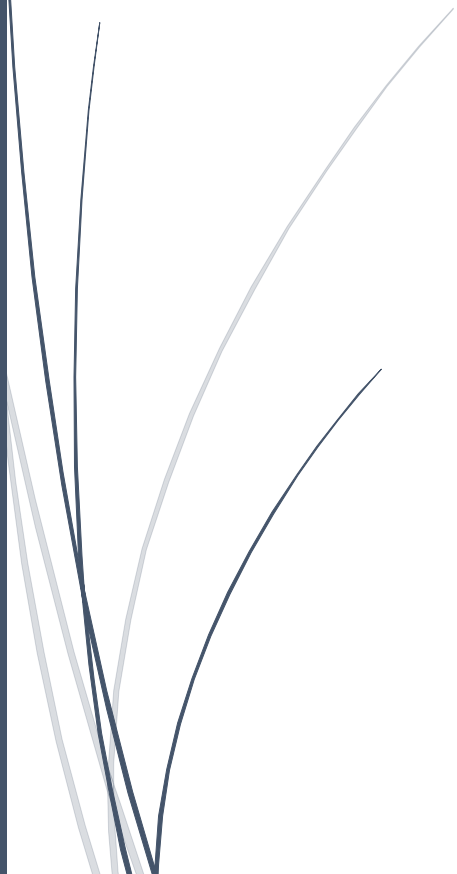
ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ

UNIVERSITY OF PIRAEUS

Artificial Intelligence

Summer Semester 2021



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Content

PROJECT GOAL

This project is about the field of Robotics in Computer Science and was implemented during the course of Artificial Intelligence.

Initially, Arduino equipment was purchased, studied, built and programmed into an object avoidance robot called Robby. Robby's sole purpose is to avoid objects for as long as his battery holds.
This task was chosen, because the appropriate route planning of technology means of transport is expected to be of key importance in the development of means of transport with Artificial Intelligence (see Google self-driving car).

In this work I present a robot that is made to perceive most of the obstacles in its path, to avoid them by going back and turning in a more favorable direction.
This robot model finds applications in vacuum cleaners, scientific exploration and emergency rescue in isolated environments.

Google self-driving car

Introduction

Robby has an "intelligence" embed into him so that he can be guided when an obstacle comes in front of him. Essentially, an algorithm is the brain that analyzes the data each time and sends commands to different parts of Robby.

The Arduino board is the one I chose to complete this task. There are other options available, such as Raspberry Pi. Arduino was chosen because of its convenience and cost.

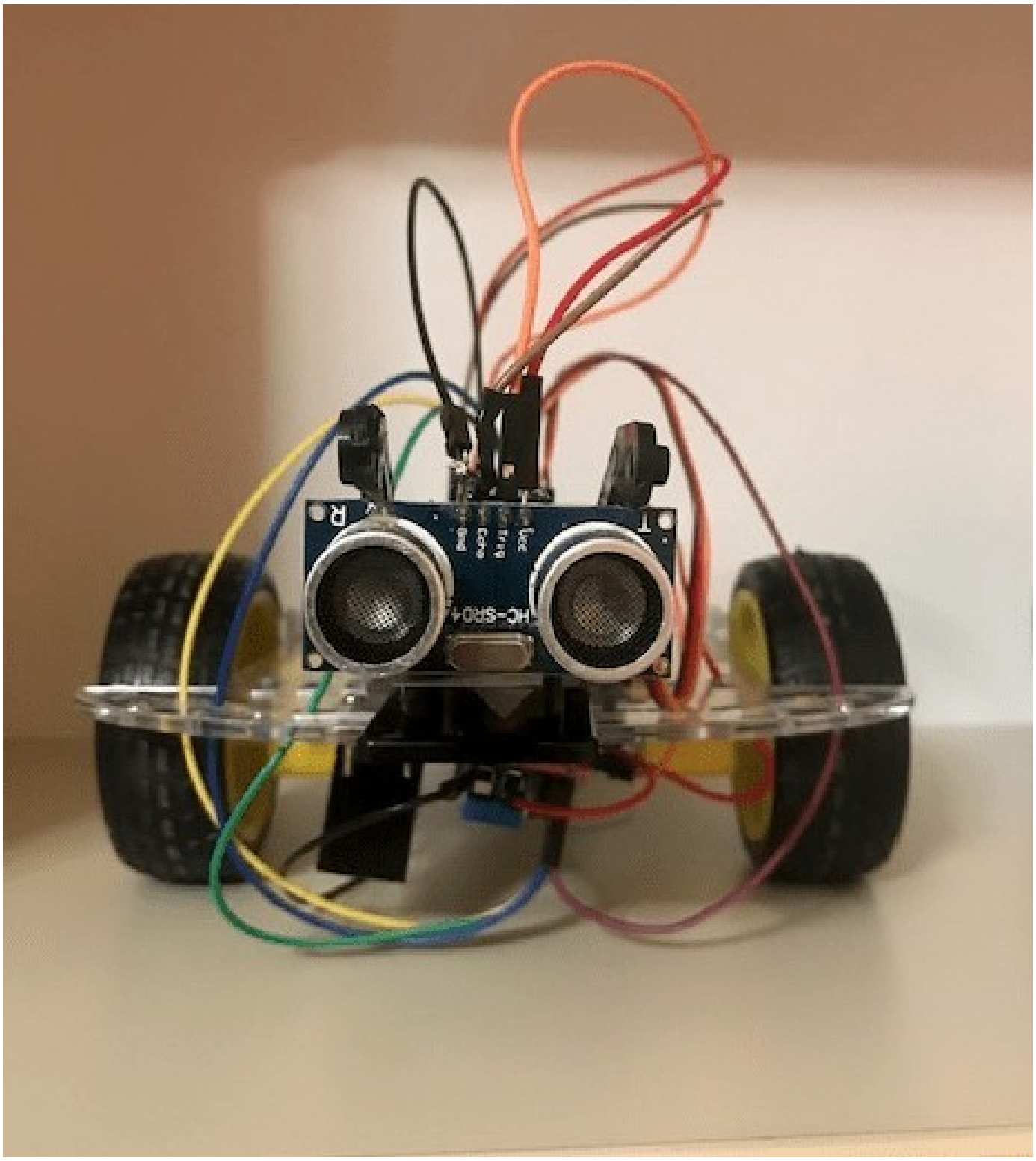
Function

With the help of Servo Motor, the sensor (which looks like a headwith eyes) scans the area left and right to find the best route for turning. This ultrasonic sensor is used to detect any obstacle in front of it and sends a command to the Arduino Board using PWM(Pulse Width Module) technology, which we will see shortly.

Depending on the input signal, the Arduino microcontroller redirects the robot to move in the appropriate direction by properly activating the motors that are interconnected via an engine driver IC (L298N Motor Driver).

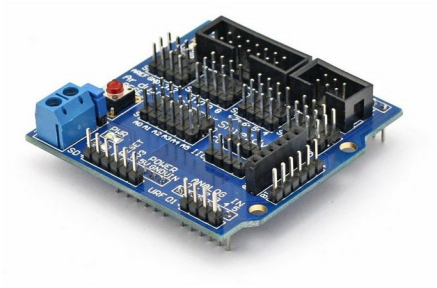
Why did I choose robotics?

A robot is a machine that can perform a task automatically or withguidance. Robotics is generally a combination of computational intelligence and physical machines (engines). Due to their high level of performance and reliability, robots have great popularity in everyday life. Come on, let me introduce you to Robby.



