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RC / Automated Grass Cutter

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Capstone 2

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Abstract

Currently, mowing the lawn can be tiring and time consuming, there are also people who has disabilities and can’t do it. Therefore we are going to create an automated and remote control machine that can cut the grass for those people that cannot or do not want to mow their lawn. Our solution, is the creation of a fully electrical grass cutter which will be controlled by a mobile application or autonomously. The mobile application will communicate with the microcontroller via Bluetooth to control the lawn mower. The autonomous part will execute the task without the need of human intervention, it will cover the area following a pattern or randomly this will be done with a microcontroller. The power supply of this machine will be supplied by three 12 V batteries, which two will be connected in series "24 V" to power the motor of the cutter and the other battery of 12 V to feed the two motors which will move the machine and the microcontroller. It will have a charging station equipped with a weather sensor to determine if precipitation occurs to reschedule the cutting process. To conclude, the purpose of this project is to make people's lives more comfortable and simple at the time of mowing the grass, without almost any effort.

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I. Introduction

Initially, today for many people it is difficult to cut the grasses either because they have a disability or unwilling to do so because it is very hard work. In this work we are going to create a machine which solves this problem. The goal of this project is to be able to create a machine that we can control in a remote way, that is to say that the person when he goes to cut the grams does it of a simple form and without any effort. Also this machine will be operated by DC batteries, which reduces the gas emissions of the majority of conventional machines and does not affect our health directly. This will also have safety sensors to protect the person's well-being in case they pick up or use the machine in an inappropriate way.

A. Problem statement

Mowing the lawn is an exhausting job, the people with disabilities are not able to do it, and pay for doing it is expensive, and reduce emissions and gasoline spills.

B. Mentors

The mentors of this project are:

- Prof. Alcides Alvear
- Dr. Miguel Goenaga
- Prof. Diego A. Aponte

C. Requirement

i. Functional

- A microcontroller to send signals to the H-Bridge to control the direction of the grass cutter.
- Communication with phone application.
- A mobile application to control de grass cutter.
- Cut the grass remotely via Bluetooth through a mobile application or autonomous mode

ii. Non – Functional

- Development the application in IOS
- Switch the grass cutter to autonomous mode
- Charging Station
- Power line communication

D. Diagrams

i. Requirement Diagram

In the Figure 1 we can see a diagram of requirement which shows the different cases of how the grass cutter should act according to the action that we give through the mobile application, either to move to the front, back, left, right, stop, or to turn the cutter on or off.

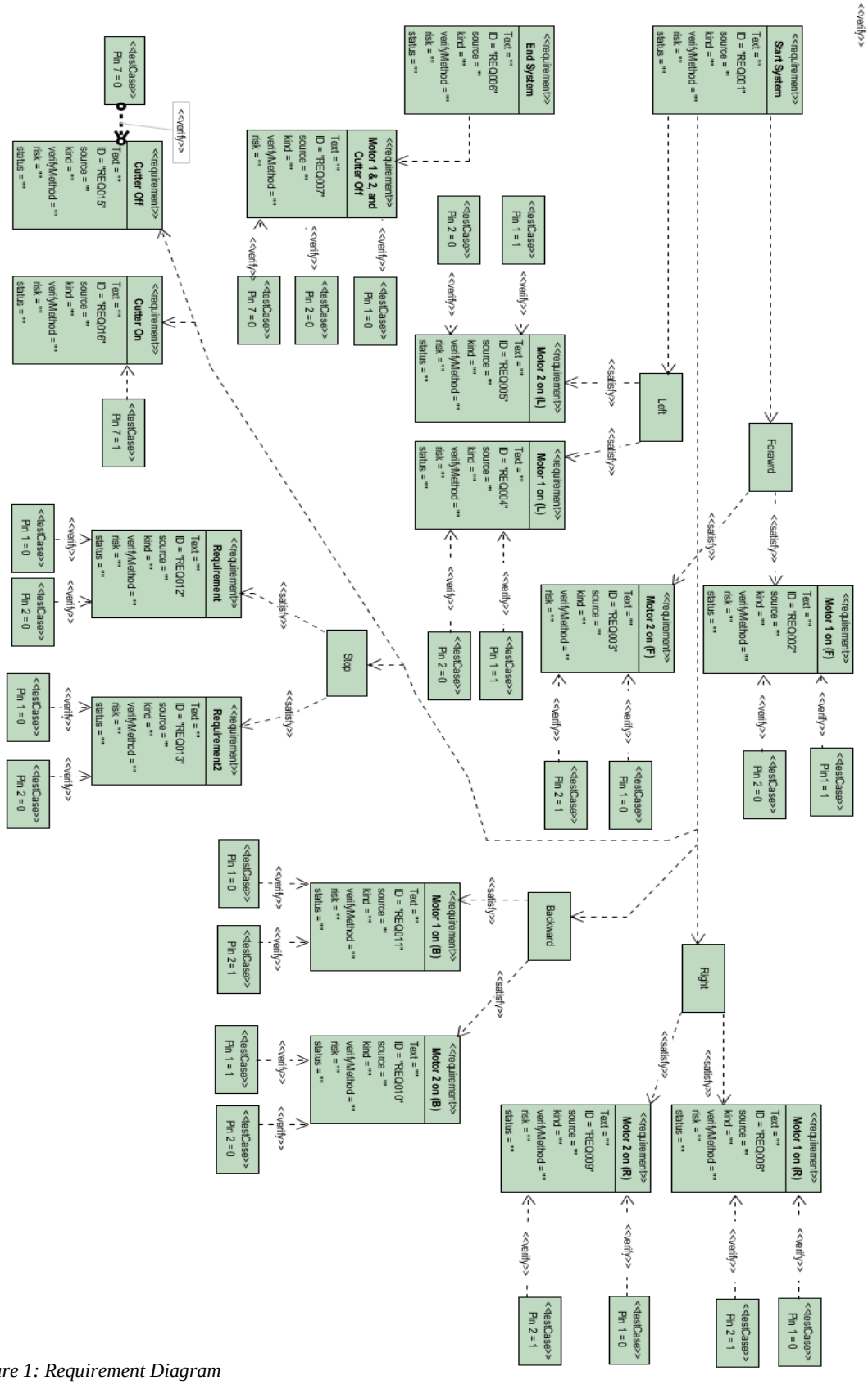


Figure 1: Requirement Diagram

ii. **Use Case Diagram**

The figure 2 show how the operator interacts with the lawn mower. The operator interacts with the mobile application when the system starts, it has different options which it uses to control the lawn mower. If the lawn mower has an obstacle to the front or if it is lifted the safety sensors are activated and the lawn mower stops moving and cutting. Finally the system ends when the operator stops interacting with the lawn mower.

