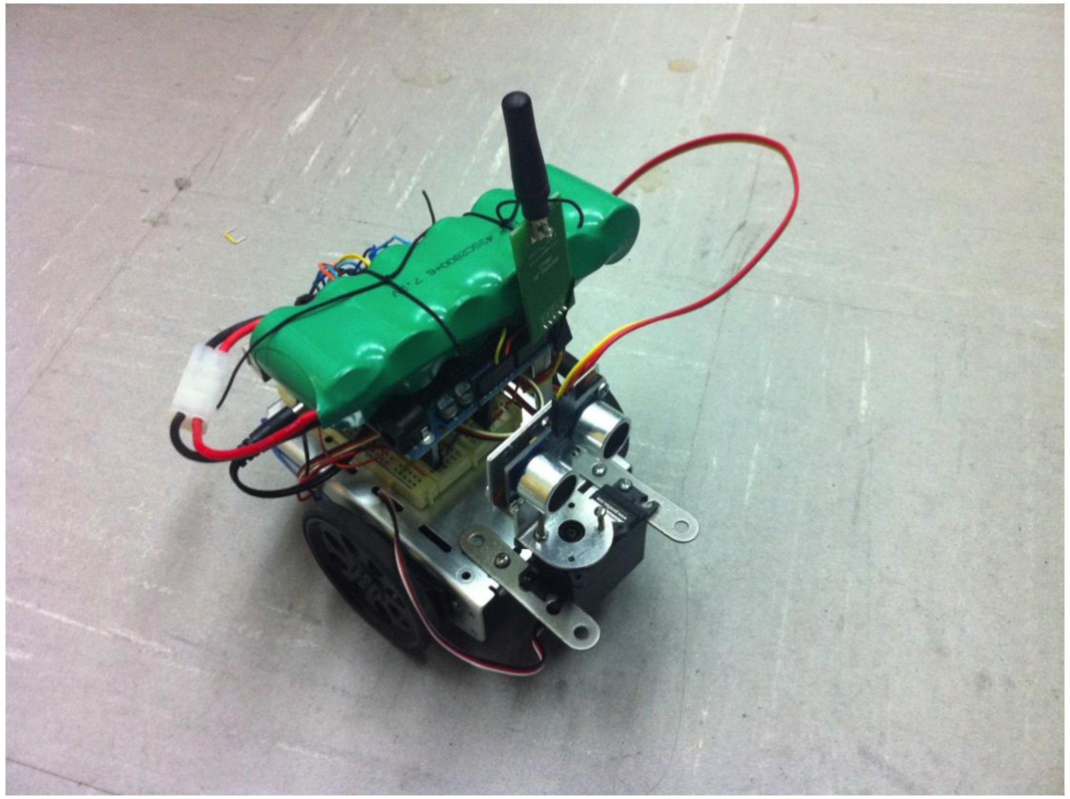
# Advanced Mechatronics
# 1st Mini Project