Robby the Robot

EQUIPMENT



Arduino Sensor Shield

Arduino Uno R3

L298N Motor Driver

Battery Holder

Car Chassis

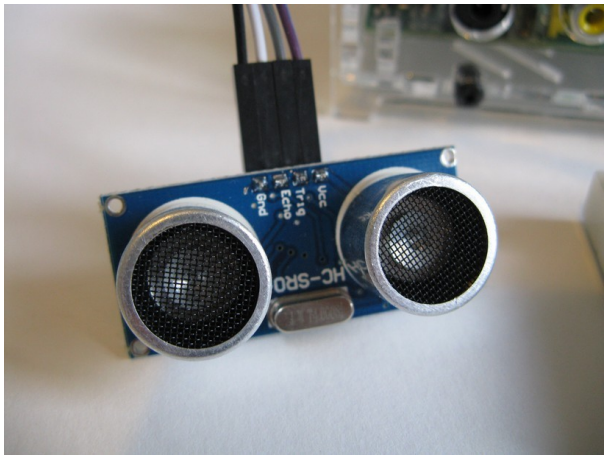
Servo Motor

Ultrasonic Sensor

Car Wheels

Jumper Wires

ULTRASONIC SENSOR HC-SR04



The HC-SR04 is a sensor that can measure distance. It emits ultrasound at 40,000 Hz, which travels in the air and if there is an object or obstacle in its path will return to the unit.

Let's see now how this is done.

The sensor has 4 terminals, two of which are for power, the other two are the Trigger Pin and the Echo Pin. The Arduino sends a pulse to the sensor via the Trigger Pin. Upon receiving this pulse, the sensor starts the timer.

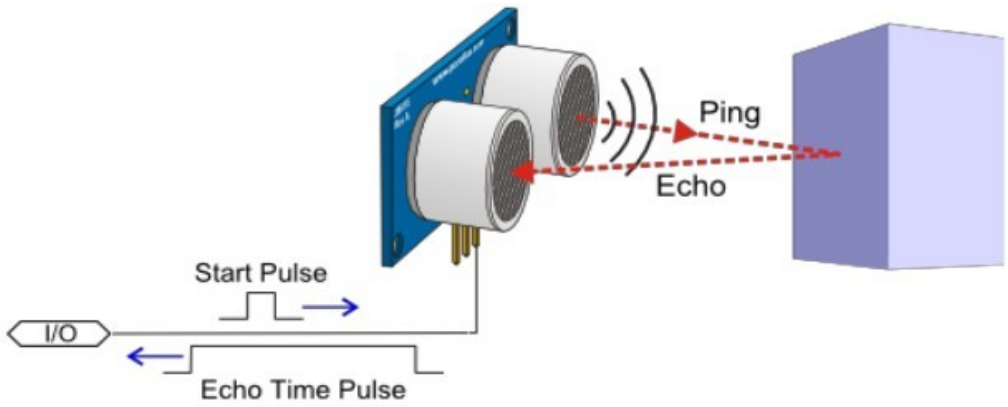
It then transmits the signal from one side and when it detects it from the other side, it sends the Arduino a pulse through the Echo Pin, the thickness of which represents the time it took for the audio signal to reach the obstacle and turn back. How does the algorithm calculate the distance? Easily, the following formula explains it.

S = (V x t)/2

S=distance

V=sound speed=340 m/s

t= time it took to return to the unit



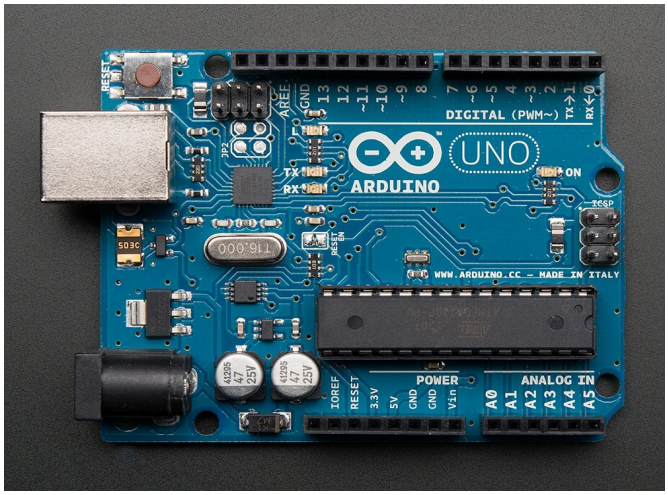
For example, if the object is 20 cm away from the sensor and if the speed of sound is 340 m / s or 0.034 cm / μs, it is assumed that the sound wave should travel for approximately 588 microseconds.

However, the pulse from the Echo Pin will be double that number, because the sound wave must travel forward and bounce backwards. So, to get the distance in cm we have to multiply the value of travel time obtained from the echo pin by 0.034 (sound speed) and divide it by 2.

Sensor Limitations

The sensor operates reliably from 2-400 cm. One of the limitations of the ultrasonic sensor is that sound waves from certain objects may not be detected, due to their shape or position in such a way that the wave bounces and deflects away from the sensor and as a result it never returns to Robby.

It is also possible for the object to be too small to reflect enough sound to return to the detected sensor. Objects can absorb the sound wave all together (fabric, carpets, etc.), which means that there is no way for the sensor to detect them accurately.



ARDUINO UNO R3

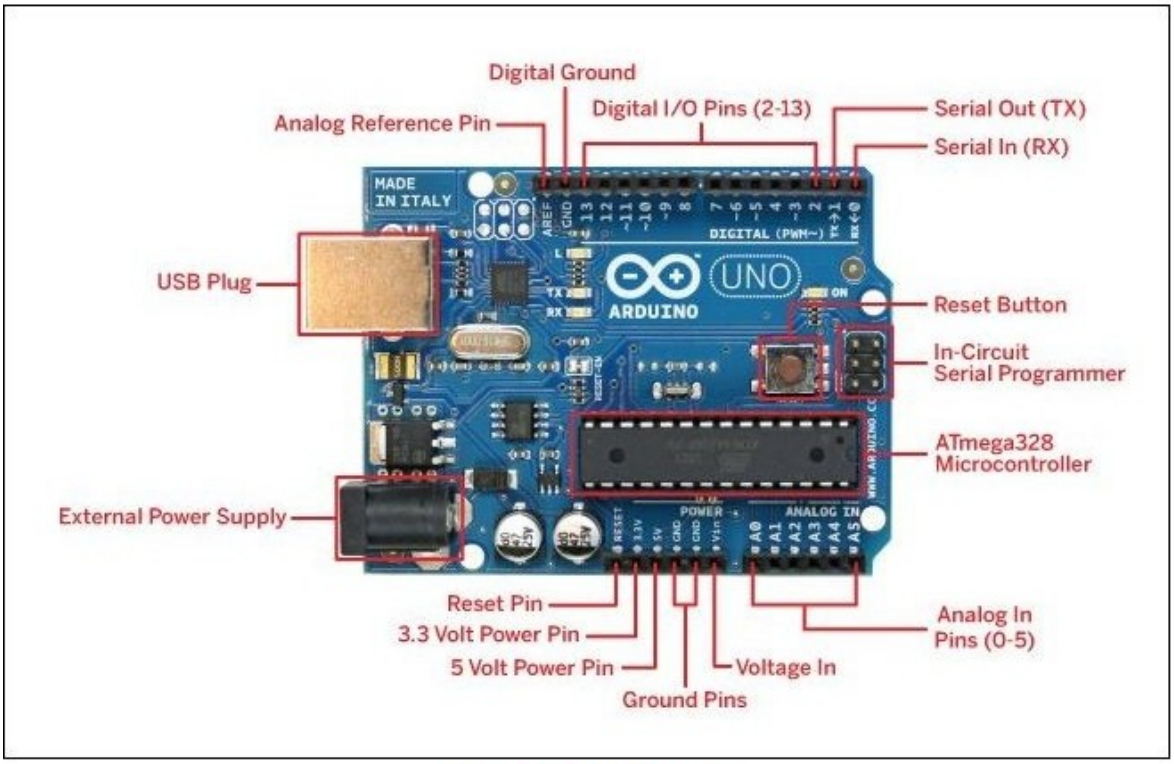
Perhaps the most basic component for Robby to work is the Arduino Uno R3. It is essentially the "brain", as it is responsible for giving instructions to Robby and guiding him throughout his journey.