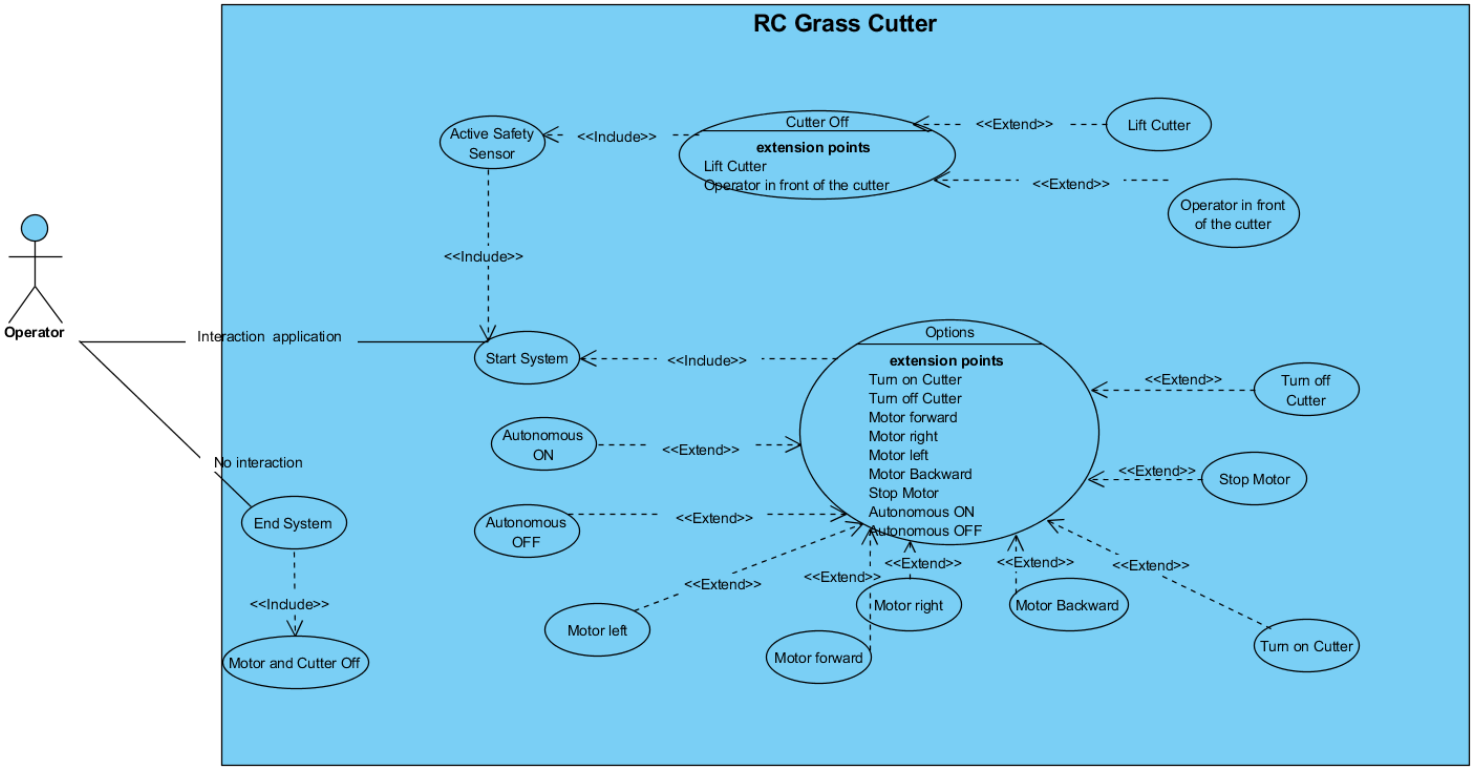


Figure 2: Use Case Diagram of the RC/Automated Grass Cutter.

E. System description

Our system have the ability to mow the lawn by controlling a mobile application via Bluetooth, this with almost no effort. In figure 3 we can see an image of what the interaction of the lawn mower would look like in any average yard.

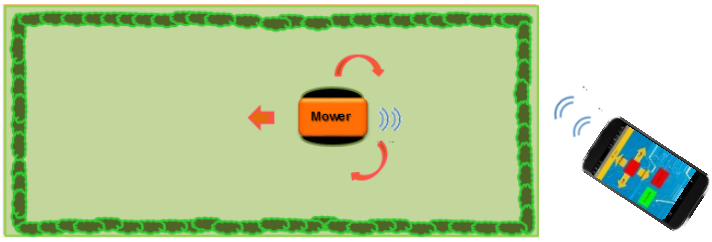


Figure 3: System functionality Grass Cutter

F. Methodology

The methodology used to develop part of this project it was the agile methodology Scrum. This allows in any time to realign the software with the objectives of the business or Project, since it can introduce functional or priority changes at the beginning of each new iteration without any problem. Also this methodology is flexibility to change the project and reduce the time to the market.

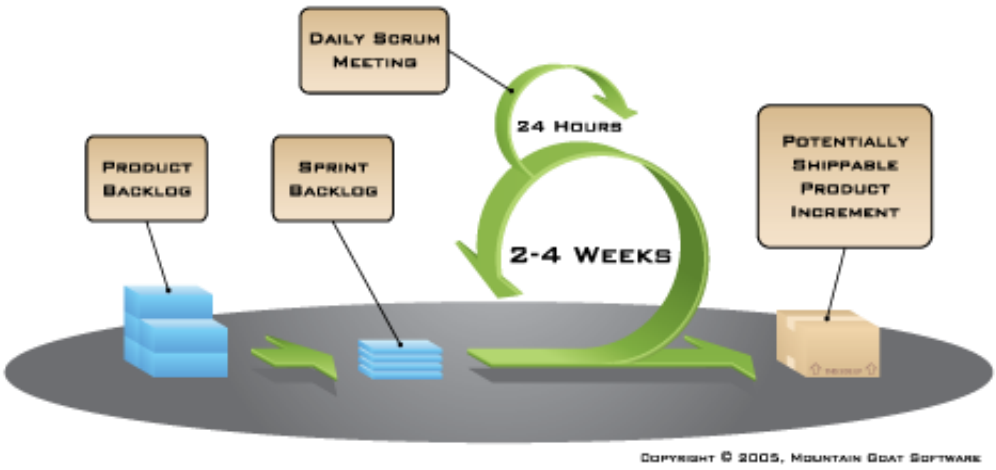


Figure 4: Agile System Development Lifecycle

II. System Description

A. System Architecture (Block Diagram)

The lawn mower system consists of a mobile application, Bluetooth module, Arduino (microcontroller), circuit, motors and a relay that activates or deactivates the motor of the mower. This works as follows; The user performs an action with the mobile application either turning the cutter on or off, moving the machine to the front, back, left, right or stop, this sends a variable to the Bluetooth module which communicates with the Arduino "microcontroller" then according to the action that carried out the user in the application we can move our machine through the motors through the circuit "H-bridge" or activate the motor of the cutter.

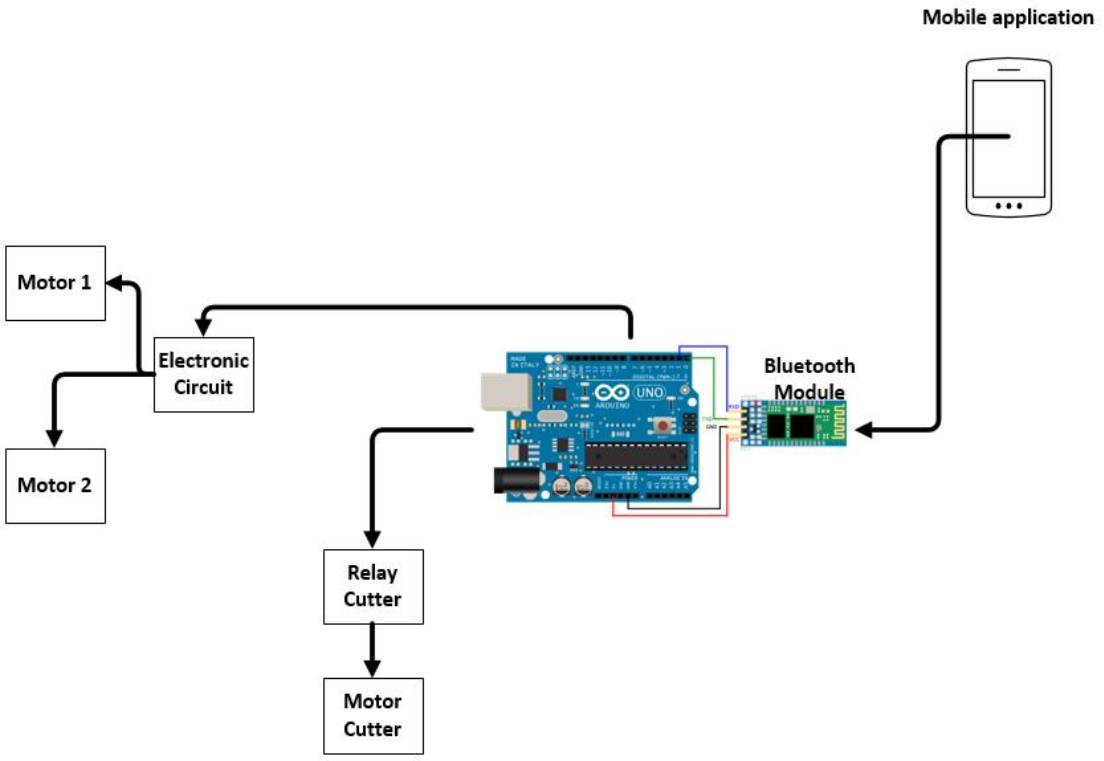


Figure 5: Functionality Grass Cutter, Block Diagram

B. Data flow

i. System design

In figure 6 we can see how the communication system works, when the mobile application is communicated with the Bluetooth module that is connected to the Arduino. First the mobile application "the remote control" is connected to the Arduino. Then the Arduino receives through the Bluetooth module the action that the user executed through the application "where the machine is going to move or activate the cutter", if the lawn mower has an obstacle in front or is lifted the security sensors detect it immediately and cancel the action that the user executes, but proceeds to the action that the user executed.

