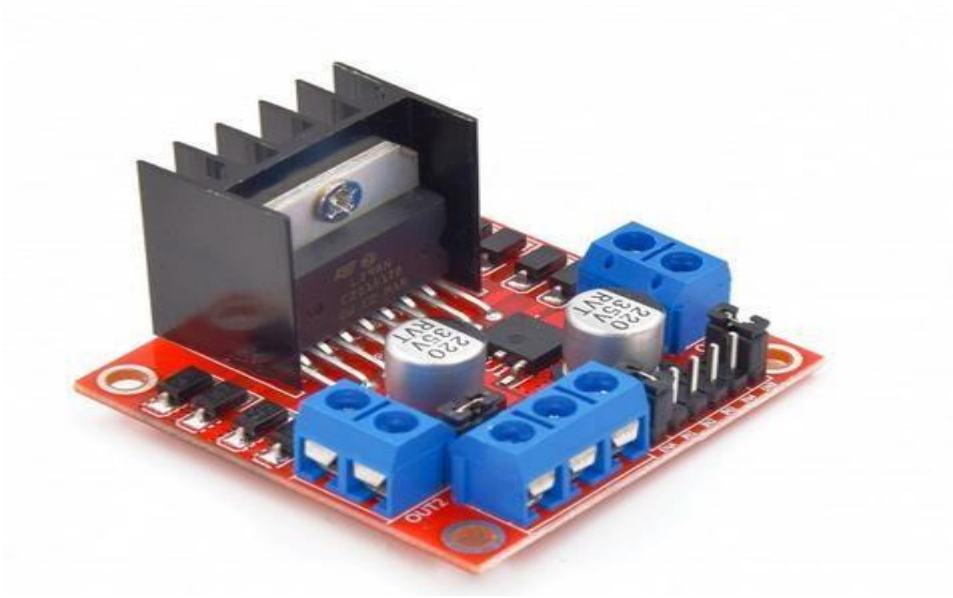
The **ESP8266** is a system on a chip (SOC) Wi-Fi microchip for Internet of Things (IoT) applications. We use it to display the temperature & humidity sensor and Gas sensor, dynamically display on web server over Wi-Fi.

5.1.6 Ultrasonic Sensor

We used Ultrasonic to avoid obstacle, so the robot can move automatically. The ultrasonic measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target).

5.1.7 L298N

The L298N is a dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time



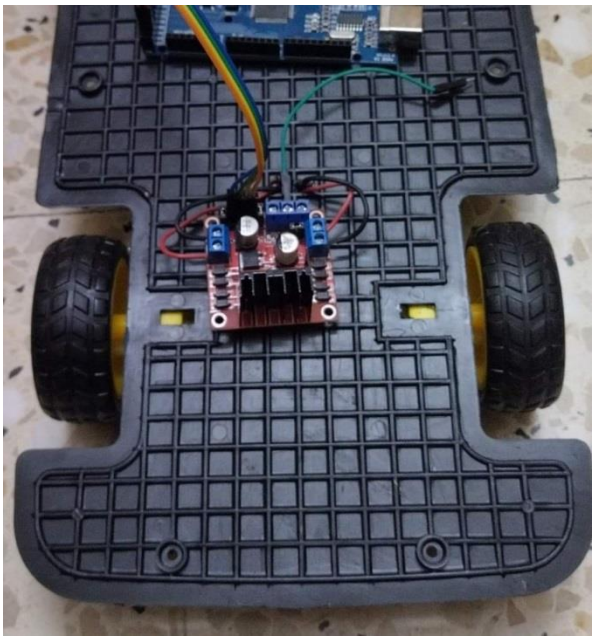
We used two of the L298N in order to control all four of our DC motors which will be used to drive the robot.

5.1.8 DC BO Motor

We use Bo motor (Battery Operated) lightweight DC geared motor which gives good torque and rpm at lower voltages. We can get bo motor with varying rated speed. It was connected to a wheel that allows the robot to move smoothly.

In our project we use 4 DC motors with 4 wheels as shown below:

5.1.9 Robot car chassis



5.1.10 Single Cell Lithium-ion Batteries

One of source of power in our project. We used four of these (2 on the back and 2 on the front) in order to power the drivers and motors.

We connected 2 batteries inside a battery case, we glued it down of thebody of the robot.

5.1.11 Power bank

Used in our project as a power supply for arduino and ESP32-cam and other components it gives 5v. It has three outputs.

5.1.12 MG996R Servo Motor

It’s a metal gear servo motor with a maximum stall torque of 11 kg/cm. Like other RC servos the motor rotates from 0 to 180 degree based on the duty cycle of the PWM wave supplied to its signal pin.

5.1.13 SG90 Micro Servo Motor

It’s a carbon fiber gear which makes the servo motor much lighter than the metal gear servo motors, it rotates from 0 to 180 degree counting on the duty cycle of the PWM that is supplied to its signal pin, and it is used for small load applications.

