



FUTURE ENGINEERS  
**RED MANACHINE**

PROJECT

**“Julián”**



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Venezuelan  
Delegation



October 2023

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## INTRODUCTION

Robotics is a science that brings together several disciplines with the aim of designing machines programmed to perform tasks automatically. It involves not only the development of robots, but also their design, programming, production and application.

It also allows you to develop cognitive and social skills and abilities such as problem solving, teamwork, independent learning and communication.



World Robotic Olympiad (WRO) is a competition first held in 2004 and its mission is to help young people develop their creativity and problem-solving skills in a fun and engaging way. To this end, robotics competitions were organized in four different categories for students between 8 and 19 years old.

The category referred in this document is future engineers, which has two challenges to accomplish

For challenge number one: the vehicle must complete three (3) laps on the track with locations. For challenge number two: the vehicle must complete three (3) laps on the track with green and red traffic signs placed randomly on the inside walls of the track. To complete the challenge, a robot is developed to be able of facing the conditions set, at the design level and at the operating level defined in the competition rules.

Following the structure of the category evaluation criteria, this document describes in detail the solution designed for the “Julián” robot, which represents the “Red Machine” team, defining the criteria applied in the mechanical part, specifically steering, driving, and design of the chassis, as well as, explaining the entire electronic system that composes it, such as the sensors, speed and direction controller, and finally its programming which is explained through the system of code modules used to achieve the fulfillment of challenges number one and two.

## 1.TEAM FORMATION

**Red Machine** team initially emerged from a group of friends who were presented with the opportunity to start in the world of robotics. Although some of them had prior knowledge, they started from the

The team for the competition is made up of:

**Samuel José**

Galbán Franco



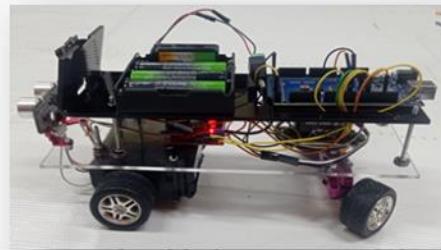
**Juan Diego**

Cano Barros



**Ángel Saúl**

Rodríguez Guerra



**Julián**

At the beginning of this journey, the team came up with the name "**Robstar**", which was created through a union of "Robotics" and "Tasks". Then, a new challenge was presented, in this case it was a robotics competition, called the **copa Kaí**, which, was an interschools event, it was decided that the name "**Maquinaria roja**" would fit perfectly with the team representing the institution. , due to a tradition in all competitions of any kind that the Los Robles high school participated in, it was known as such. Finally, when starting in the WRO the team decided that the best name option would be "**Red Machine**" in honor of "**Maquinaria Roja**".

To save and share this process it was decided to open social media on

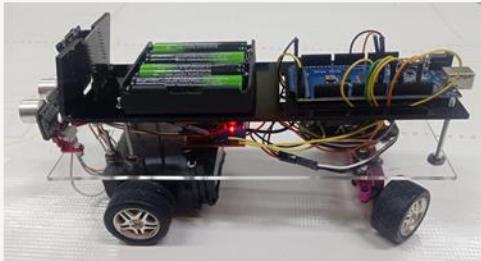
**Instagram...@redmachine\_vzla** and on **YouTube....@REDMACHINE.WRO.**

<https://www.youtube.com/@REDMACHINE.WRO./featured>

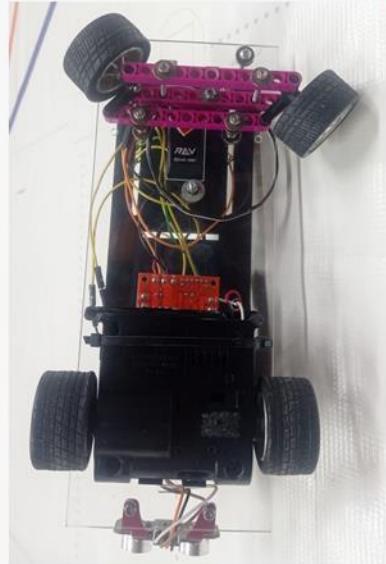
## 2. DESIGN PROCESS

The designing process of each of the phases of the project is presented below, describing in detail each of the mechanical, electronic and programming systems.

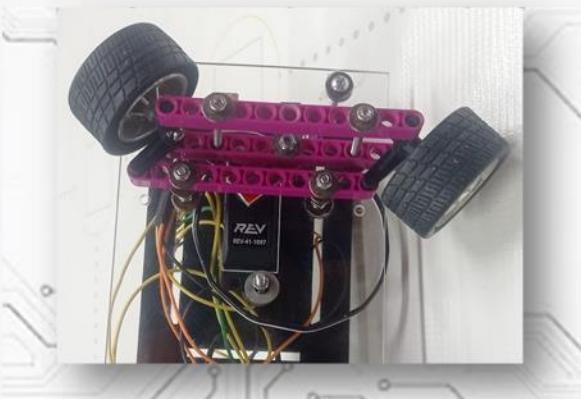
### 2.1. Mechanical System



The mechanical system was taken from a remote control Ford Mustang model car, from which the driving elements were extracted by coupling to the motors presented in the electronic system.



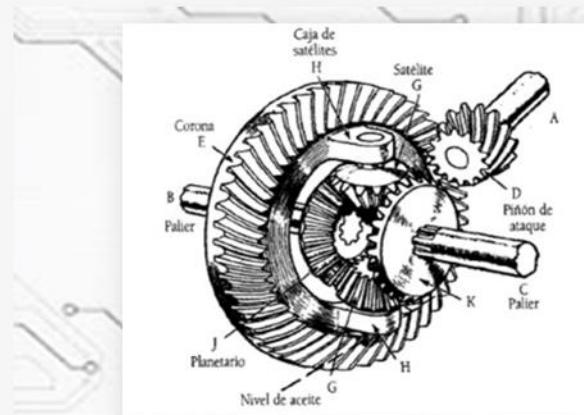
#### 2.1.1. Direction



The robot's steering subsystem is located in the rear part of it, in order to provide a greater turning radius, it was created with Lego pieces from a robotics kit called Lego Spike Prime Kit, joining these pieces with the wheels of a car remote control (RC) Ford Mustang model, to which a Rev Robotics brand servomotor was adapted. It was later programmed through an Arduino mega 2560, connecting the servomotor to the GND, 5V and 4 pins of the Arduino as can be seen in the following image.