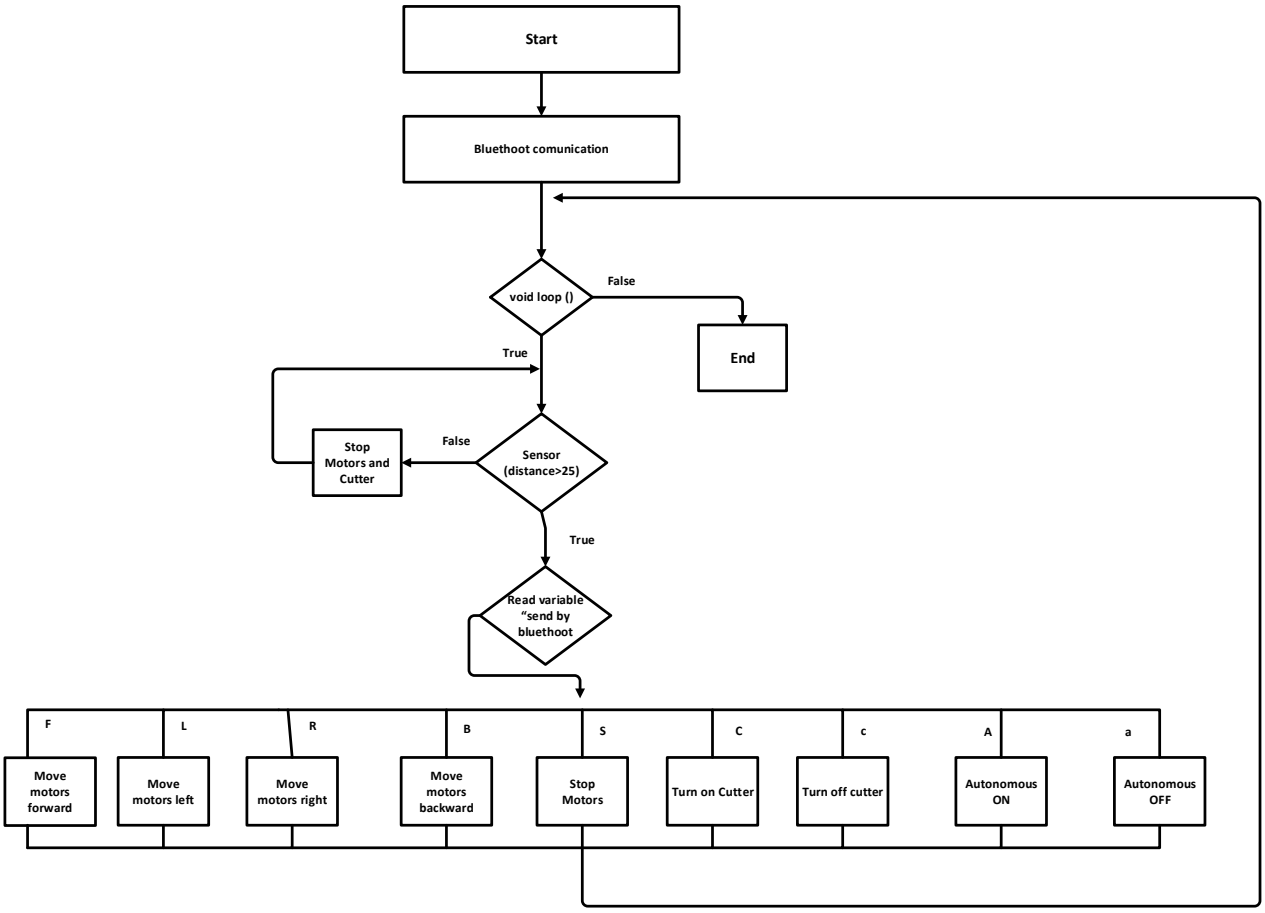


Figure 6: Flow chart of the system functionality.

ii. Cyclomatic complexity

The cyclomatic complexity is a software metric, used to indicate the complexity of a program. This is computed using the control flow graph of the program: the nodes of the graph correspond to indivisible groups of command might be executed immediately after the first command. In the figure 7 we can see the cyclomatic complexity of our flow graph (figure 6).

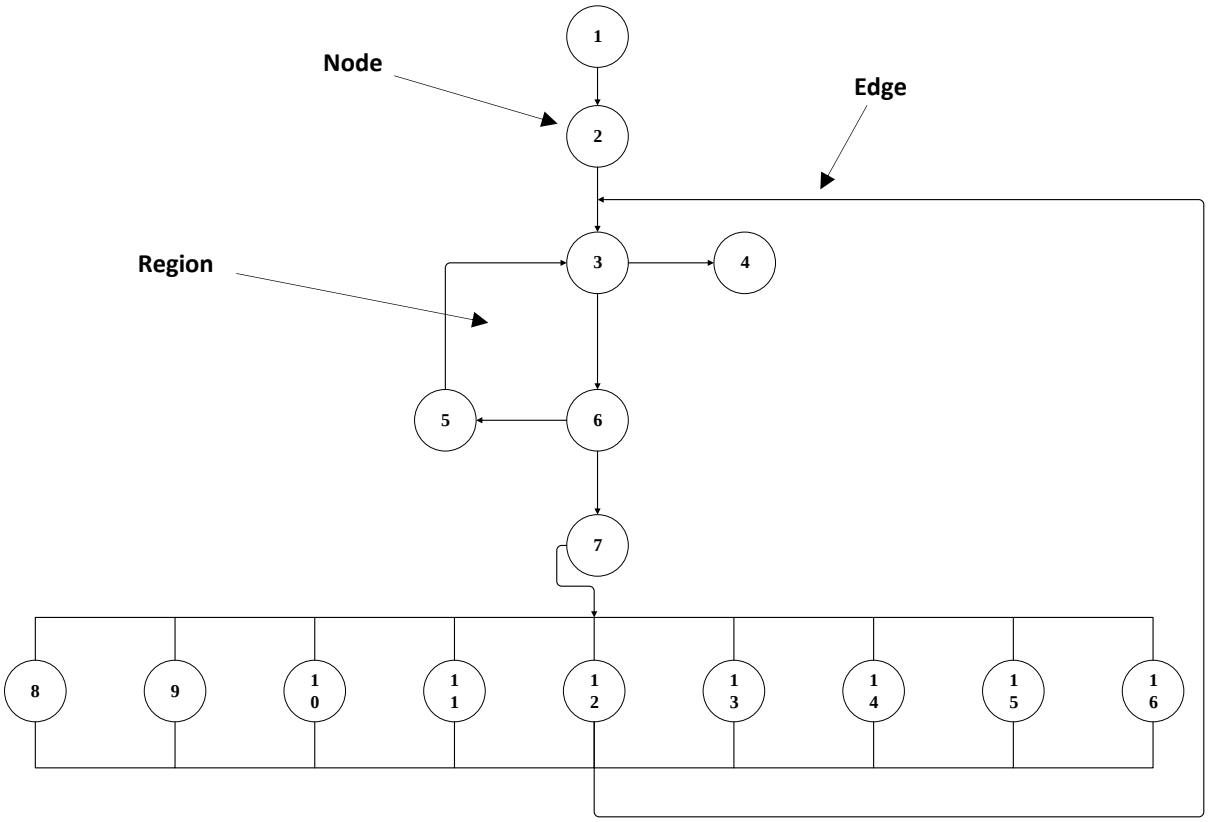


Figure 7: Cyclomatic complexity diagram

V (G) = numbers of regions = 4

V (G) = Edges – node + 2 = 16 -14 + 2 = 4

V (G) = Predicted nodes + 1 = 3 + 1 = 4

- Path 1: 1-2-3-4
- Path 2: 1-2-3-6-5
- Path 3: 1-2-3-6-7-8-3-4
- Path 4: 1-2-3-6-7-9-3-4
- Path 5: 1-2-3-6-7-10-3-4
- Path 6: 1-2-3-6-7-11-3-4
- Path 7: 1-2-3-6-7-12-3-4
- Path 8: 1-2-3-6-7-13-3-4