The Arduino Uno R3 is a microprocessor in the Arduino family. Itis the third and final version of the family and was released in 2011. Its main advantage is its ease of use and programming. That is, it allows the user to create and 'upload' their code on the Arduino very easily and quickly.

The Arduino is quite popular for small robotics projects, which it makes it ideal for beginners. It is based on the ATmega328P processor and comes with 14 input / output PINs, 6 analog inputs,16 MHz quartz crystal, USB connection, power socket, ICSP header, which allows us to program the Arduino microcontroller without removing it from the circuit. Last but not least, the Arduino also has a reset button, in case we need to use it.

How do we program the brain? Easily, we simply connect the USB port of the Arduino to our computer with a USB cable. We use a program, Arduino IDE, to write, but also to 'upload' our code to the processor. I will show later images of the code (C ++) through the IDE that I have uploaded to Arduino.

Processor features



Arduino Uno Pin Diagram

Vin (Voltage In): It is the Pin that manages the current voltage, when it does not receive power directly from USB or the External Power Supply, but from the Sensor Shield or the Motor Driver.

5 Volt Power Pin: The Pin from which it draws power when the Arduino is connected to either the Sensor Shield or the Motor Driver.

3.3 Volt Power Pin: It offers 3.3 current and thus makes the current at 50 microamperes.

GND (Ground): It works in synergy with the VCC and indicates the zero voltage of the current.

Memory: 32 KB is the microcontroller memory on the Arduinoand 0.5 KB is used to boot it. It also includes 2KB SRAM-2 (RAM type) as well as 1 KB EEPROM (ROM type).

I/O Pins: It has a total of 14 input / output pins used in the Mode,Read and Write code functions (we will see them in a moment).
They operate with a voltage of 5V and give a current of 20 microamperes and include a 20k ohm resistor.

TX/RX: They are the Transmitter and Receiver Pin, responsible for data communication (bits).

LED Pin: The Pin that shows whether current passes or not.

Analog Reference Pin: Adjusts the reference voltage used for analog input (i.e. the value used as the upper part of the input range).

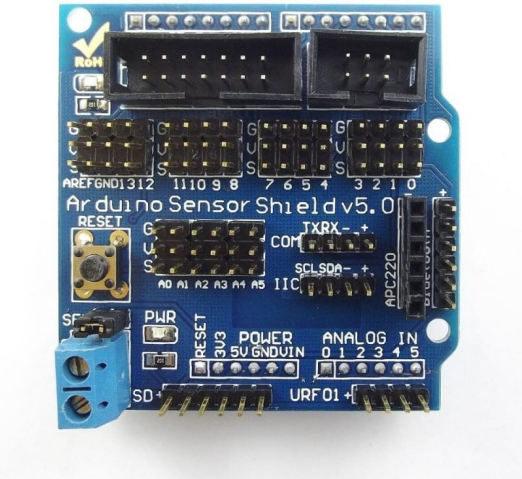
Reset Pin: Resets the Arduino microcontroller. The Sensor Shield attached to this pin prevents the reset from coming out of the rest of the Arduino.

In general, the Arduino has several Pins, each of which is responsible for a specific job. All of which are necessary for its safe and successful operation.

Arduino Architecture

The design of the Arduino is a branch of the Wiring platform foropen source software and is programmed using a Wiring-based language, similar to C ++ with simplifications and changes, as well as a set of libraries and a development environment (IDE).

ARDUINO SENSOR SHIELD



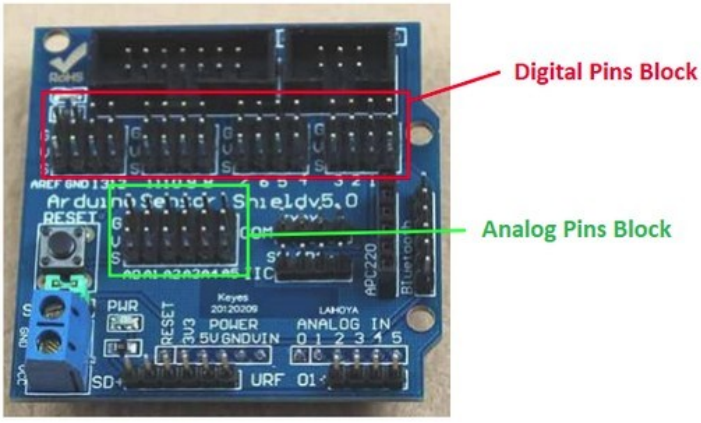
The purpose of the Sensor Shield is to make it easier for us to connect the parts of the Robby to the "brain", i.e. the microcontroller on the Arduino. With the help of Sensor Shield the need to weld the various cables to the Arduino is removed and we can now use female jumper wires.

As we can see from the picture, the sensor shield has multiple Pins, each of which has separate functions. The Sensor Shield has 3 concepts that exist in each Pin. These are G, V and S.

G: It is the acronym for Ground Pin. Represents 0 Volt.

V: It is the acronym for Volt. Represents 5 Volts.

S: It is the acronym for Signal.



Arduino Sensor Shield V5

Sensor Shield divides its Pins into Analog and Digital. I used the Analog Pins to connect the Arduino to the Echo, Trigger, Gnd, 5V of the Ultrasonic Sensor.

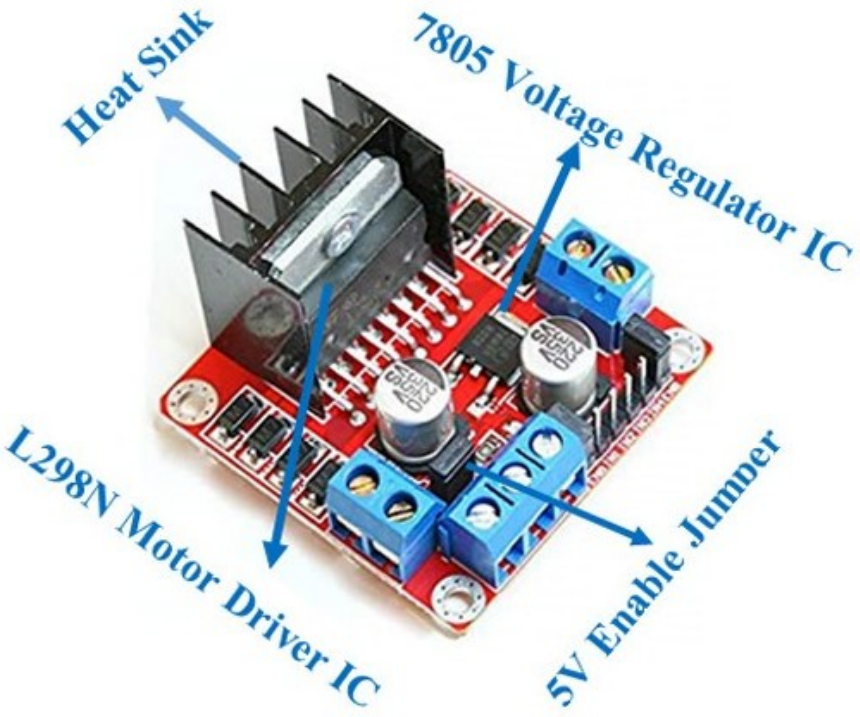
I used the Digital Pins to connect the Arduino to theL298N Motor Driver and Servo Motor.