We used it in robot arm as shown below:

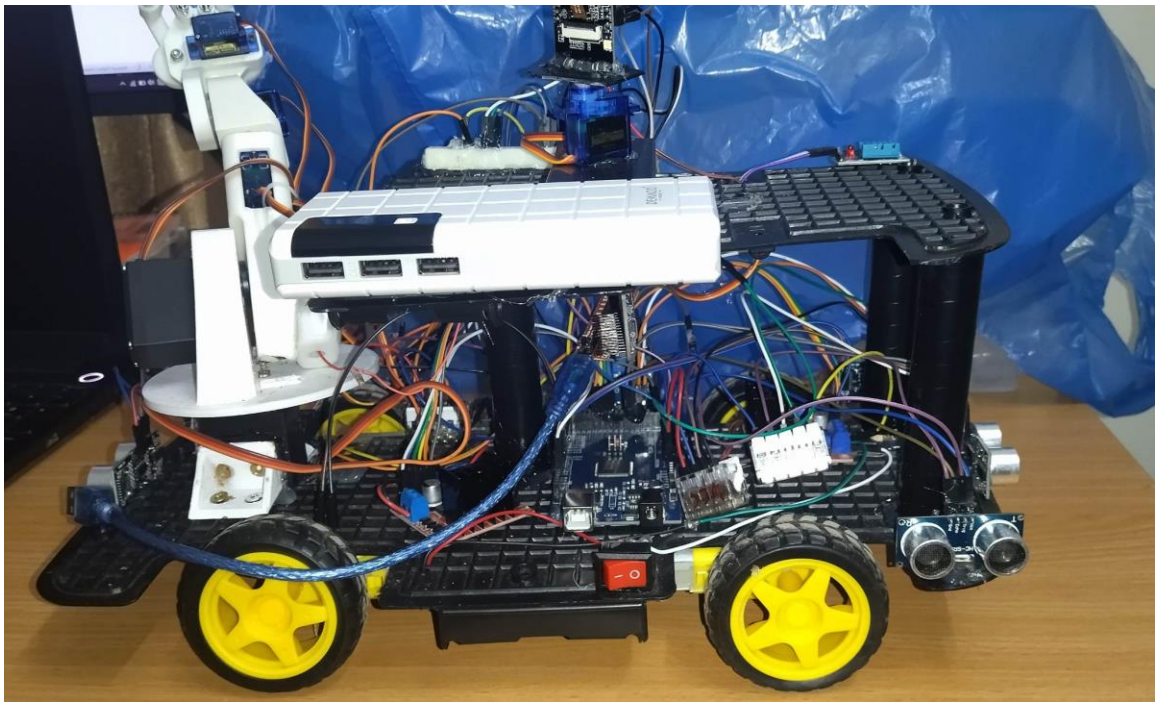
5.2 Components Implementation

Having the components is just a fraction of the work needed now we had to test each component independently and make sure that they all work as intended which needed a lot of experience and trial and error for it to eventually work then we were able to start implementing them in our project.

5.2.1 Motors and Drivers

As stated above each driver has to control two motors. The drivers take an input logic of 5V and outputs that are connected to motors. There is a speed pin which is used to control the analog speed of the drivers so we use this pin to control the speed of motor.

After connecting both of the drivers to the motors we also connect the drivers to the Arduino in order to receive the logic that we need to move the robot.



From the previous picture we can see all connection between different types of component.

5.2.2 The Power Supply

We used more than one power source such as power bank, which give 5v output it used in order to power the arduino ,ESP32-cam and other components.

Another power source, we used 4 Single Cell Lithium-ion Batteries where each on gave us an output voltage of 3.7V knowing that the battery case can fit 2 of each we can calculate that about 7.4V coming out of each one of these battery cases.it used for motors.