- Path 9: 1-2-3-6-7-14-3-4
- Path 10: 1-2-3-6-7-15-3-4
- Path 11: 1-2-3-6-7-16-3-4

C. Components Architecture

Resistors

The resistor are used to generate the base current of the transistors.

Power Supply

The power in our system is supplied by two 12V 5A/h batteries and one 12V 7A/h used to power the Arduino and supply to the motors. 5A/h batteries are in series configuration to get 24V to power the motor that drives the cutting mechanism.

Motors

There are two 12V, 3Amp motor for propulsion and one 24V, 1.5Amp for cutting the grass.

Diodes

The diodes are used to protect the system. They eliminate the possibility of current entering currents through the emitters of the power transistors that are not in use.

Transistors 2N2222A, Tip3055T y Tip42C

We used these transistors to make an H-bridge configuration, to change the direction of the propulsion motors.

Microcontroller

An Arduino Uno is a board with a microcontroller Atmega 328, voltage regulators and a USB port connected to a USB-Serial adapter module that allows to program the microcontroller. This microcontroller is used to control the direction of the motor through its input and output port to move the grass cutter.

Switch

We used a double pole double throw switch to turn on or off the 12V and 24V power sources.

Relay (SRD-05VDC-SL-C)

This relay was used to power the 24V that drivers the cutting mechanism.

Bluetooth HC-06

This Bluetooth allows communication between the application and the microcontroller.

HC-Sr04 Ultrasonic (random)

This was used for the autonomous mode when the grass cutter moves randomly.

Optical Flow V1.0 & ITG/MPU (patron)

The Optical Flow is a camera which works like a mouse (x and y axis), we use it to read the distance that the cutter must travel. ITG / MPU this is an accelerometer and gyroscope of 6 degrees. This was used to turn the cutter to 180 degrees, after it stopped with the optical sensor thus creating a possible patron.

D. Estimated material cost

In the table 1 you can see an estimate of the costs of the materials.

Table 1 Estimated Material Cost RC Grass Cutter

Estimated Material Cost		
Materials	Amount	Sub-Total
Arduino Uno	1	$ 5.00
Diode	8	$ 4.00
Transistor (2N2222a)	4	$ 4.00
Relay (SRD-05VDC-SL-C)	1	$ 3.00
Resistor	12	$ 1.20
Transistor (Tip 31C)	4	$ 6.00
Transistor (Tip 32C)	4	$ 6.00
Batteries 12V	3	$ 75.00
Motor 12V	2	$ 50.00
Motor 24V	1	$ 20.00
Bread Board	1	$ 2.50
Switch	1	$ 2.00
Bluetooth HC-06	1	$ 2.75
Total		$ 181.45

E. Implementation

i. Circuit of the grass cutter

In Figure 8 we can see a complete diagram of the H-bridges and the Arduino connections. The function of the H-bridges is to give the motors direction for the front or back. The Arduino sends a pulse of 5V or 0V, which activates or deactivates the movement of the motor, which in our case we use to move the lawn mower.

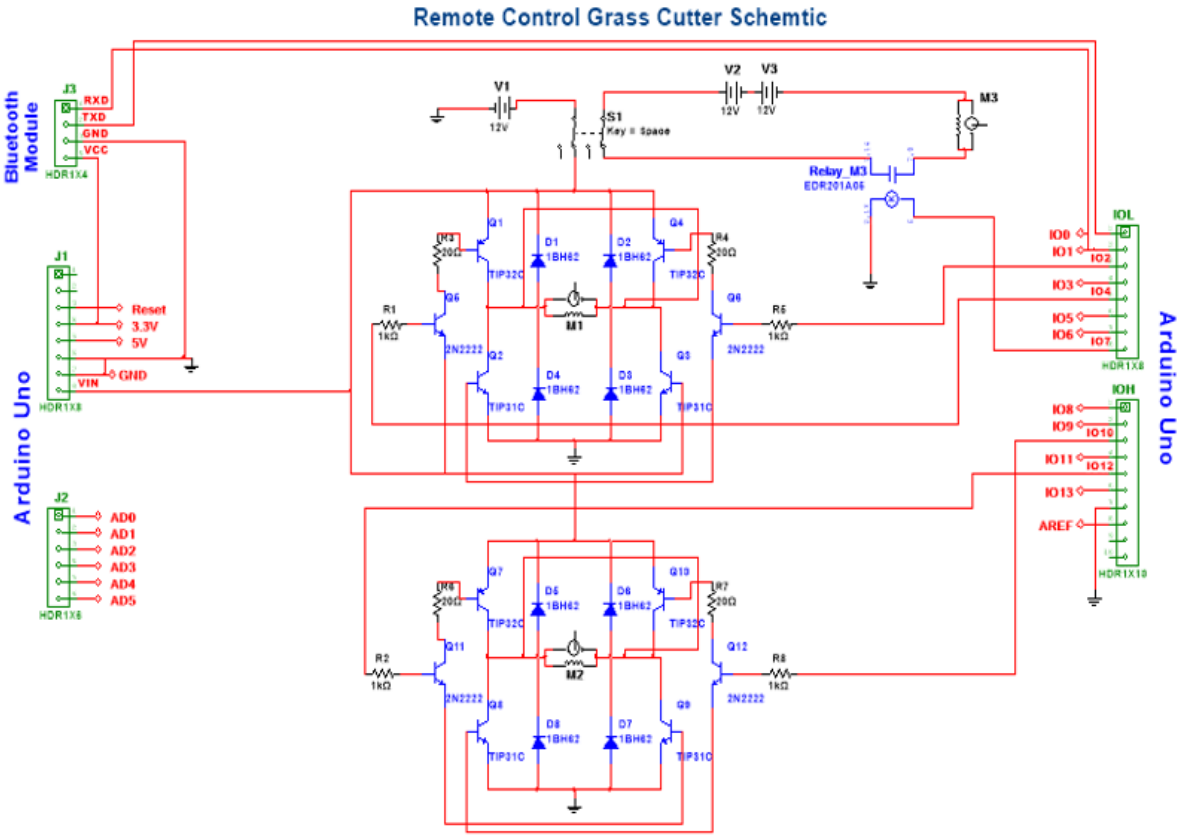


Figure 8: Schematic of the grass cutter "H-bridge"

ii. Development application

In Figure 9 we can see the page on which we are developing the application which is, MIT App Inventor. Basically this page is an open-source Web Development, in which we can develop applications in a simple way.