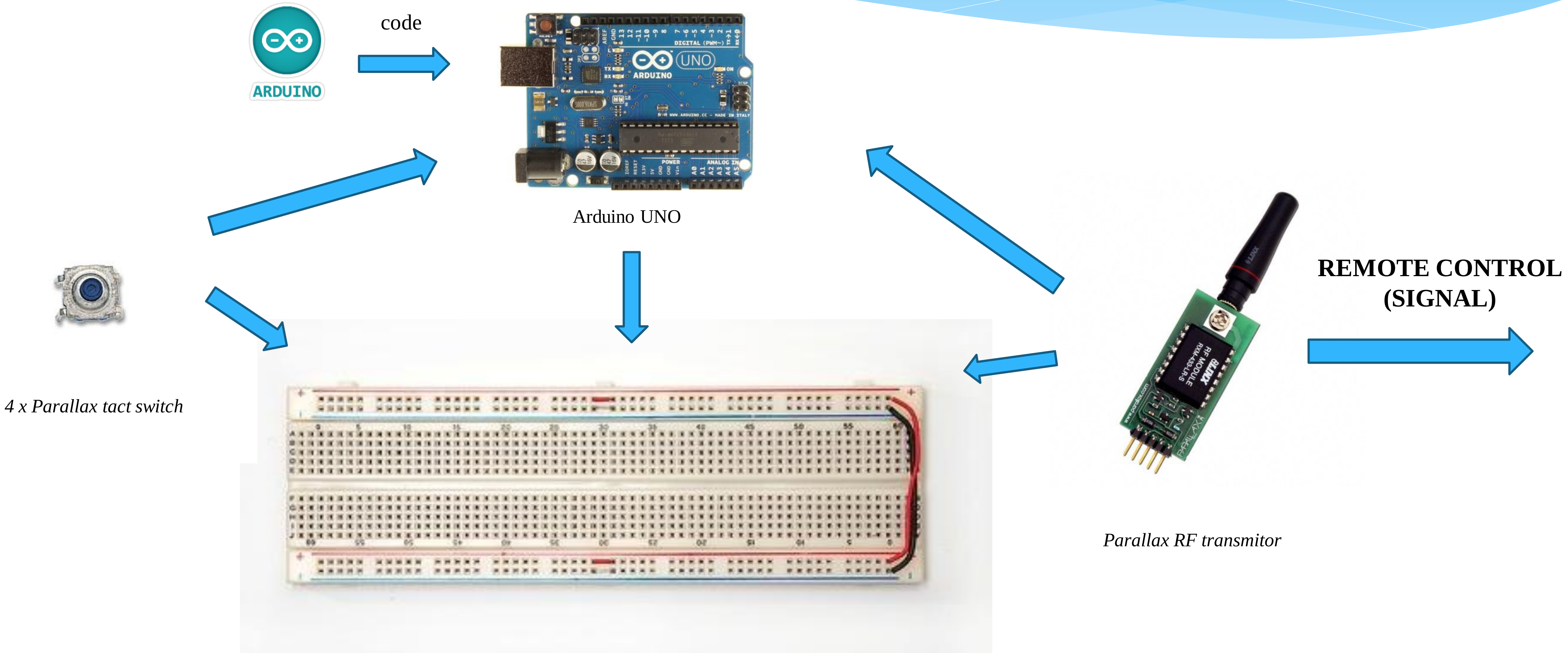
# Remote Control Car

## Remote Control Car

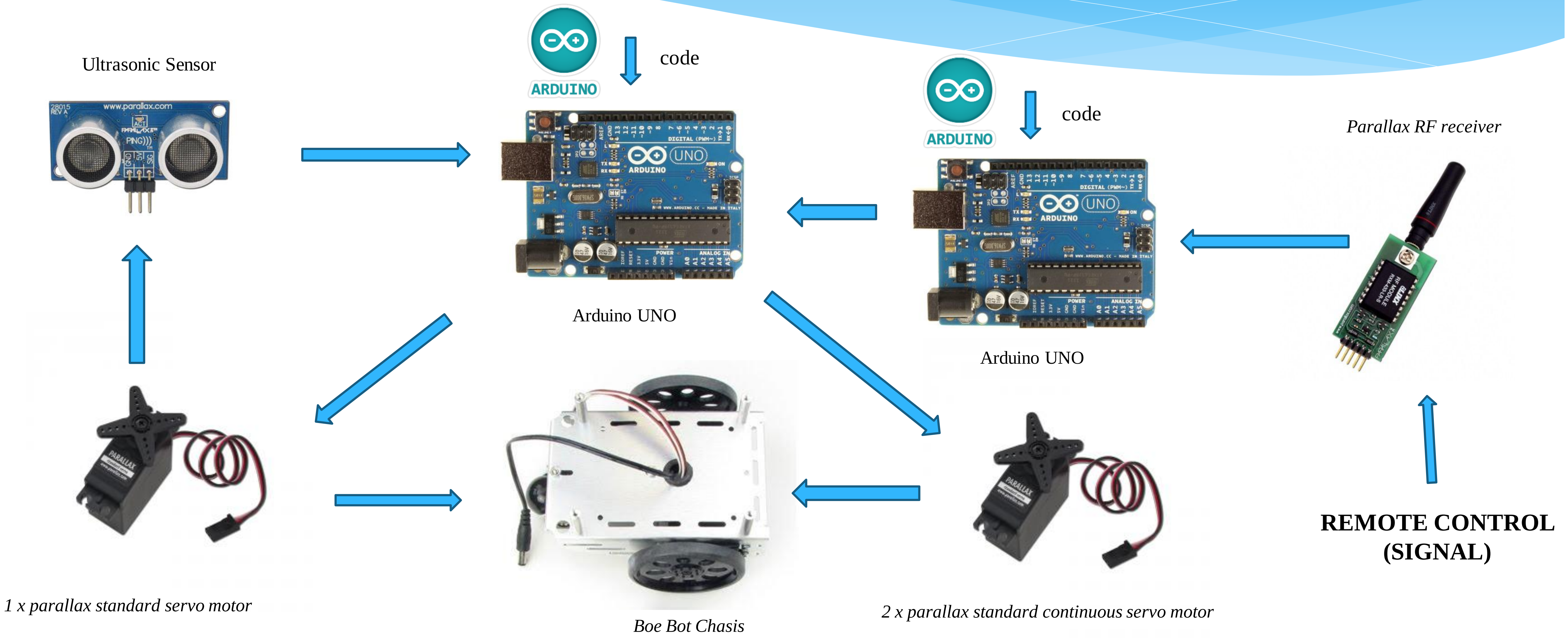
- Manual Control with the remote and direction buttons
- Automatic control detecting and avoiding obstacles.
- The car is controlled by Radio frequency using the remote control



## How Does It Work?
## Remote



# How Does It Work?
# Car



## How Does It Work?
## Remote

- Arduino constantly monitors the pushbuttons
- Each button is assigned a number i.e. 1, 2 ..
- Cyclic Redundancy Check is performed on the input
- Data (byte) is sent over RF using the SoftwareSerial library

## How Does It Work?
## Cyclic Redundancy Check:

- Used to detect accidental changes to raw data
- Simple protection against noise in the transmission channel
- A generator polynomial is used in conjunction with the data to perform polynomial long division.
  - The generator polynomial (x^2 + 1, in this case) is the divisor and the data is the dividend.
  - Only the remainder is used

## How Does It Work?
## CRC Implementation

- Counter – How many individual piece of information (byte)
- Data – User input
- Save user input in a byte
- Pack Counter and Data into a single value (int)
- Pad the data with 0’s i.e. shift left by 3 bits
- Padded data XOR 101 = Result