## 2.1.2. Driving

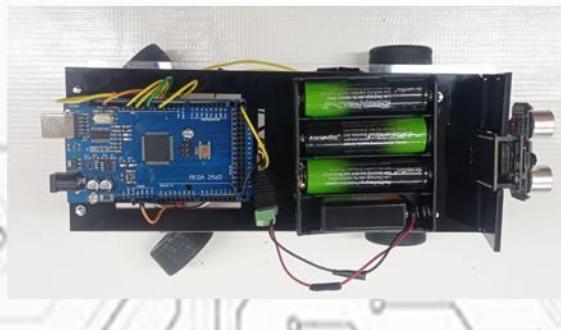
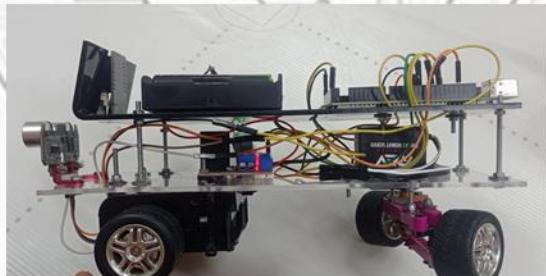
The robot's driving subsystem was taken from a Ford Mustang remote control car. This system was used because it had a motor and a gearbox, and provided the necessary torque and speed for the robot.



. This works with a set of gears, which allows the robot to rotate at different speeds without losing grip. This mechanism was located in the front of the robot. The system is powered through a double H-bridge model L298n by means of a pack of three 3.7 V batteries.

## 2.1.3. Chassis design

The base of the chassis was built with acrylic, which was cut and drilled based on the needs of the wiring and the assembly of the parts used as can be seen in the image on the right.

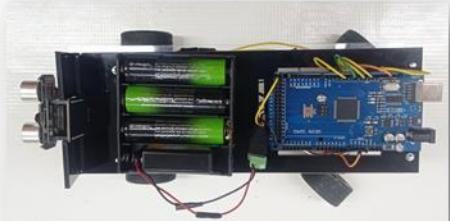


The robot has two decks, both built with acrylic, as shown in the image to the left. On the “first deck” of the robot, the traction and steering systems, the ultrasound sensor, the TCS 34725 RGB color sensor, two switches (one for power on and the other for start) and the double H-bridge model L298n were assembled. ; while on the “second” there is the battery pack, the 9V battery, the ESP 32-cam camera, the Arduino Mega 2560, and the connector for the batteries.

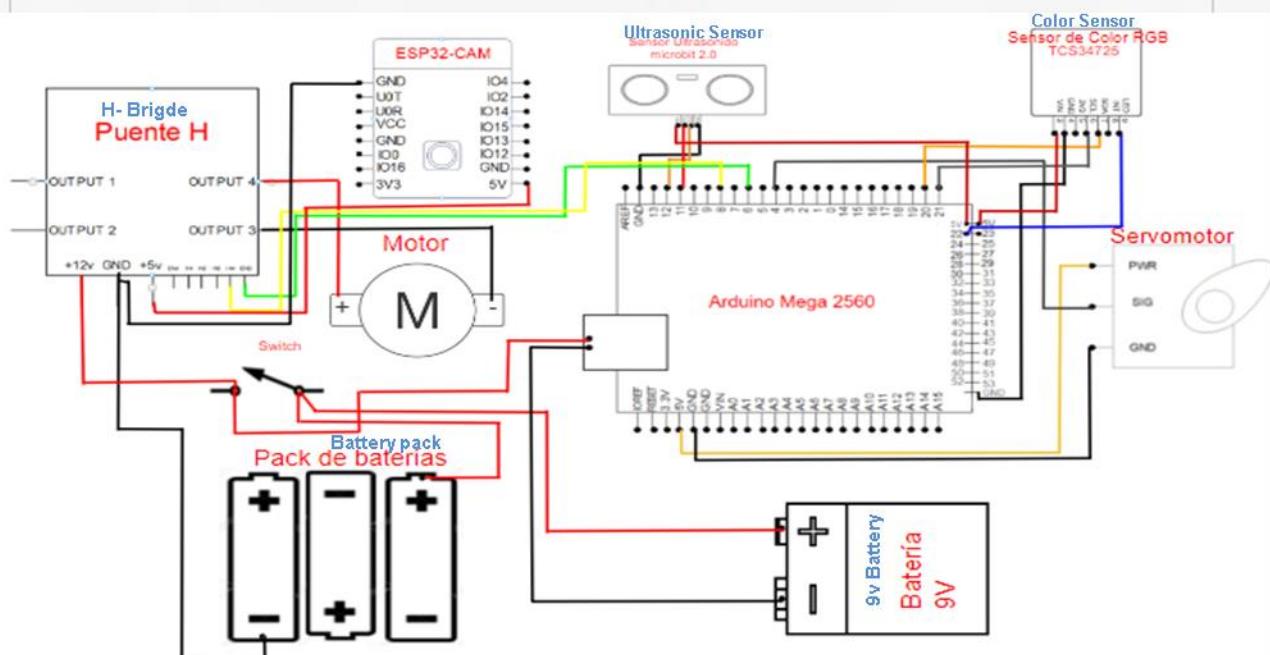
## 2.2. Electronic

The robot's electronic system is based on an Arduino Mega 2560 microcontroller with which, according to the original design, three sensors and two actuators are controlled as follows:

- A color sensor model: RGB TCS-34725.
- A DC motor type: RS390 electric motor, 12V.
- One ultrasonic proximity sensor model: microbit 2.0
- A servo motor model: REV Robotics Smart Robot Servo (SRS).
- A webcam model: ESP32-cam.



Below is the connection diagram of the components that were used in this design.



Each of the sensors are specified in Appendix C - Specification of Sensors and Appendix D - Specification of Actuators.

## 2.2.1. Sensors

### Microbit 2.0

The robot originally has an ultrasound sensor.



This is used to measure the distance between the robot and the walls of the playing court. This sensor is located on the front of the robot, and is used to measure the distance between the robot and the wall, in order to determine when it should cross.