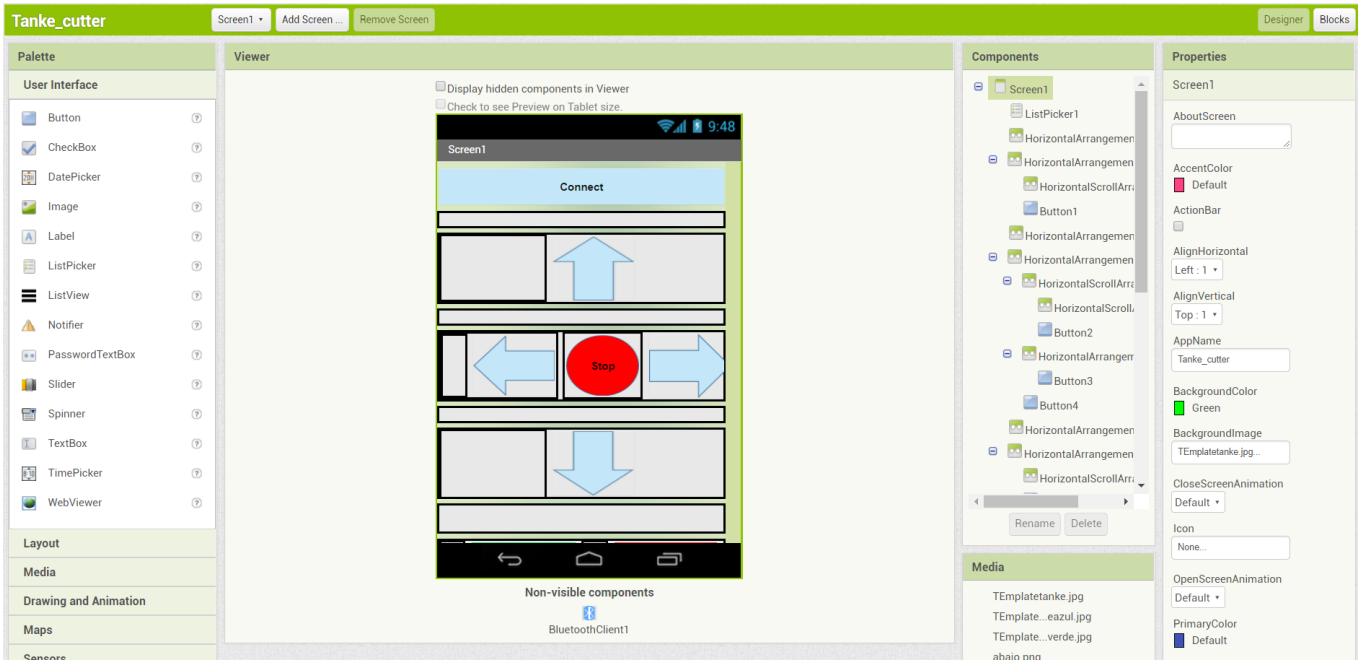


Figure 9: Development application, MIT App Inventor

iii. Autonomous mode

In this mode the cutter must move independently, either with a pattern or randomly. In figure 10 we can see how would be the pattern of the cutter in this mode. *Note: this is a concept in this way, since there are many variables such as: the terrain and the texture of the grass, this proved its functionality and worked at 75%.*

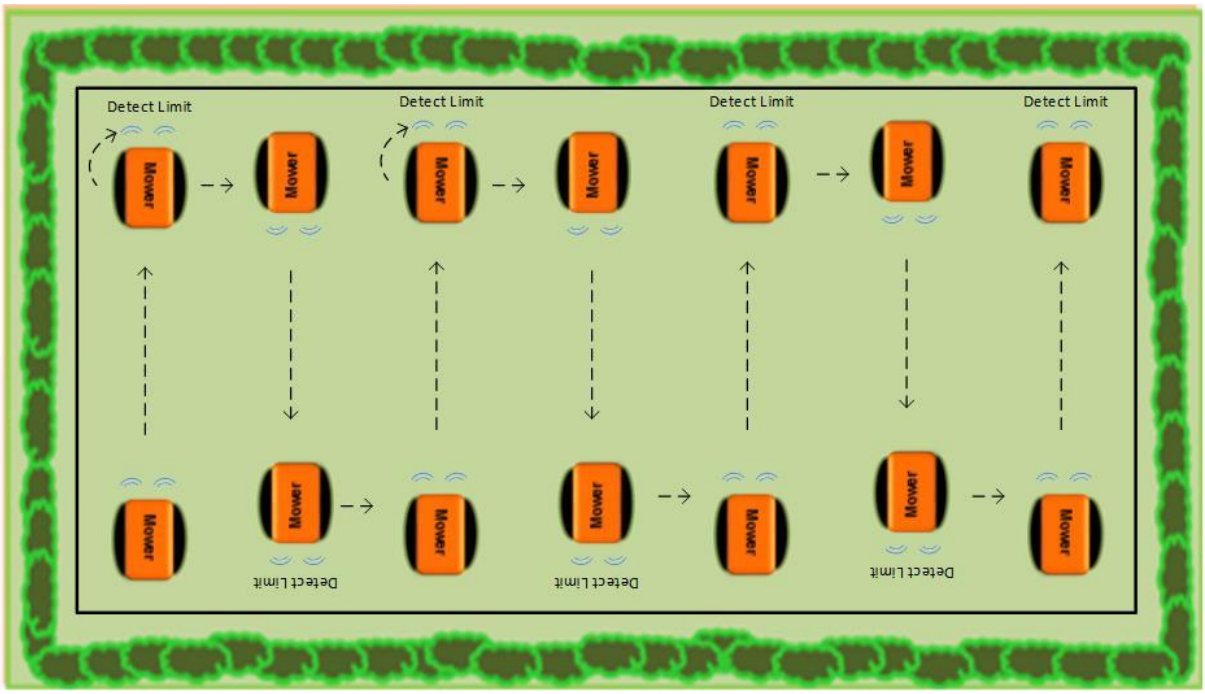


Figure 10: Autonomous mode concept

III. Testing

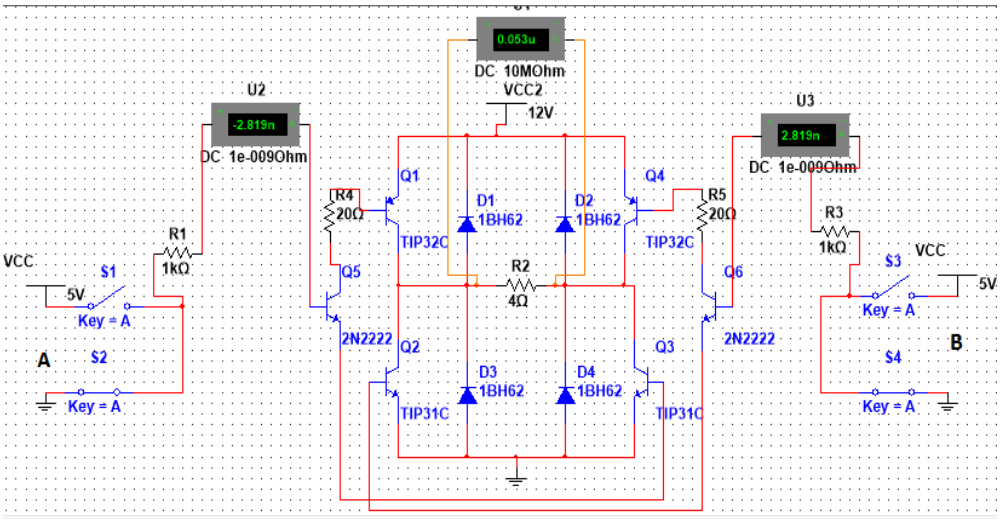


Figure 11: H-Bridge, inputs A and B are both 0V.