The Sensor Shield has two more bases (the blue ones in thepicture) to power the Arduino from the L298 Motor Driver.

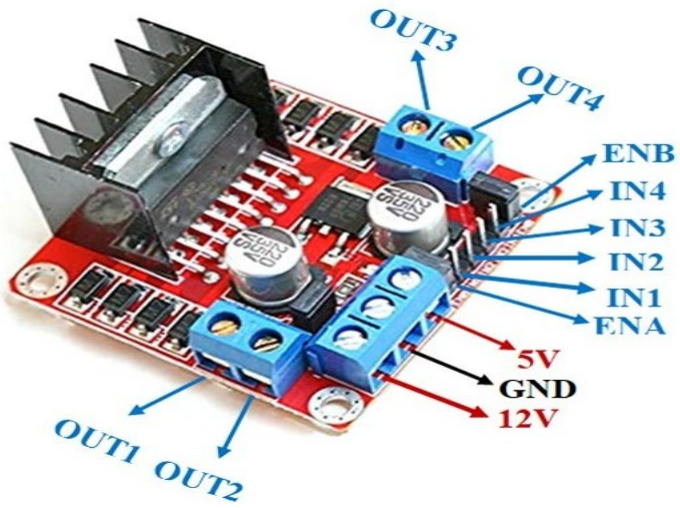
Another remarkable feature of the Sensor Shield is that it has the ability to communicate with devices wirelessly, but also with Bluetooth.

L298N MOTOR DRIVER

The L298N is essentially the interpreter between the Arduino and the engines. It has multiple Pins to support up to 4 motors. It consists of 6 separate parts, the main one is the driver itself, but it also hasa voltage regulator, resistors, a capacitor, an LED, and a 5 Volt jumper.



Pins



IN1/IN2: The Pins that connect one engine to the Arduino.

IN3/IN4: The Pins that connect one engine to the Arduino.

ENA: Responsible for modulating the thickness of the pulse it sends to the engine (Pulse Width Modulation), in order to control its speed.

ENB: Responsible for modulating the pulse thickness it sends to the second engine (Pulse Width Modulation), to control its speed.

OUT1/OUT2: They connect one engine to the L298N.

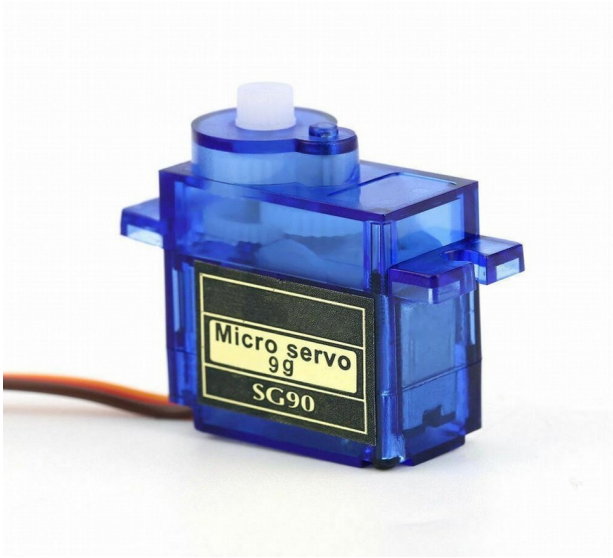
OUT3/OUT4: They connect the second engine to the L298N.

12V: Base for connection to 12 Volt power source.

5V: Base for connection to 5 Volt power source.

0V: Base with 0 Volt. Operates in proportion to 5V.

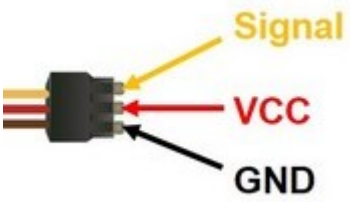
SERVO MOTOR



The Servo Motor is responsible for making the ultrasonic sensor to rotate degrees so that it can send sound waves in different directions and read their distance from Robby.

Thus, we understand that it is quite important in the smooth daily life of Robby.

Pins



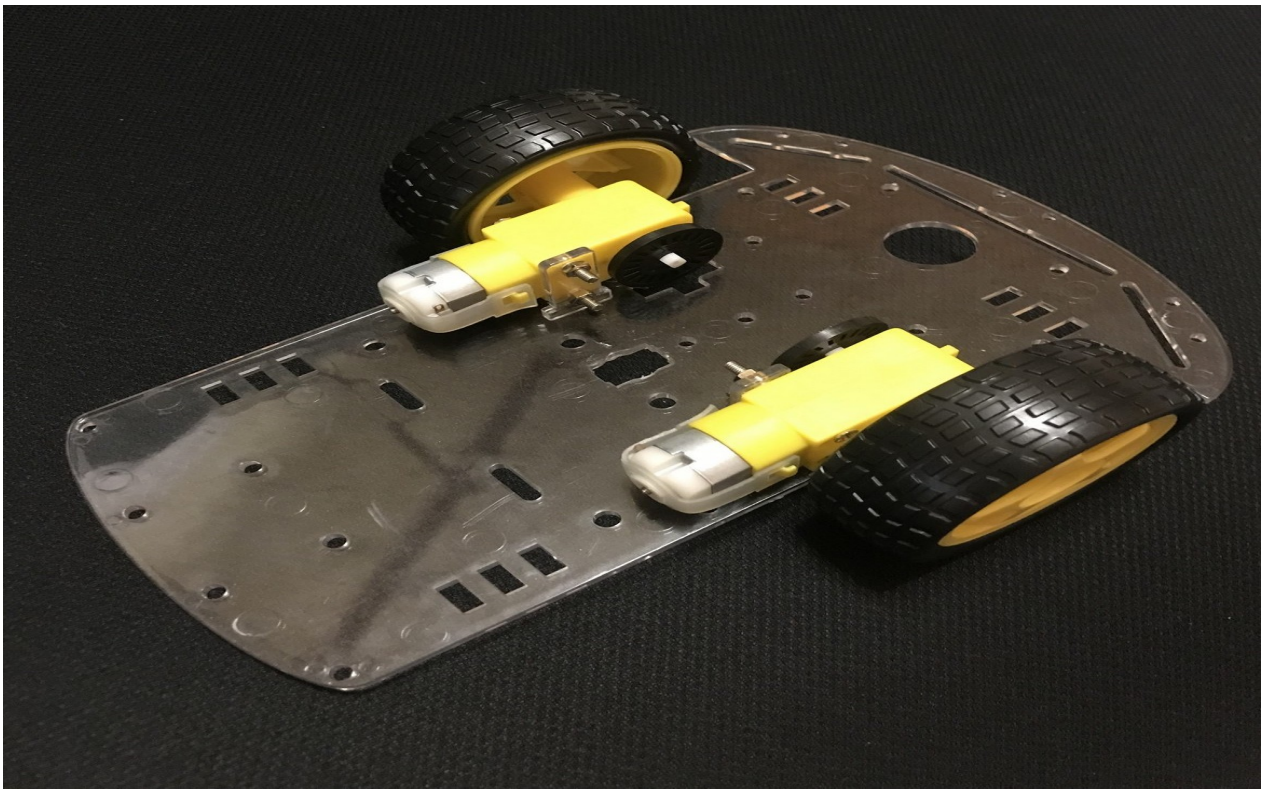
The Servo Motor has 3 pins, which are connected to the Sensor Shield digital block,two of which VCC and GND are for power, Volt and Ground Pin respectively.