The microbit 2.0 sensor detects distances from 2 cm to 500 cm with excellent precision. This sensor has four pins:

- VCC (direct current voltage): is the power input, it receives 5V.
- TRIG (trigger): pin that sends the ultrasound pulse.
- ECHO (echo): pin that calculates the time it takes for the pulse to return to the ultrasound, in order to determine the distance.
- GND (ground): pin that functions as a ground connector.

The operation of the sensor is as follows: the piezoelectric emitter emits eight ultrasound pulses (40KHz) after receiving the order on the TRIG pin. Sound waves travel in the air and bounce when they encounter an object, the bouncing sound is detected by the piezoelectric receiver, then the ECHO pin changes to High (5V) for a time equal to the time the wave took from when it was emitted to when it was detected. The time of the echo pulse is measured by the microcontroller and thus the distance to the object can be calculated.

## RGB TCS34725

The robot has a color sensor.



This is used to identify the colors of the orange and blue lines that are at the corners of the track, in order to determine which direction the robot should cross.

The TCS34725 RGB sensor has the following pins:

- **VIN** (input voltage): it is one of the power supplies of the module that receives 5V.
- **3V3**: Power supply of the module that receives 3.3V.
- **GND** (ground): device ground pin.
- **SCL**: used as an I2C clock signal.
- **SDA**: used for I2C data exchange.
- **INT**: Set I2C address.
- **LED** (Light-emitting diode): pin that works to turn on the LED of the Active Low module.

TCS34725 is an I2C bus-based color light-to-digital converter with an IR filter that provides digital return of red, green, blue (RGB), and clear light detection values.

## ESP32-cam

This camera is used to identify the color of traffic lights (red or green), in order to avoid them correctly.

This camera has the following pins:

5V	GPIO 14
3V	GPIO 3
GND	GPIO 2
GPIO 16	GPIO 1
GPIO 12	GPIO 4
GPIO 0	GND
GPIO 13	
GND	
GPIO15	
3.3V/5V	

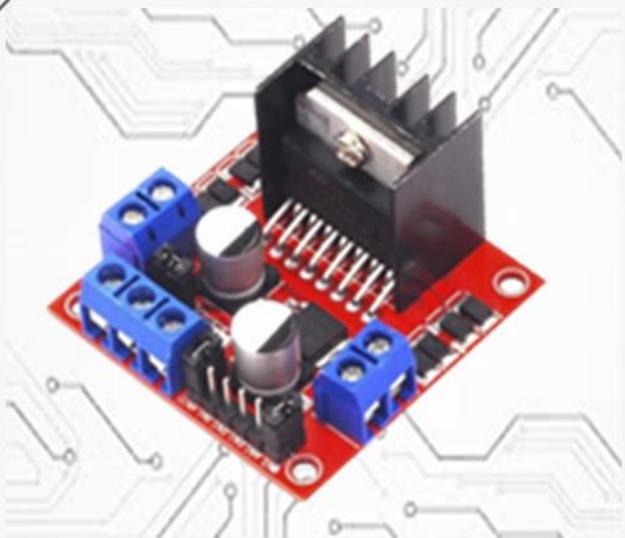


The camera has three ground pins and two pins for power: either 3.3V or 5V. GPIO 1 and GPIO 3 are the serial pins that this camera has. You need these pins to load code onto your board. Additionally, GPIO 0 also plays an important role as it determines whether the ESP32 is in intermittent mode or not.

The following pins are connected internally to the microSD card reader:

- GPIO 14: CLK
- GPIO 15: CMD
- GPIO 2: Data 0
- GPIO 4: Data 1 (also connected to the integrated LED)
- GPIO 12: Data 2
- GPIO 13: Data 3

## 2.2.2. Speed/Direction Control.



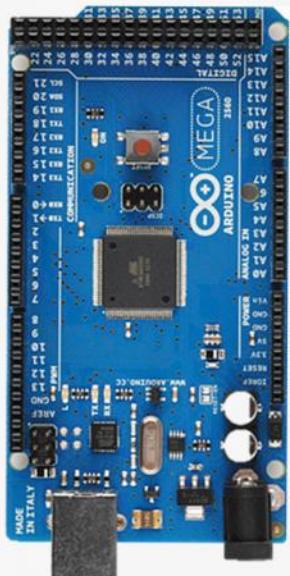
**The speed** is controlled through a double H-bridge model **L298N**, which, thanks to an analog signal sent by the Arduino Mega 2560, is capable of controlling the voltage that is emitted to the motors, thus varying and controlling the speed necessary to that the robot meets the challenge.

**The direction** is controlled with a **smart servo** robot created by the **company Rev Robotics**, which, through an analog signal sent by the **arduino mega 2560**, controls its turning radius to achieve an optimal change of direction.



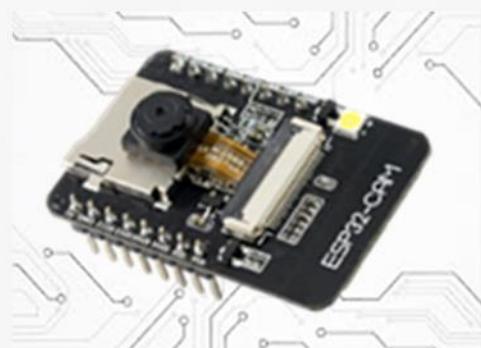
## 2.3. PROGRAMMING.

The robot has two programmable devices:



**2.3.1. The Arduino Mega 2560** which is used for general control of the robot devices.

**2.3.2. The ESP32 Cam** camera whose function is fundamentally to detect the colors of traffic lights.



In both cases, the Arduino IDE software (<https://www.arduino.cc/en/software>) was used as a development environment taking advantage of the USB connections available on both devices.