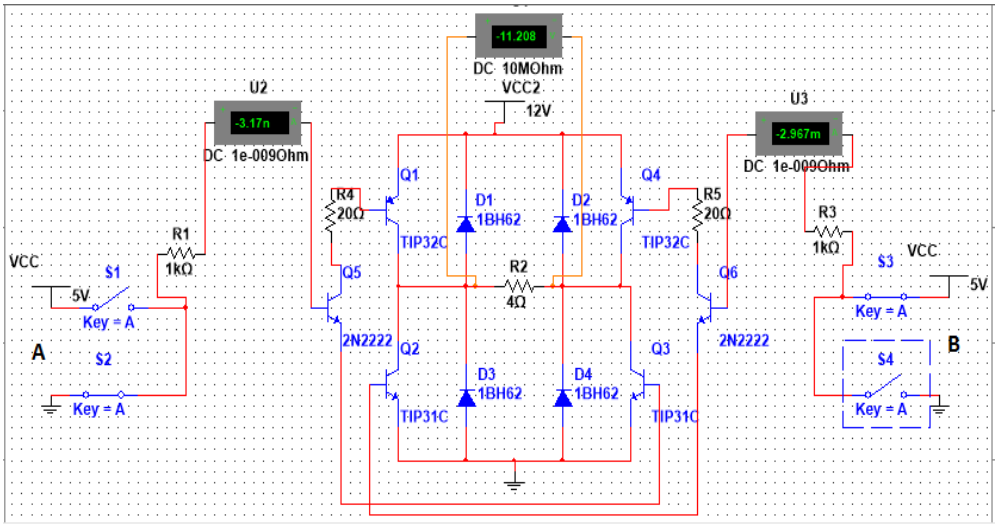


Figure 12: H-Bridge, inputs A is 5V and B is 0V.

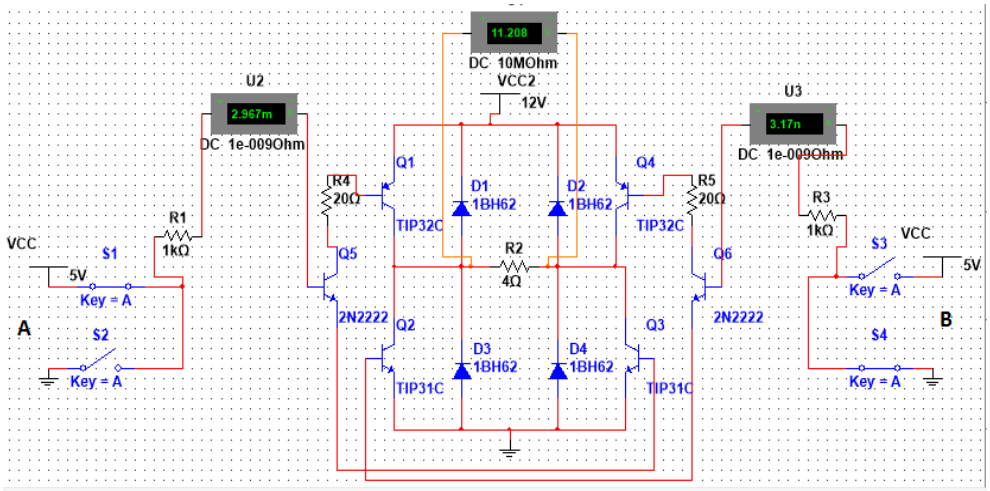


Figure 13: H-Bridge, inputs A is 0V and B is 5V.

Figure 11 shows that when inputs are 0 the motor will receive 0V and it will not move. If inputs are 5V and 0V the motor will receive 11.08V (see figure 12) and will move forward while if inputs are 0V and 5V motor will receive -11.08V (see figure 13) and will move backwards. If both inputs are 5V it will short circuit the bridge and this state should not happen. All possible combinations and output are listed in table 2.

Table 2: H-bridge Truth table

A	B	Output Voltage
0V	0V	0V
5V	0V	11.08V
0V	5V	-11.08V
5V	5V	FORBIDDEN

IV. Results

Android application

Basically this is the application that we use to control the lawn mower and through this we connect to our machine via Bluetooth or autonomously, through the "Connect" button.

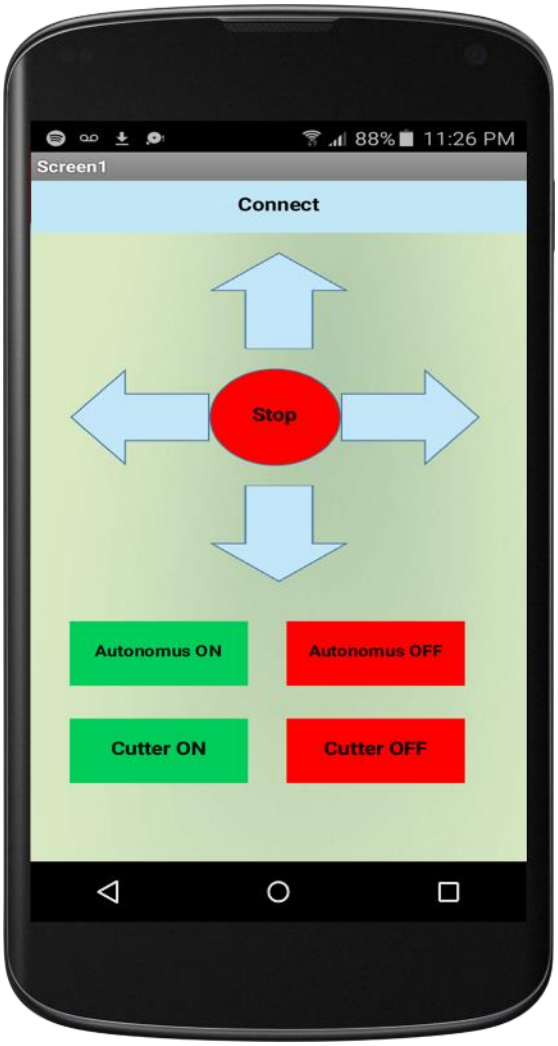


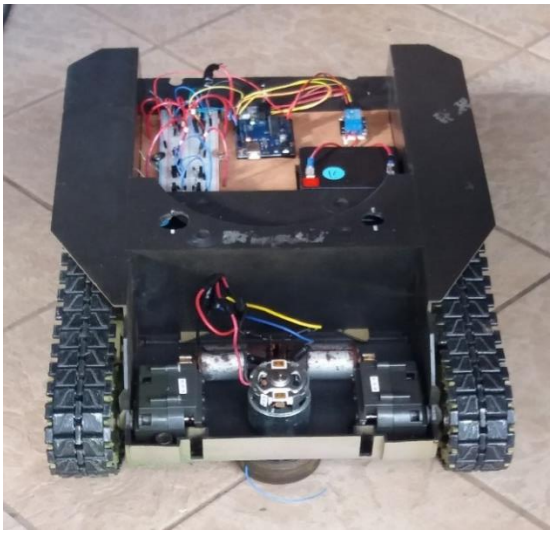
Figure 14: Android application to control de grass cutter

Grass Cutter prototype

In the figure 15 we can see what the lawn mower looks like.

Figure 15: Grass cutter

In the figure 16 and 17 we can see the connection in the lawn mower looks like.



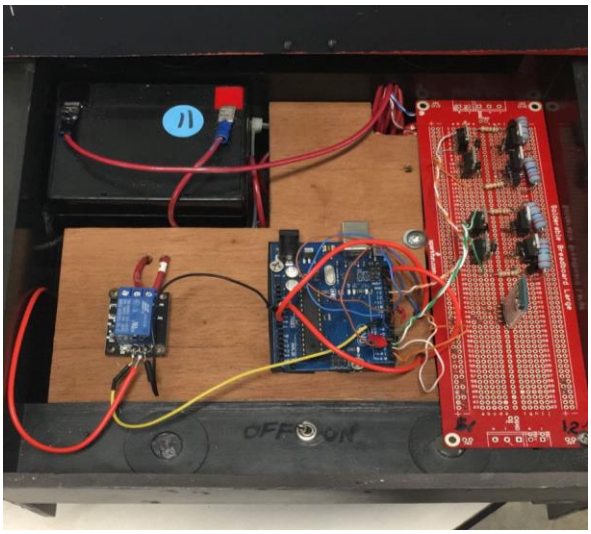


Figure 16 & 17: Connection of the lawn mower.