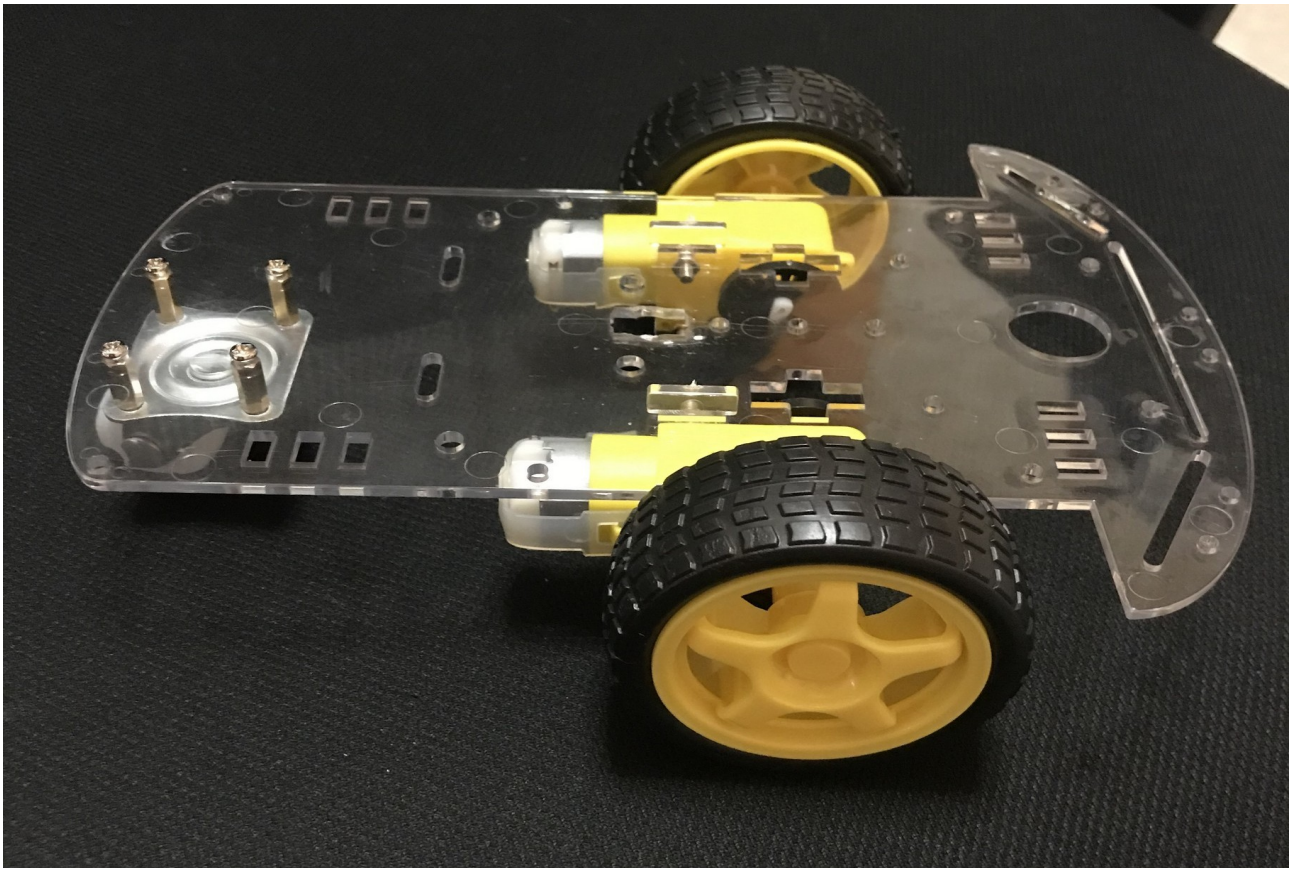
The third Pin is the Signal, which is of particular importance as it uses PWM (Pulse Width Modulation) technology to direct the ultrasonic sensor according to the thickness of the pulse it will receive.

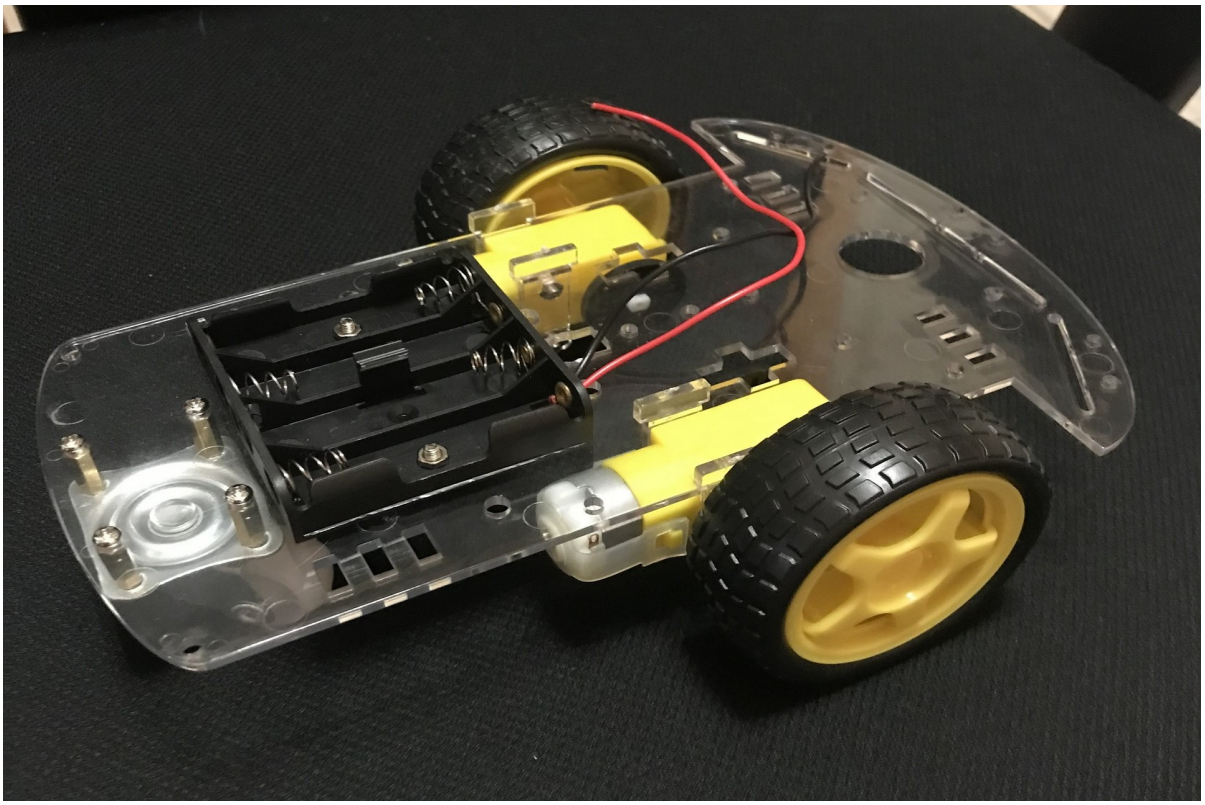
If the thickness of the Signal is equal to WIDTH_MIN, then the servo motor will turn 0 °. Respectively if the thickness is equal toWIDTH_MAX, then it will turn 180 °. We can easily predict that if the pulse is somewhere between the two, then it will return similar degrees.