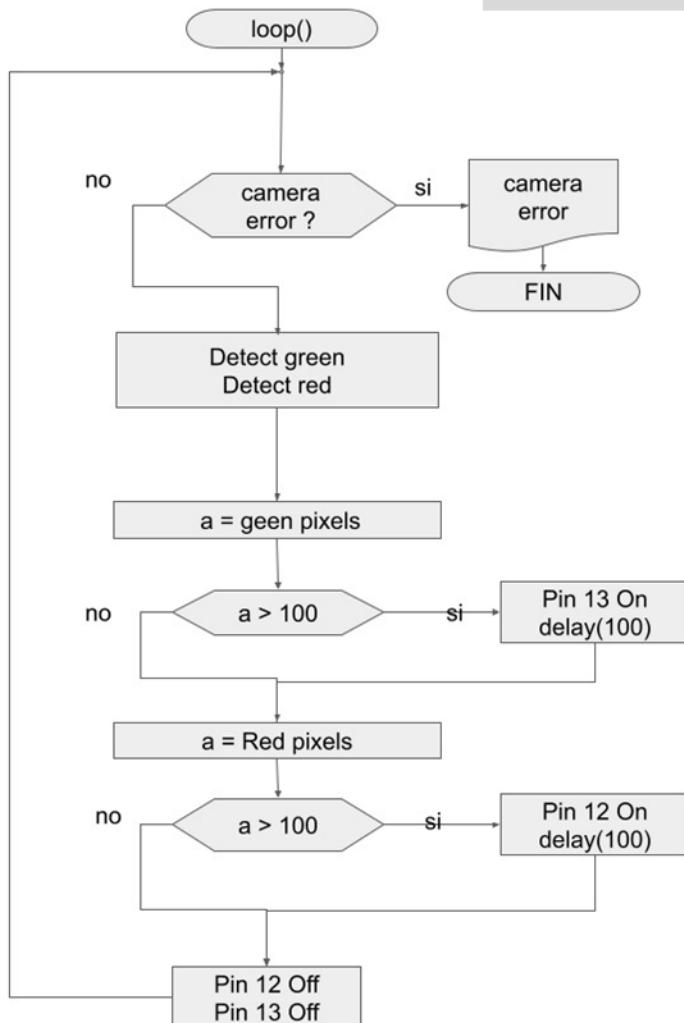
Regarding the algorithms shown in the flowchart, only the one used in the loop() section of the Arduino Mega is being presented since in the setup() section, only configurations and declarations were made.

It is understood that the algorithm presented in the flowchart is repeated indefinitely as part of the Arduino programming structure, which is why it is not expressly represented in the diagram.

## 2.3.1. Flow diagram.

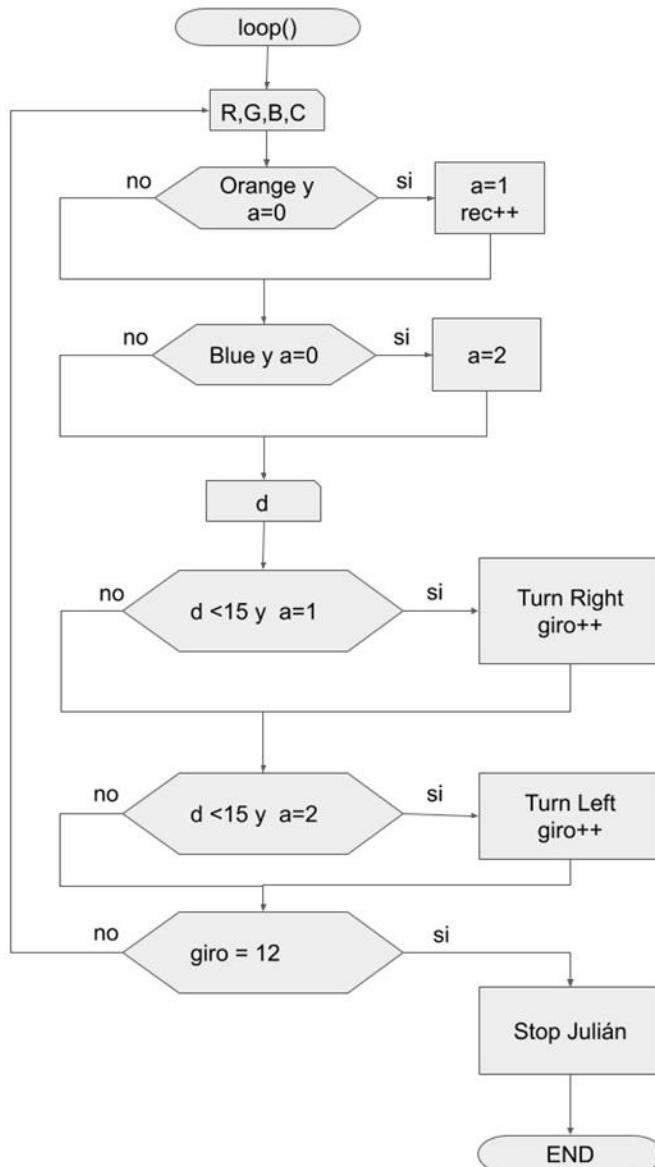
The following graph shows the flow chart of the first and second challenge, in which the vehicle in challenge number one must complete three (3) laps on the track with locations and in challenge number two the vehicle must complete three (3) laps on the track with randomly placed green and red traffic signs random from the inside walls of the track.

CAMARA CODE



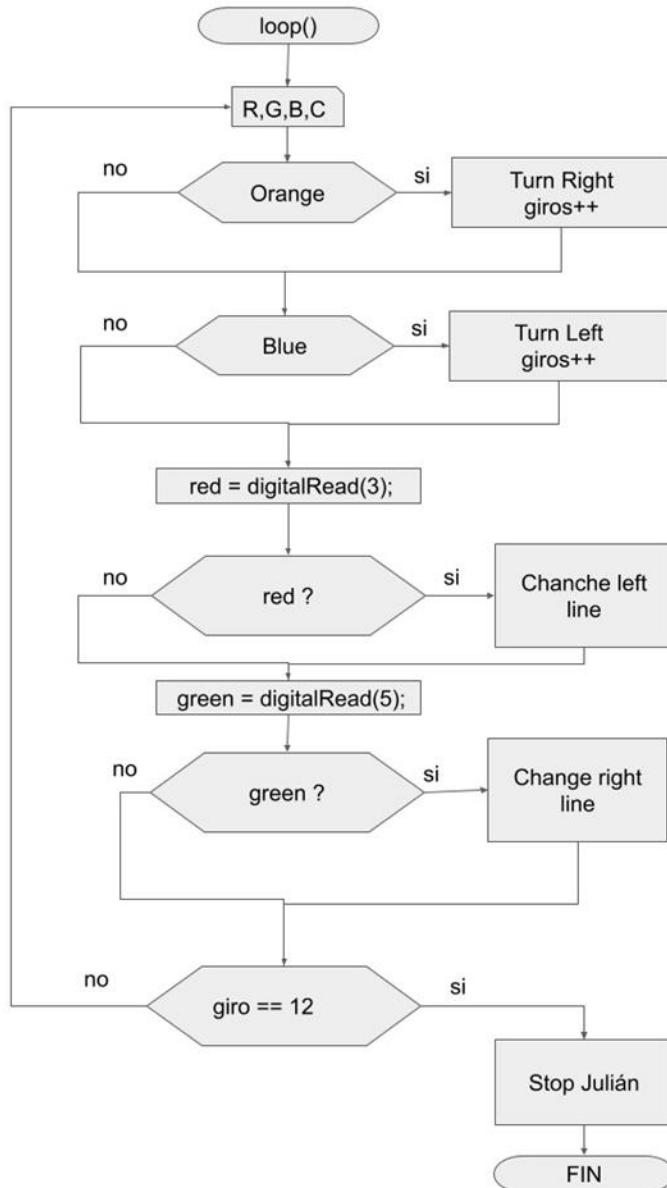
## 2.3.1. Flow diagram.