V. Code

The code of this machine is development in Arduino IDE.

```
//////////LIbrerias//////////////
#include <Wire.h>
#include <HMC5883L.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_HMC5883_U.h>

HMC5883L compass;


// Create instance of digital compass
Adafruit_HMC5883_Unified mag = Adafruit_HMC5883_Unified(12345);

////////// Motors ////////////////////
const int motor1Pin1 = 12;
const int motor1Pin2 = 10;

const int motor2Pin1 = 4;
const int motor2Pin2 = 6;

//************************************************VARIABLE                                DIRECTION
CONTROL**************************//
float initial_heading;
float target_heading;
float diff_heading;
bool turn_init;
bool target_reached;


//***************Left & right*****************//
#define LEFT 0
#define RIGHT 1


int acc = 0;//Acumulacion de y
double Ang = 0;//Acumulacion de angulo
int serialA='S'; //inicia detenido

double x =0;
//////// Cutter ///////////////////
const int pin7 = 7;

long distancia,duracion;


/////// Flow Sensor ////////////
#include "SPI.h"

// these pins may be different on different boards
// this is for mega
#define PIN_SS        11
#define PIN_MISO      50
```

```
#define PIN_MOSI      51
#define PIN_SCK       52

#define PIN_MOUSECAM_RESET     3
#define PIN_MOUSECAM_CS        2

#define ADNS3080_PIXELS_X               30
#define ADNS3080_PIXELS_Y               30

#define ADNS3080_PRODUCT_ID           0x00
#define ADNS3080_REVISION_ID          0x01
#define ADNS3080_MOTION               0x02
#define ADNS3080_DELTA_X              0x03
#define ADNS3080_DELTA_Y              0x04
#define ADNS3080_SQUAL                0x05
#define ADNS3080_PIXEL_SUM            0x06
#define ADNS3080_MAXIMUM_PIXEL        0x07
#define ADNS3080_CONFIGURATION_BITS   0x0a
#define ADNS3080_EXTENDED_CONFIG      0x0b
#define ADNS3080_DATA_OUT_LOWER       0x0c
#define ADNS3080_DATA_OUT_UPPER       0x0d
#define ADNS3080_SHUTTER_LOWER        0x0e
#define ADNS3080_SHUTTER_UPPER        0x0f
#define ADNS3080_FRAME_PERIOD_LOWER   0x10
#define ADNS3080_FRAME_PERIOD_UPPER   0x11
#define ADNS3080_MOTION_CLEAR         0x12
#define ADNS3080_FRAME_CAPTURE        0x13
#define ADNS3080_SROM_ENABLE          0x14
#define ADNS3080_FRAME_PERIOD_MAX_BOUND_LOWER      0x19
#define ADNS3080_FRAME_PERIOD_MAX_BOUND_UPPER      0x1a
#define ADNS3080_FRAME_PERIOD_MIN_BOUND_LOWER      0x1b
#define ADNS3080_FRAME_PERIOD_MIN_BOUND_UPPER      0x1c
#define ADNS3080_SHUTTER_MAX_BOUND_LOWER          0x1e
#define ADNS3080_SHUTTER_MAX_BOUND_UPPER          0x1e
#define ADNS3080_SROM_ID              0x1f
#define ADNS3080_OBSERVATION          0x3d
#define ADNS3080_INVERSE_PRODUCT_ID   0x3f
#define ADNS3080_PIXEL_BURST          0x40
#define ADNS3080_MOTION_BURST         0x50
#define ADNS3080_SROM_LOAD            0x60

#define ADNS3080_PRODUCT_ID_VAL       0x17

void mousecam_reset()
{
  digitalWrite(PIN_MOUSECAM_RESET,HIGH);
  delay(1); // reset pulse >10us
  digitalWrite(PIN_MOUSECAM_RESET,LOW);
  delay(35); // 35ms from reset to functional
}

int mousecam_init()
{
  pinMode(PIN_MOUSECAM_RESET,OUTPUT);
  pinMode(PIN_MOUSECAM_CS,OUTPUT);
```

```
  digitalWrite(PIN_MOUSECAM_CS,HIGH);

  mousecam_reset();

  int pid = mousecam_read_reg(ADNS3080_PRODUCT_ID);
  if(pid != ADNS3080_PRODUCT_ID_VAL)
    return -1;

  // turn on sensitive mode
  mousecam_write_reg(ADNS3080_CONFIGURATION_BITS, 0x19);

  return 0;
}

void mousecam_write_reg(int reg, int val)
{
  digitalWrite(PIN_MOUSECAM_CS, LOW);
  SPI.transfer(reg | 0x80);
  SPI.transfer(val);
  digitalWrite(PIN_MOUSECAM_CS,HIGH);
  delayMicroseconds(50);
}

int mousecam_read_reg(int reg)
{
  digitalWrite(PIN_MOUSECAM_CS, LOW);
  SPI.transfer(reg);
  delayMicroseconds(75);
  int ret = SPI.transfer(0xff);
  digitalWrite(PIN_MOUSECAM_CS,HIGH);
  delayMicroseconds(1);
  return ret;
}

struct MD
{
 byte motion;
 char dx, dy;
 byte squal;
 word shutter;
 byte max_pix;
};

void mousecam_read_motion(struct MD *p)
{
  digitalWrite(PIN_MOUSECAM_CS, LOW);
  SPI.transfer(ADNS3080_MOTION_BURST);
  delayMicroseconds(75);
  p->motion =  SPI.transfer(0xff);
  p->dx =  SPI.transfer(0xff);
  p->dy =  SPI.transfer(0xff);
  p->squal =  SPI.transfer(0xff);
  p->shutter =  SPI.transfer(0xff)<<8;
  p->shutter |=  SPI.transfer(0xff);
  p->max_pix =  SPI.transfer(0xff);
  digitalWrite(PIN_MOUSECAM_CS,HIGH);
```

```
  delayMicroseconds(5);
}

// pdata must point to an array of size ADNS3080_PIXELS_X x ADNS3080_PIXELS_Y
// you must call mousecam_reset() after this if you want to go back to normal operation
int mousecam_frame_capture(byte *pdata)
{
  mousecam_write_reg(ADNS3080_FRAME_CAPTURE,0x83);

  digitalWrite(PIN_MOUSECAM_CS, LOW);

  SPI.transfer(ADNS3080_PIXEL_BURST);
  delayMicroseconds(50);

  int pix;
  byte started = 0;
  int count;
  int timeout = 0;
  int ret = 0;
  for(count = 0; count < ADNS3080_PIXELS_X * ADNS3080_PIXELS_Y; )
  {
    pix = SPI.transfer(0xff);
    delayMicroseconds(10);
    if(started==0)
    {
      if(pix&0x40)
        started = 1;
      else
      {
        timeout++;
        if(timeout==100)
        {
          ret = -1;
          break;
        }
      }
    }
    if(started==1)
    {
      pdata[count++] = (pix & 0x3f)<<2; // scale to normal grayscale byte range
    }
  }

  digitalWrite(PIN_MOUSECAM_CS,HIGH);
  delayMicroseconds(14);

  return ret;
}
void setup() {
    pinMode(motor1Pin1, OUTPUT);
    pinMode(motor1Pin2, OUTPUT);
    pinMode(motor2Pin1, OUTPUT);
    pinMode(motor2Pin2, OUTPUT);
    pinMode(pin7,OUTPUT);

  pinMode(PIN_SS,OUTPUT);
```

```
  pinMode(PIN_MISO,INPUT);
  pinMode(PIN_MOSI,OUTPUT);
  pinMode(PIN_SCK,OUTPUT);

  SPI.begin();
  SPI.setClockDivider(SPI_CLOCK_DIV32);
  SPI.setDataMode(SPI_MODE3);
  SPI.setBitOrder(MSBFIRST);

  Serial.begin(9600);
///////Compass////////
// Initialize Initialize HMC5883L "Sensor"

// Initialise the sensor
  if(!mag.begin())
  {
    /* There was a problem detecting the HMC5883 ... check your connections */
    Serial.println("Ooops, no HMC5883 detected ... Check your wiring!");
    while(1);
  }

  // Initialise direction variables
  turn_init = false;
  target_reached = false;

  //////////////Flow Sensor/////////////////
  if(mousecam_init()==-1)
  {
    Serial.println("Mouse cam failed to init");
    while(1);
  }

}

char asciiart(int k)
{
  static char foo[] = "WX86*3I>!;~:,`. ";
  return foo[k>>4];
}

byte frame[ADNS3080_PIXELS_X * ADNS3080_PIXELS_Y];

void loop() {

///////////////// Sensor "Optical Flow" ////////////////////////
  #if 0

  // if enabled this section grabs frames and outputs them as ascii art

  if(mousecam_frame_capture(frame)==0)
  {
    int i,j,k;
    for(i=0, k=0; i<ADNS3080_PIXELS_Y; i++)