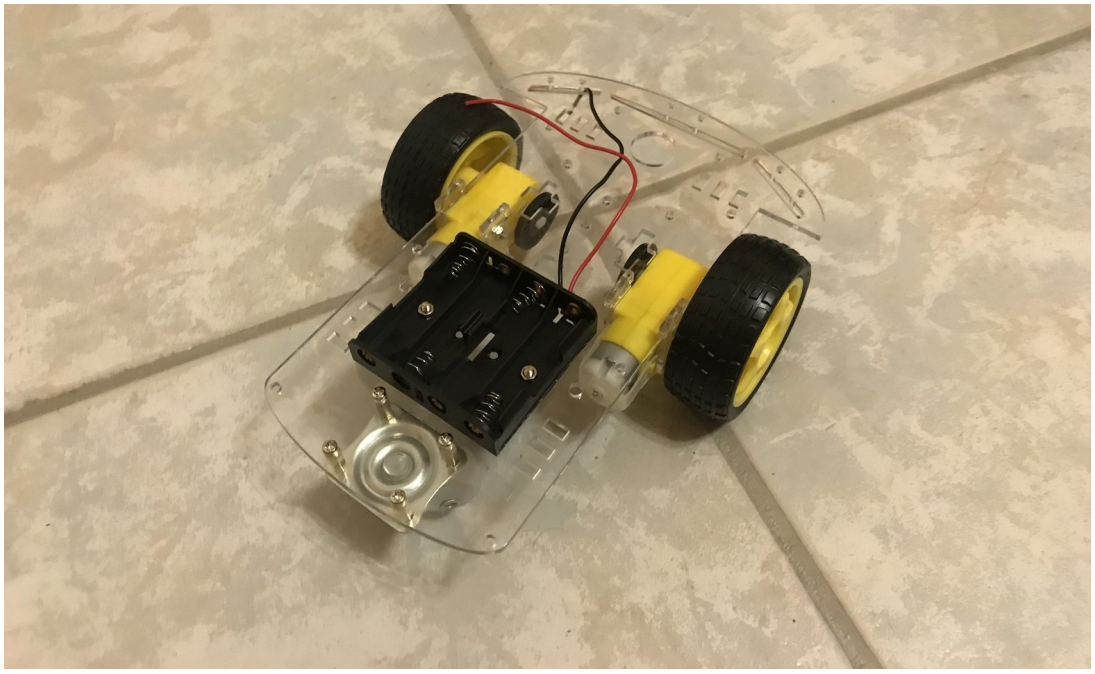
These pulses range in thickness from 1 ms up to 2 ms.