### FIRST CHALLENGE



## 2.3.1. Flow diagram.

**SECOND CHALLENGE**



### 3. Strategy

The strategy is one of the fundamental parts of the entire challenge, therefore, in the creation process it was the task for the entire team to find and define the best methods based on the components.

**As a first strategy**, the work team decided that it would be best to focus on challenge number one. In this it was considered that:

-The biggest challenge would be to define the direction. To do this, the work team used the orange and blue lines found on the court to determine whether to make a clockwise or counterclockwise turn.

-Under this, as the team already knew that after the first turn, the others would be in the same direction, it was decided that after the detection of the color sensor, the robot would rotate with the ultrasound sensor.

**As a second strategy** for challenge number two, the ESP32-cam camera and the ultrasound sensor are used to define:

-The color of the traffic lights and how you should avoid them, to avoid crashing and deviating from the road.

- The position in which the robot is located, to reposition itself if necessary.

## 4. CODE DISCUSSION

The programming language used to prepare the code is C++ developed for the autonomous operation of the robot and subsequent discussion. The developed codes can be seen in Appendix E.

The code is essentially divided into six parts, which would be the following:

### **The libraries.**

The libraries used were “Servo.h” in charge of facilitating the task of mobilizing the servo and in general the direction and “Adafruit\_TCS34725.h” in charge of facilitating color detection by the “RGB TCS-34725” sensor.

### **Pin declaration.**

The function of each of the Arduino Mega 2560 pins is defined, so that most are found in “OUTPUT” (output) and some in “INPUT” (input) depending on needs.

### **Color Sensor Initialization**

The color sensor is turned on and then checked using the serial monitor, confirming if there is any type of problem when starting up.

### **Color detection**

Once the “Setup” process has been completed, the RGB values defined by the color sensor begin to be saved in variables called “R”, “G”, and “B” that can be used using an “IF” command to make certain steering movements.

### **Distance detection**

When defining distances, to do it more efficiently we established it in the ping() function; so that in this way it is much easier to carry out actions based on that.

### **Movements to perform**

Whenever the color orange or blue is detected in the color sensor, the robot will move clockwise or counterclockwise respectively, at an angle of 90 degrees, where this movement is efficient for carrying out the three turns, which are all completely important when programming the robot. Being programmed in the Arduino IDE, everything is in the C++ language.

## 5. Diary entries

### 5.1. Chronology. Challenges and solutions.

#### 1st week of July



On the first day of preparation for the regional competition the team began to study and analyze the rules of the competition.

The following days the team began to study what could be the first model of the chassis and investigated various ways to solve what would be the first problems that arose, which were how the steering system would be designed and what engine would be used to achieve the speed and torque needed.



Later the team began to look for motors that could be used, disassembling toys, printers, among other devices.



<https://www.youtube.com/watch?v=9tLaDAoxio>

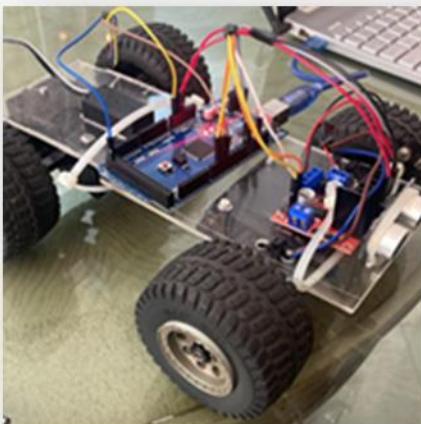
Finally, the necessary engine was obtained by disassembling a Nikko brand Dodge T-Rex Ram remote control car, which provided the necessary mechanical parts to design the steering system.

## 2nd week of July

Once the problem of the traction system was resolved, the problem of the steering system was addressed, and after investigating different solutions, a way was found to fit a servomotor to the mechanical parts previously obtained.



Consecutively, the work team resumed the search for different solutions to **detect the colors** of traffic lights, deciding to use an ESP32-cam camera with an OV2640 lens, the next problem being how to program this with Arduino.



The team finished the first prototype of what would be the chassis, and were able to continue with the programming area.

## 3rd week of July

For programming, an Arduino Mega 2560 was used as a programmer, a double H-bridge as a power and speed regulator and an ultrasound sensor to measure distance.



Consecutively, the work team resumed the search for different solutions to detect the colors of traffic lights, deciding to use an ESP32-cam camera with an OV2640 lens, the next problem being how to program this with Arduino.



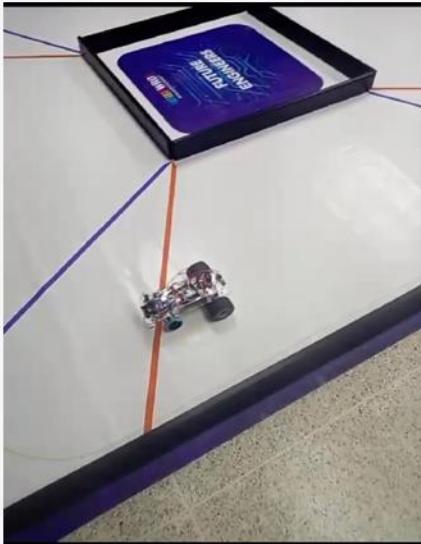
It was investigated what power source was going to be used to power the robot, because after using 9V batteries, the team realized that these were not ideal for the robot because they wear out in a very short time. Consequently, two battery packs ended up being joined, which had eight 1.2 V rechargeable batteries in series, which finally added up to a total of 9.6 V.