    {
      for(j=0; j<ADNS3080_PIXELS_X; j++, k++)
      {
```

```
      Serial.print(asciiart(frame[k]));
      Serial.print(' ');
     }
    Serial.println();
   }
 }
 Serial.println();
 delay(250);

 #else

 // if enabled this section produces a bar graph of the surface quality that can be used to focus the camera
 // also drawn is the average pixel value 0-63 and the shutter speed and the motion dx,dy.

 int val = mousecam_read_reg(ADNS3080_PIXEL_SUM);
 MD md;
 mousecam_read_motion(&md);
 for(int i=0; i<md.squal/4; i++)
   Serial.print('*');
 Serial.print(' ');
 Serial.print((val*100)/351);
 Serial.print(' ');
 Serial.print(md.shutter); Serial.print(" (");
 Serial.print((int)md.dx); Serial.print(','); //AQUI VARIABLES X Y
 Serial.print((int)md.dy); Serial.println(')');
 acc = acc + md.dy;
 // Serial.println(md.max_pix);
 delay(100);

 #endif

//****************************************Angle move "HMC5883" **********************//

 // Read which button is pressed
 int key_value = 138;

 /* // KEY1
 if (key_value > 130 && key_value < 140) {
   turn(90, RIGHT);
 }

  // KEY2
 if (key_value > 570 && key_value < 580) {
   turn(90, LEFT);
 }*/

////////////////////// Option Grass Cutter //////////////////////

if (Serial.available() > 0) {serialA = Serial.read();}

   ////// Foward ////////
  if (serialA == 'F'){
      Forward();
  }
    ////// Left ////////
  if (serialA == 'L'){
```

```
      Left();
    }
    ////// Right ////////
    if (serialA == 'R'){
      Right();
    }
   ////// Reverse ////////
    if (serialA == 'B'){
      Reverse();
    }
   ////// Stop ////////
     if (serialA == 'S'){
       Stop();
     }


 ////// Cutter On ////////
    if (serialA == 'C'){
      digitalWrite(pin7,HIGH);
    }

 ////// Cutter Off ////////
   if (serialA == 'c'){
      digitalWrite(pin7,LOW);
   }

 ////// Autonomous On ////////
  if (serialA == 'A'){
      if (acc > -500){ // Aqui cambiamos la distancia
       Forward();

}
else {
   Stop();
   delay(2000);
  if (key_value > 130 && key_value < 140) {
   turn(90, RIGHT);
   acc = 0 ;
 }
}


      }

  ////// Autonomous Off ////////

  if (serialA == 'a'){

      digitalWrite(motor1Pin1, LOW);
      digitalWrite(motor1Pin2, LOW);
      digitalWrite(motor2Pin1, LOW);
      digitalWrite(motor2Pin2, LOW);
      digitalWrite(pin7,LOW);
  }
```

```
//*****************************************Funciones de las direcciones cortadora ************************************************//

}
void Forward()
{
      digitalWrite(motor1Pin1, HIGH);
      digitalWrite(motor1Pin2, LOW);
      digitalWrite(motor2Pin1, LOW);
      digitalWrite(motor2Pin2, HIGH);
}
void Left()
{
      digitalWrite(motor1Pin1, HIGH);
      digitalWrite(motor1Pin2, LOW);
      digitalWrite(motor2Pin1, HIGH);
      digitalWrite(motor2Pin2, LOW);
}
void Right()
{
      digitalWrite(motor1Pin1, LOW);
      digitalWrite(motor1Pin2, HIGH);
      digitalWrite(motor2Pin1, LOW);
      digitalWrite(motor2Pin2, HIGH);
}
void Reverse()
{
      digitalWrite(motor1Pin1, LOW);
      digitalWrite(motor1Pin2, HIGH);
      digitalWrite(motor2Pin1, HIGH);
      digitalWrite(motor2Pin2, LOW);
}
void Stop()
{
      digitalWrite(motor1Pin1, LOW);
      digitalWrite(motor1Pin2, LOW);
      digitalWrite(motor2Pin1, LOW);
      digitalWrite(motor2Pin2, LOW);
}


//*****************************************Funciones para movimiento angulo*****************************************//

// Turn of a given angle
void turn(float angle, bool turn_direction) {

  // Get initial heading
  if (!turn_init) {
    Serial.println("Starting turn ...");
    initial_heading = get_heading();

    if (turn_direction) {
      target_heading = initial_heading + angle;
    }
    else {
```

```
    target_heading = initial_heading - angle;
  }

  Serial.print("Initial heading: ");
  Serial.println(initial_heading);
  Serial.print("Target heading: ");
  Serial.println(target_heading);

  turn_init = true;
  target_reached = false;
  diff_heading = 0;
}

float heading = get_heading();

if (turn_direction) {
  diff_heading = target_heading - heading;
}
else {
  diff_heading = heading - target_heading;
}

while (diff_heading > 0 && !target_reached) {

  // Move & stop
  if (turn_direction) {
    //right_angle(255);
    Right();
  }
  else {
    //left_angle(255);
    Left();
  }
  delay(450);
  //right_angle(0);
  Right();
  delay(450);

  // Measure heading again
  float heading = get_heading();

  if (turn_direction) {
    diff_heading = target_heading - heading;
  }
  else {
    diff_heading = heading - target_heading;
  }
  Serial.print("Difference heading (degrees): "); Serial.println(diff_heading);

  if (diff_heading < 0 && !target_reached) {
    target_reached = true;
    turn_init = false;
    diff_heading = 0;
  }
  return  'A';
}
```

```
  // Stop
  Serial.println("Stopping turn ...");
}

// Get heading from the compass
float get_heading() {

  // Get a new sensor event
  sensors_event_t event;
  mag.getEvent(&event);

  // Calculate heading based on magnetic intensity in X & Y axis
  float heading = atan2(event.magnetic.y, event.magnetic.x);

  // Correct for when signs are reversed.
  if(heading < 0)
    heading += 2*PI;

  // Check for wrap due to addition of declination.
  if(heading > 2*PI)
    heading -= 2*PI;

  // Convert radians to degrees for readability.
  float headingDegrees = heading * 180/M_PI;
  return headingDegrees;
}
```

VI. Conclusion and Future work

A. Conclusion

In this project we could find a small problem which we tried to find a solution. The problem with this job was that it is difficult for some people or they cannot cut the grass, our solution was to create a lawn mower which they could handle through a mobile application remotely and without any effort. During the development of this project we endorsed our knowledge learned in class and learned new skills which allowed us to reason in an orderly way to carry out this work and find a correct solution. The part a little more complicated of this project was the part of the bridges H since this heated us, but quickly we found a solution. The part of the mobile application was a bit laborious since it was something new, but it could be carried out in a simple and comfortable way. Our goal for this work is to be able to continue perfecting this project to be able to make it autonomous and to be able to make it commercial.

B. Future work

The future work of this Project is the implementation of autonomous capability, safety features capabilities, change propulsion motors to 24V, create a charging station, improve the mobile device application and develop an IOS application.