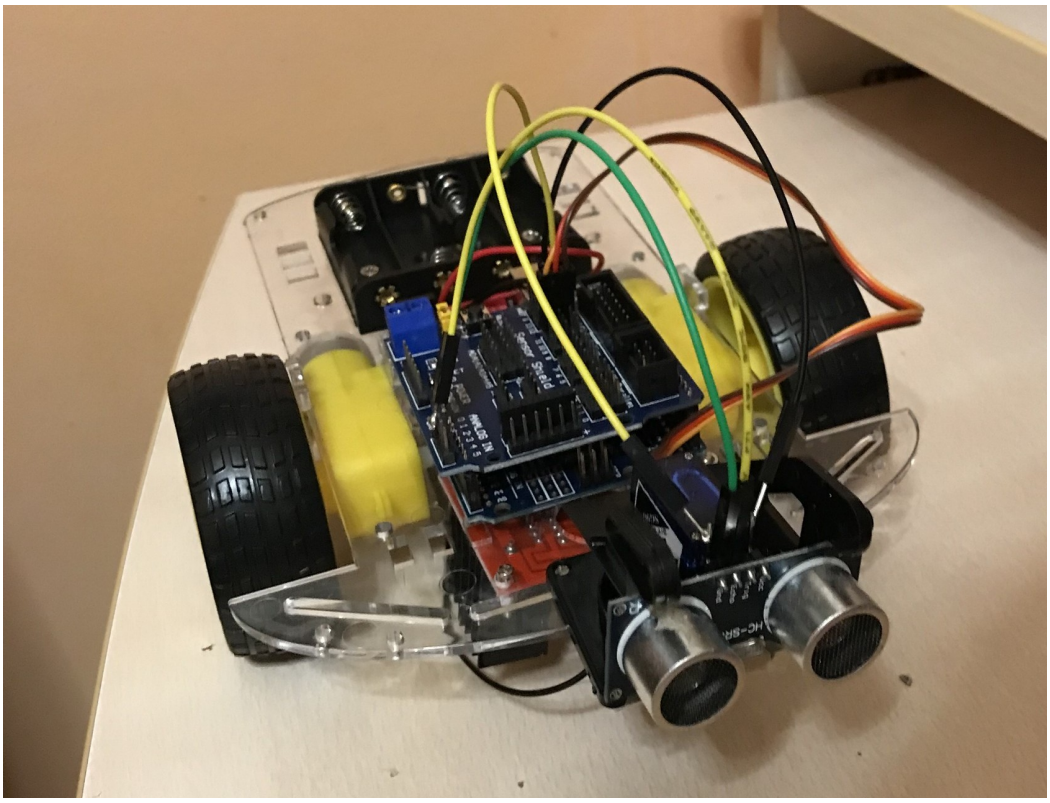
CONSTRUCTION



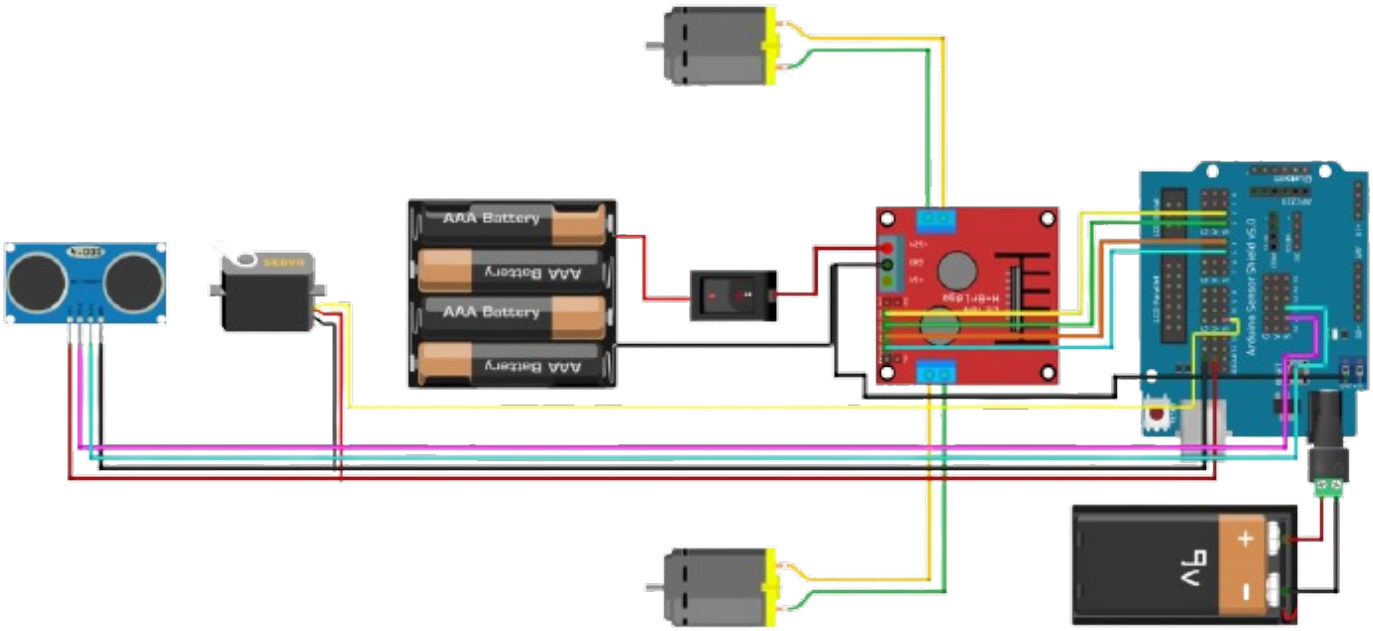


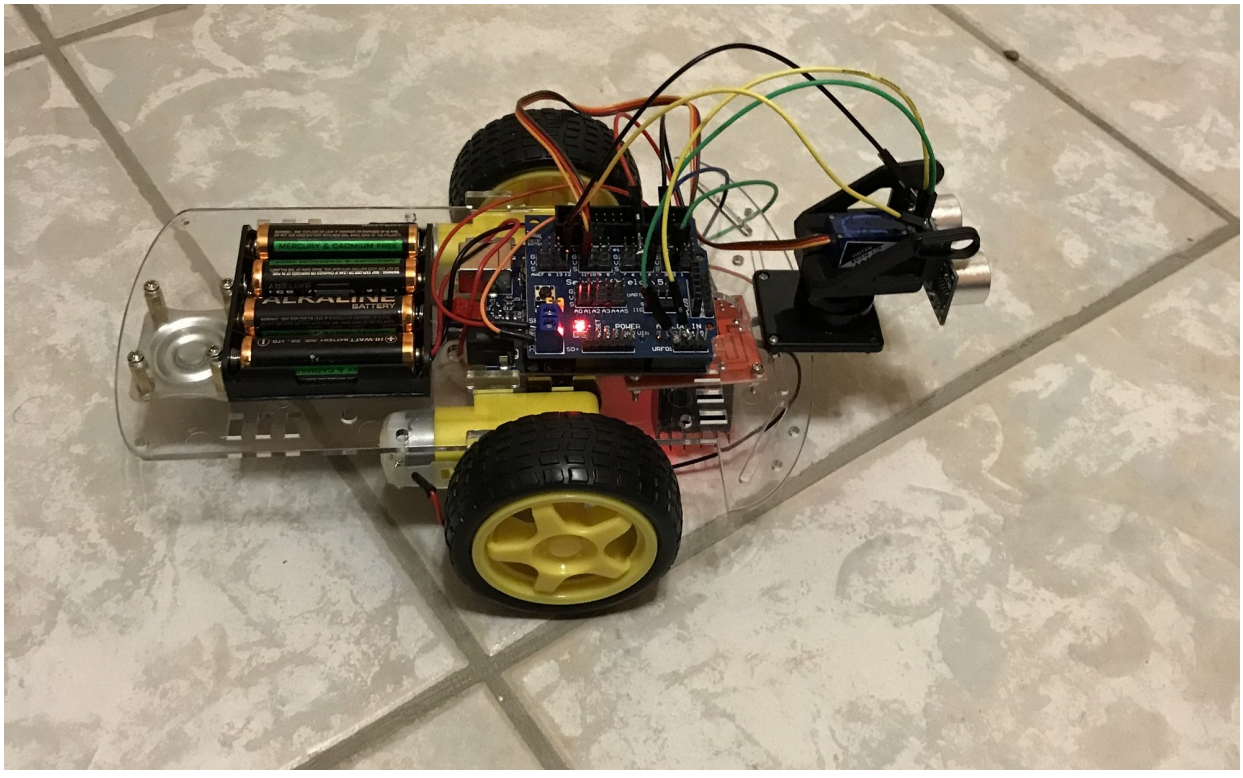




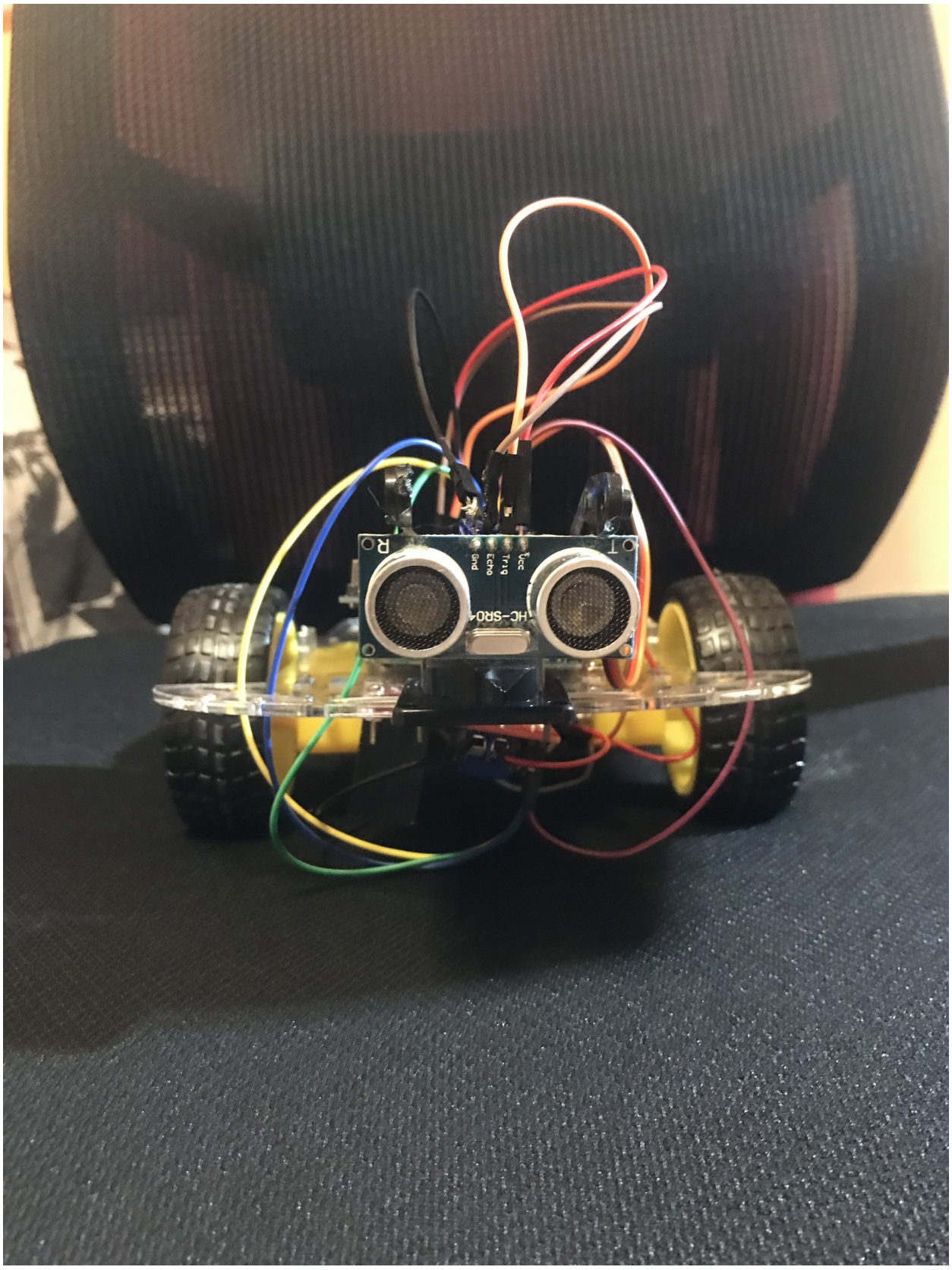


Wiring





Finished



CODE

```
#include <Servo.h> //standard library
#include <NewPing.h> //ultrasonic sensor function library.

//L298N control pins
const int LeftMotorForward=5;
const int LeftMotorBackward=4;
const int RightMotorForward=2;
const int RightMotorBackward=3;

//sensor pins
// me to #define den 8eteis mnhmh san to const int pixi.
#define trig_pin A2 // analog input 1
#define echo_pin A1 // analog input 2

#define maximum_distance 200
boolean goesForward=false;
int distance=100;

//QUESTIONS

 //Q: Giati vazoume delays????

 //A: gia na dwsoume xrono sta shmata na kanoun kinhseis.

//kalei to sonar function
NewPing sonar(trig_pin, echo_pin,maximum_distance); //NewPing setup of pins and maximum distance.
Servo servo_motor; //the servo name
```

Explanation: Here I set the variables for the Pins of the motor andthe sensor, but also a variable to know if it goes forward, and one to hold the distance.

```
void setup() {
 //runs once:

  pinMode(LeftMotorForward, OUTPUT);
  pinMode(LeftMotorBackward, OUTPUT);
  pinMode(RightMotorForward ,OUTPUT);
  pinMode(RightMotorBackward, OUTPUT);

  servo_motor.attach(11);  //our servo pin

//gia configuration tou sensora to apo katw.
  servo_motor.write(85);
  delay(2000);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
}
```

Explanation: The above code runs only the first time the Arduino starts. Here it adjusts the pins of the servo and the motors, but also the sensor itself.

```
void loop() {
   //runs repeatedly:

  int distanceRight=0;
  int distanceLeft=0;
  delay(50);

  if (distance<=35)
  {
    moveStop();
    delay(300);
    moveBackward();
    delay(400);
    moveStop();
    delay(300);
    distanceRight=lookRight();
    delay(300);
    distanceLeft=lookLeft();
    delay(300);

    if (distance>=distanceLeft)
    {
      turnRight();
      moveStop();
    }
    else{
      turnLeft();
      moveStop();
    }
  }
  else{
    moveForward();
  }
  distance=readPing();
}
```

Explanation: The above function runs in a loop, i.e. it is repeated all the time, after the Arduino is setup. It basically corresponds to the main function that each program has.

In this function I define the algorithm that the Arduino will follow, during its course.

```
int lookRight()
{
  servo_motor.write(130);
  delay(500);
  int distance=readPing();
  delay(100);
  servo_motor.write(90);
  return distance;
  delay(100);
}
```

Explanation: The variable servo_motor holds the degrees that the Servo motor will turn from the left. In this example it will turn 130 degrees from the left, so Robby looks right, read the distance, return in front of degrees and return the distance it read.

```
int lookLeft()
{
  // to write einai to stripsimo tou kefaliou se moires
  servo_motor.write(50);
  delay(500);
  // analoga to mege8os tou palmou pou lamvanei einai kai h apostash apo ta antikeimena
  int distance=readPing();
  delay(100);