Due to the space needed, a second prototype was designed in which it was decided to add a second floor to the robot, locating the electronics area in it, and the batteries, the traction system and the steering system on the first floor.



## 4th week of July

Without yet being able to solve the programming, it was **decided to use a 34725 RGB sensor** so that the robot could detect which direction it should cross.



A strategy is proposed, it is decided to cross with the color detection of the lines of the track, also using two more ultrasounds, one on each side of the robot, so that, once it detects a wall, it crosses to avoid a crash. However, these two ultrasounds were not a help, but rather a problem, since, when they detected, the robot lost its trajectory, which is why it was finally decided not to use these two ultrasound sensors.

Before the regional competition, the work team found **rechargeable batteries** with a higher voltage (3.7 V), so it was decided to eliminate one of the two battery packs, and modify the remaining one so that it works with three batteries.



## 1st week of August



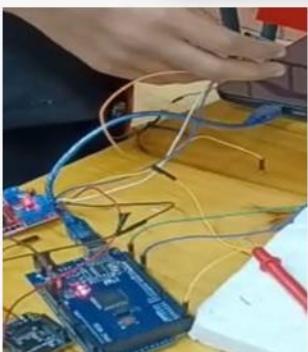
After participating in the First Regional Competition, the research for solutions to the problems presented began. It was decided to change the steering system, creating a new one with parts obtained from a Spike Prime robotics kit number 45678, since with this new steering system it would be possible to have a greater turning radius, as well as a more precise turn.

## 2nd week of August

New strategies were proposed, it was decided that the ideal way to cross would be with the help of ultrasound and that the TCS34725 sensor would only detect the first line to determine if the robot should cross clockwise or counterclockwise.

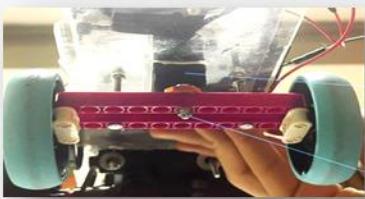


## 3rd week of August



Following with the second part of the challenge, the team began to program the camera looking for how to transfer the information from the camera to the Arduino without having to use Wi-Fi. After searching several sources, the solution was found by transmitting the information through serial ports.

## 4th week of August

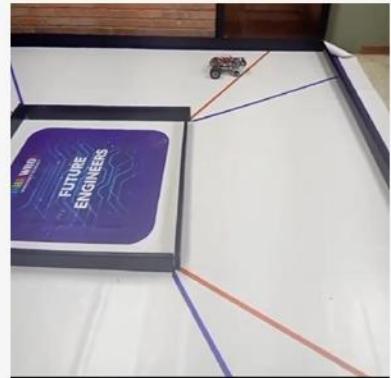


Then the engine used for all this time began to fail very frequently, preventing the team from progressing in the second challenge, so with just a few days left before the competition, the work team removed the engine and therefore the gearbox from another remote control car to attach it to the robot.

To provide a greater turning radius, the steering system was modified, using pieces from a Lego Spike Prime Kit.

## 1st week of September

Practices were carried out on the track, for the performance of the robot in challenge number one and two.



## 2nd week of September



Preparation and updating of the report

## 3rd week of September

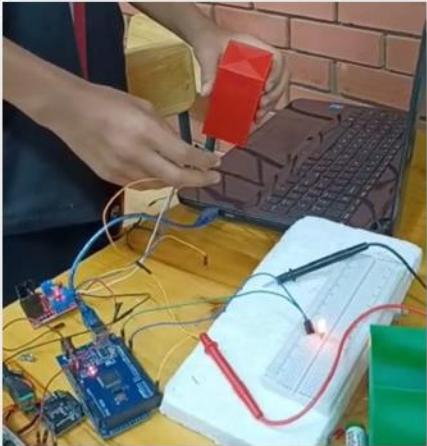


National  
Competition



National  
Competition

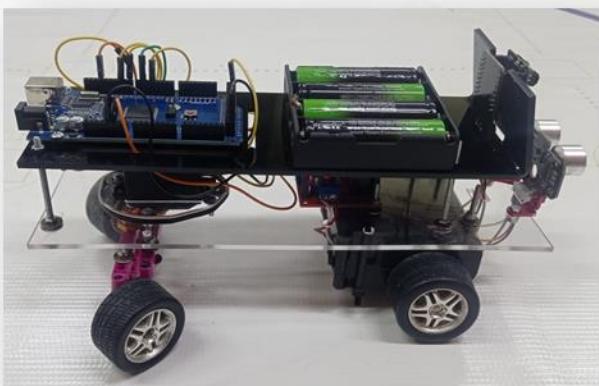
## 4th week of September



The camera programming for challenge #2 continued.

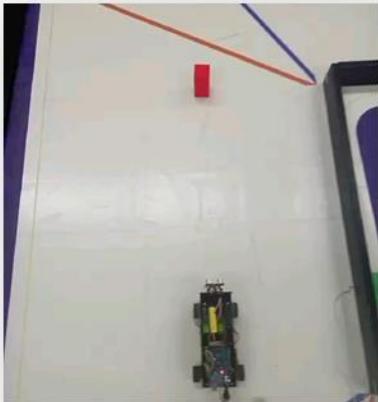
Replacement of steering system wheels to increase safety and aesthetics.

## 1st week of October



Construction of the third prototype of the robot, which is based on the restoration of the acrylics, organization of the cables through connectors to improve the aesthetics.

## 2nd week of October



Programming the camera and practicing with it.



Looking for camera options with better image clarity and width of vision. Testing is done with Raspberry Pi card and wide-angle webcam.



## 6. IMPROVEMENT OPPORTUNITIES

The functions of the robot presented are sufficient to overcome all the challenges posed by the category. However, the following opportunities for improvement were identified, and will be carried out on future competitions.

**Add two ultrasonic sensors** for distance detection: The aim is to avoid lateral collisions, therefore a sensor should be placed on each side of the robot.

**Add connectors:** Adding a greater number of connectors makes it easier to change parts and improve the organization of dupont cables.

**Build a bodywork:** It is an important element which will provide better aesthetics of the robot.

**Looking for camera options** with better image clarity and width of vision.

## CONCLUSION

The work team managed to develop an autonomous robot "Julian" capable of carrying out the two challenges required for the Future Engineers category. To achieve this, a robot equipped with different electronic and mechanical components was used, in turn meeting the specifications established in the competition premises.