5.3 ESP32-CAM Implementation

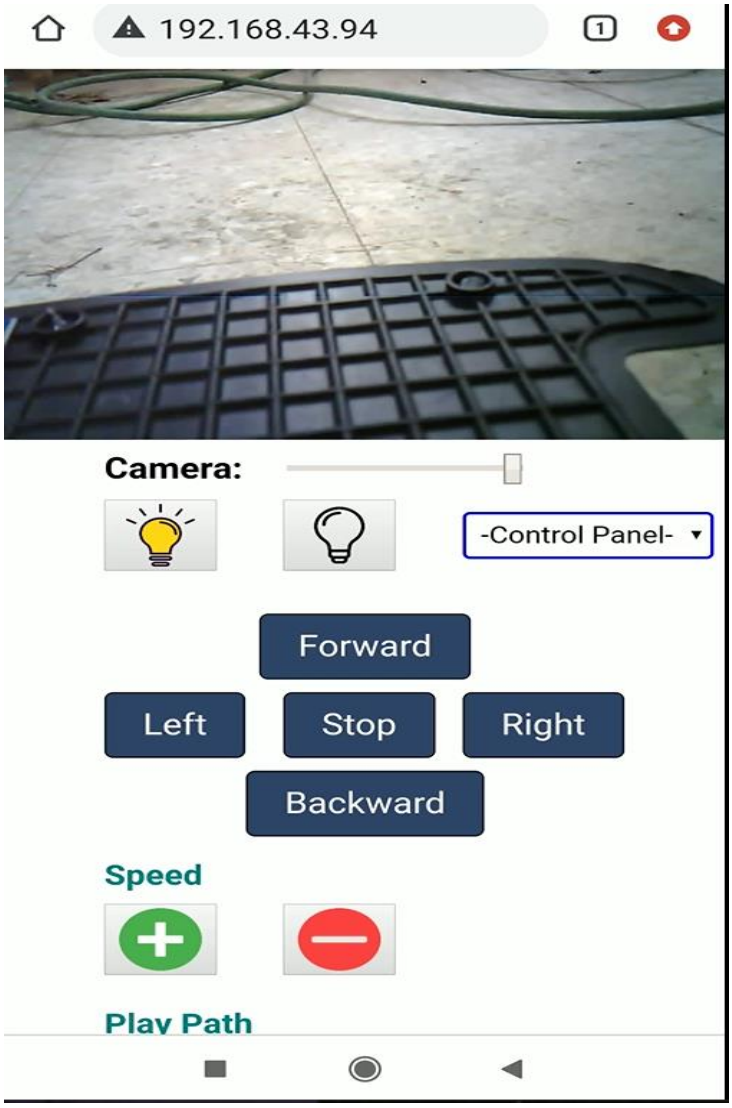
We control the robot via Wi-Fi using ESP32-CAM. We create a web-based interface to control the robot, that can be accessed in any device inside the local network. The web page also shows a video streaming of what the robot "sees".

Robot manual Controls

1- we could change the view of the camera using the camera slider .

2- Control buttons: Forward, Backward, Left, Right, and Stop.

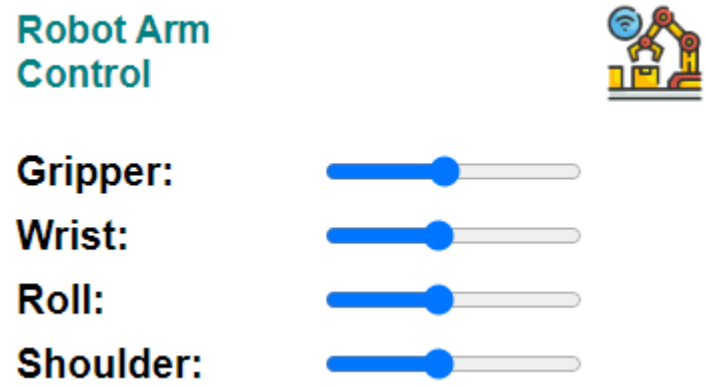
3- Speed buttons: increase and decrease the speed of motors.



5.4 Robot Arm

The robot arm that can be helping in carrying objects or helping in reaching places that can't be reached or are dangerous to be reached by humans ,this robot arm can be wirelessly controlled via Wi- Fi.

Using the sliders in the web page we can manually control the movement of each servo or axis of the robot arm as shown below:



Chapter 6

Results & Discussion

In the end we can say that we made a project that provides multiple features that will help to discover and enter unknown areas:

- Drive the car manually using a web page to control directions ,speed and camera visions
- Saving the path on which the car was driven, and repeat it as much as wanted.
- Auto driving mode , if there is an obstacle and doesn't appear on the camera this mode will help to avoid It , and if the path was clear for the ultrasonic sensors the car will drive through it automatically
- Robot Arm to take sample, dangerous materials, or anything we want from that place.
- Sending all sensors reads to a web page to help the user knowing the nature of this place (air quality, temperature, humidity and distances).

Chapter 7

Conclusion & Future Work

7.1 Conclusion:

In this project, we got familiar with new microcontrollers and how to use them how to make two or more microcontrollers communicate. We learned about sensors and drivers and how to deal with them and connect them correctly. Also we learned how to use ultrasonic sensors and how to provide the project with enough and good power .In addition to that we learned how to make two or more microcontrollers communicate. It was a big challenge to put all these feature in one project, but in the end we success.

7.2 Future Work:

There are many things that we can do to upgrade our project some of these ideas that we can do such as:

- Using Image processing to detect objects in real-time with great accuracy.
- Work on the design of the arm to increase its strength and length to reach greater distances.
- Using larger motors to increase the ability to carry heavy weights.
- Make the car chassis from Aluminum to make it stronger
- Use a long-last power bank to provide the robot with power for longer duration of work.

References:

- https://docs.arduino.cc/hardware/mega-2560 (Arduino Documentation)
- https://randomnerdtutorials.com/esp32-cam-ai-thinker-pinout/ (ESP32 Camera Documentation)
- https://digit.site36.net/2022/06/26/packbot-german-army-receives-new-ground-robots/