  servo_motor.write(90);
  return distance;
}
```

Explanation: Servo_motor writes the degrees that the Servo motor will turn from the left. That is, here it will turn 50 degrees from the left, read the distance, return in front of degrees and return the distance it read.

```
int readPing()
{
  delay(70);
  // edw diavazei to mege8os tou palmou
  int cm=sonar.ping_cm();
  // ama paei la8os h metrhsh kai gyrisei 0, tote ype8ese oti den hr8e pote kai kala einai makria.
  if (cm==0)
  {
    cm=250;
  }
  return cm;
}
```

Explanation: Reads the distance using the sonar library.

```
void moveStop()
{
  goesForward=false;
  // proypo8etei to Pinmode. To digitalWrite xeirizetai ta Volt sto ka8e pin.
  //5 Volt h 0 volt. Volt einai h piesh pou askeitai sta hlektronia.
  digitalWrite(RightMotorForward, LOW);
  digitalWrite(LeftMotorForward,LOW);
  digitalWrite(RightMotorBackward,LOW);
  digitalWrite(LeftMotorBackward,LOW);
}
```

Explanation: This is where all the engines stop. Low is 0 Volts and High is 5 Volts.

```
void moveForward()
{
 //mono an exei stamathsei na phgainei mprosta (goesForward=false),
 //8a synexisei na phgainei mprosta.
  if (!goesForward)
  {
    goesForward=true;

    digitalWrite(LeftMotorForward,HIGH);
    digitalWrite(RightMotorForward,HIGH);

    digitalWrite(LeftMotorBackward,LOW);
    digitalWrite(RightMotorBackward,LOW);
  }
}
```

Explanation: Here I give power to the corresponding motors, to move Robby forward.

```
void moveBackward()
{
  goesForward=false;

  digitalWrite(LeftMotorBackward,HIGH);
  digitalWrite(RightMotorBackward,HIGH);

  digitalWrite(LeftMotorForward,LOW);
  digitalWrite(RightMotorForward,LOW);
}
```

Explanation: Here I give power to the corresponding motors, to move Robby back.

```
void turnRight()
{
  // otan strivei einai to delay pou xeirizetai to poses moires 8a stripsei o arduino

  digitalWrite(LeftMotorForward,HIGH);
  digitalWrite(RightMotorBackward,HIGH);

  digitalWrite(LeftMotorBackward,LOW);
  digitalWrite(RightMotorForward,LOW);

  delay(250);

  digitalWrite(LeftMotorForward,HIGH);
  digitalWrite(RightMotorForward,HIGH);

  digitalWrite(LeftMotorBackward,LOW);
  digitalWrite(RightMotorBackward,LOW);
}
```

Explanation: In this function, I give power to the corresponding motors so that Robby turns right. How right? It is determined by the delay in ms in the function.

```
void turnLeft()
{
  digitalWrite(LeftMotorBackward,HIGH);
  digitalWrite(RightMotorForward,HIGH);

  digitalWrite(LeftMotorForward,LOW);
  digitalWrite(RightMotorBackward,LOW);

  delay(250);

  digitalWrite(LeftMotorForward,HIGH);
  digitalWrite(RightMotorForward,HIGH);

  digitalWrite(LeftMotorBackward,LOW);
  digitalWrite(RightMotorBackward,LOW);
}
```

Explanation: In this function, I give power to the corresponding motors so that Robby turns left. It works similar to the above function.

ROBBY IN ACTION

https://drive.google.com/file/d/14FvEovajwiAFF0gKQyQJa3PiuSdeYsOo/view?usp=sharing

https://drive.google.com/file/d/16P3teBcpuYRo8HXFCq8muX3QvXLyJ37e/view?usp=sharing

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