During the process, they will face several challenges, such as detecting and avoiding obstacles, completing the three laps and detecting the lines on the track.

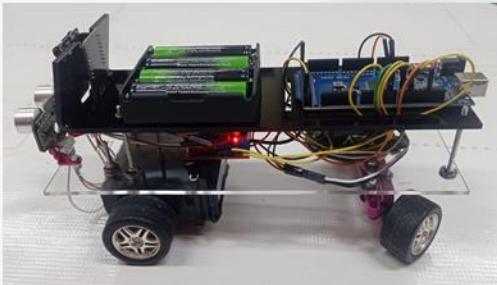
The results obtained demonstrate the effectiveness of this approach in controlled environments and the robot's ability to adapt to changing situations.



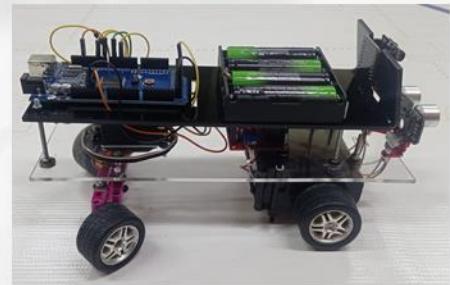
During these months of hard work, the team has managed to meet its objectives in terms of the competition, as well as each of the participants deepened their knowledge in the various areas in which the WRO was deepened, such as programming, electronics, the mechanics, among others.

# APPENDICES

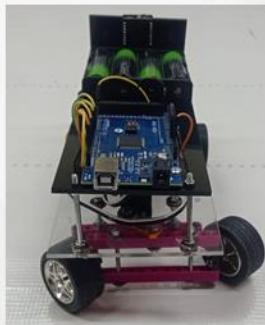
## Appendix A Views of the robot car (photos)



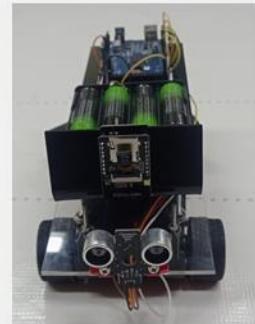
LEFT SIDE VIEW



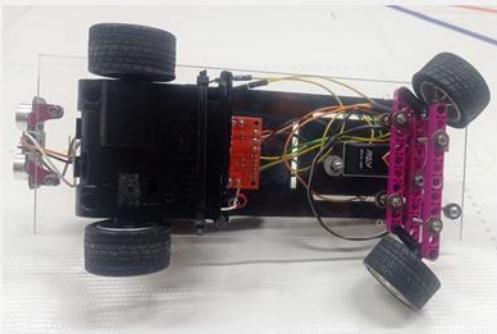
RIGHT SIDE VIEW



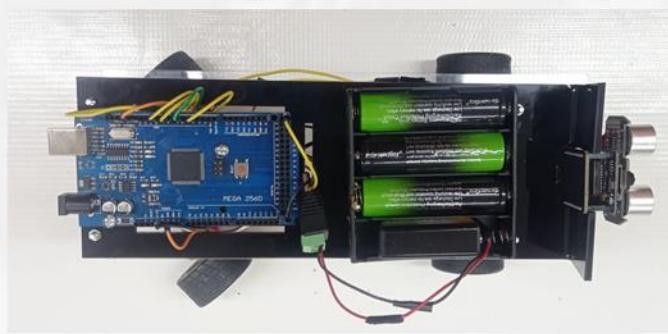
BACK VIEW



FRONTAL VIEW



INFERIOR VIEW



SUPERIOR VIEW

## Appendix B Performance Videos

### Challenge 1



<https://youtu.be/8zjeBPan2Oo?si=eekGrBMWVPs4Mw3y>



### Challenge test 2

[https://youtu.be/8zjeBPan2Oo?si=UVurdqN9m1lv\\_jjU](https://youtu.be/8zjeBPan2Oo?si=UVurdqN9m1lv_jjU)

## Appendix C Sensor specification

### HC Ultrasonic Ranging Module - SR04

Source:

<http://www.datasheet.es/PDF/779948/HC-SR04-pdf.html>



#### Product characteristics:

The microbit 2.0 ultrasonic ranging module provides non-contact measurement function from 2cm to 500cm, the ranging accuracy can reach 3mm. The modules include ultrasonic transmitters, receiver and control circuit.

#### The basic working principle:

- (1) Using the IO trigger for at least 10us of high level signal.
- (2) The module automatically sends eight 40 kHz and detects whether there is a return pulse signal.
- (3) IF the signal returns, via high level, the high output IO duration time is the time from ultrasonic send to return.

$$\text{Test distance} = (\text{high level time} \times \text{sound speed (340M/S)}) / 2.$$

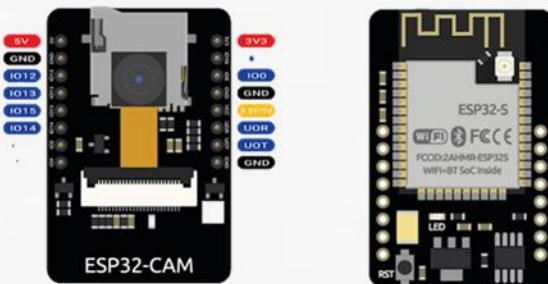
Working voltage	DC 5V
Working current	15mA
Work frequency	40Hz
Maximum range	4m
Minimum range	2cm
Angle measurement	15 degree
Trigger input signal	10 uSTTL pulse
Echo output signal	TTL toggle signal and range in proportion
Dimension	4*20*15mm

## Appendix C Sensor specification

### ESP32-cam camera

Source:

[https://media.digikey.com/pdf/Data%20Sheets/DFRobot%20PDFs/DFR0602\\_Web.pdf](https://media.digikey.com/pdf/Data%20Sheets/DFRobot%20PDFs/DFR0602_Web.pdf)



#### CHARACTERISTICS

- Clock speed up to 160 MHz, summary computing power up to 600 DMIPS
- Built-in 520KB SRAM, external 4MPSRAM
- Support UART/SPI/I2C/PWM/ADC/DAC-Support OV2640 and OV7670 cameras, built-in flash lamp.
- Support WiFi image upload-Support TF card
- Supports multiple sleep modes.
- Integrated Lwip and FreeRTOS
- Support STA/AP/STA+AP operation mode-Support Smart Config/AirKiss technology
- Support for remote and local serial port (FOTA) firmware updates



## SPECIFICATIONS

- SPI Flash: default 32Mbit
- RAM: built-in 520KB+4MPSRAM external
- Dimension: 27\*40.5\*4.5 ( $\pm 0.2$ )mm/1.06\*1.59\*0.18"
- Bluetooth: Bluetooth 4.2 BR/EDR and BLE standards
- WiFi: 802.11 b/g/n/e/i
- Support interface: UART, SPI, I2C, PWM
- TF card support: maximum support 4G
- I/O port: 9
- Serial port baud rate: Default 115200 bps
- Image output format: JPEG (only compatible with OV2640), BMP, GRayscale
- Spectrum range: 2412 ~ 2484 MHz
- Antenna: Integrated PCB antenna, 2dBi gain
- Transmission power: 802.11b: 17±2 dBm (@11Mbps);  
802.11g: 14±2 dBm (@54Mbps);  
802.11n: 13±2 dBm (@MCS7)
- Reception sensitivity: CCK, 1Mbps: -90dBm;  
CCK, 11Mbps: -85dBm;  
6Mbps (1/2 BPSK): -88dBm;  
54Mbps (3/4 64-QAM): -70dBm; }  
MCS7 (65Mbps, 72.2Mbps): -67dBm
- Power consumption:  
Turn off flash: 180mA@5V  
    Turn on the flash and set the brightness to maximum: 310mA@5V  
Deep sleep: lowest power consumption can reach 6mA @ 5V  
Modern-sleep: up to 20mA@5V  
    Light sleep: up to 6.7 mA at 5 V
- Security: WPA/WPA2/WPA2-Enterprise/WPS
- Power supply range: 5V
- Operating temperature: -20°C ~ 85°C
- Storage environment: -40°C ~ 90°C, < 90% RH
- Weight: 10g

## Rs390 electric motor

### Source:

<https://es.aliexpress.com/i/32891103572.html?gatewayAdapt=Msite2Pc>



### Characteristics

- Model: Rs390
- Nominal voltage: 6V
- Power: 25-35W
- No-load speed: 14000/ min
- Size: approx. 70\*28mm
- Axis: 2mm

## Smart Robot Servo

Source: <https://www.revrobotics.com/rev-41-1097/>

### Characteristics

- Size: 40.2mm x 20.0mm x 38.0mm
- Weight: 2.05 ounces.
- Speed: 0.14 s/60° (at 6 V): Stalling torque: 13.5 kg-cm / 187.8 oz-in (at 6 V)
- Standby current: 2A (at 6V)
- Nominal voltage: 4.8V - 7.4V, 6V nominal
- Input pulse range: 500 µs - 2500 µs
- Default angular range: 270°
- Maximum programmable range in angular mode - 280°
- Gear Material: Metal
- Knurled type - 25T
- Spline Internal Thread Size: M3
- Spline internal thread depth: 6mm



## Appendix E

```

// APAGAR LED ALUMINIO AL INICIAR LA APP
#include <Servo.h>
#include "Adafruit_TCS34725.h"
Adafruit_TCS34725 tcs =
Adafruit_TCS34725(TCS34725_INTEGRATIONTIME_50MS, TCS34725_GAIN_1X);

Servo pro;
int d = 16; // Distancia ultrasonido izquierdo
int a = 0;
int giro = 0; // Valor del servo para avanzar derecho
int da=16; // Distancia ultrasonido derecho
int t; // ultrasonido tiempo de rebote izquierdo
int ta; // ultrasonido tiempo de rebote derecho
int vel= 83;
int giroval=20;
int pingval=20;

void setup()
{
  pinMode(0, OUTPUT);
  pinMode(1, OUTPUT);
  pinMode(2, OUTPUT);
  pinMode(3, OUTPUT);
  pinMode(4, OUTPUT);
  pinMode(5, OUTPUT);
  pinMode(6, OUTPUT);
  pinMode(8, OUTPUT);
  pinMode(9, OUTPUT);
  pinMode(10, OUTPUT); // Trigger
  pinMode(11, INPUT); //cho
  pinMode(12, OUTPUT); //Trigger
  pinMode(13, INPUT); //Echo
  pinMode(22, OUTPUT);
  pro.attach(11); // Pin de control del servo
  digitalWrite(22,HIGH);
  Serial.begin(9600);
  if(tcs.begin(0)){
    Serial.println("Inicializando");
    delay(2000);
  }
  else{
    Serial.println("Error");
    Serial.println("Debe de revisar las condiciones e iniciar nuevamente");
  }
}

void loop() {
  //CALCULAR COLOR
  uint8_t R,G,B,C;
  tcs.getRGBData(48,4G,4B,4C);
  //DIRECCIONAR Y MOVER MOTORES

  //giro antihorario (Naranja)
  if((R<120)&&(B<160)&&(a==0)){
    a=2;
  }

  //detectar giro horario(Azul)
  if((B<120)&&(B<160)&&(a==1)){
    a=1;
  }

  ping();
  //Hacer giro horario (azul)
  if((G<10)&&(a==1)){
    pro.write(70);
    analogWrite(6,g1);
    delay(700);
    pro.write(rec);
    analogWrite(6,vel);
  }
  d=100;
  delay(2500);
  giro++;
}

//detectar 3 vueltas y detenerse
if (giro == 12){
  digitalWrite(8, 0);
  a=40;
}

// Control del sensor de ultrasonido y cálculo de distancia
int ping() {
  digitalWrite(10, HIGH); //Enviamos un pulso de 10us
  delayMicroseconds(10);
  digitalWrite(10, LOW);

  t = pulseIn(11, HIGH); //obtenemos el ancho del pulso
  d = t/59;
}

// Hacer giro horario (azul)
if((G<10)&&(a==2)){
  pro.write(140);
  analogWrite(6,g1);
  delay(700);
  pro.write(rec);
}

```

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<https://www.youtube.com/watch?v=9tLaDAoxxio>

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ESP32-CAM Video Streaming and Face Recognition with Arduino IDE:

<https://randomnerdtutorials.com/esp32-cam-video-streaming-face-recognition-arduino-i/>

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<https://cdn-shop.adafruit.com/datasheets/TCS34725.pdf>

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