- Result XOR 0101 (shifted right) until remainder is found

## How Does It Work?
### Data Transmission

- Counter – How many individual piece of information (2 bits)
- Data – User input (3 bits)
- CRC check value – remainder (3 LSB’s only mask the MSB’s)
- Pack all these information in a byte
  - (Counter << 6) | (Data << 3) | CRC
- Send over RF

## How Does It Work?
### Receiver

- Unpack the data
  - Mask out irrelevant bits in each case and then shift i.e.
    - Counter >> 6, Data >> 3
- Calculate CRC value and compare with the received value to verify integrity
- Make decision based on the data (i.e. drive pins high or low)

## How Does It Work?
## Boe-bot

- It goes on autonomous mode if no data is sent (no buttons are pressed)
  - During the autonomous mode it will go forward, if it detects an obstacle, it will check distances in both sides and it will go to side of bigger distance.

- Monitor the pins constantly, if any button is pressed, it will change to the Manual mode

  - Based on the data received it determines servo angles

## Components

- 3 x Arduino UNO
- Ultrasonic Distance Sensor
- Parallax Standard Servo Motor
- 2 x Parallax Continuous Rotation Servo
- Parallax RF Transmitter
- Parallax RF Receiver
- 4 x Parallax tact switch
- Parallax Boe bot chasis
- Piezo Speaker

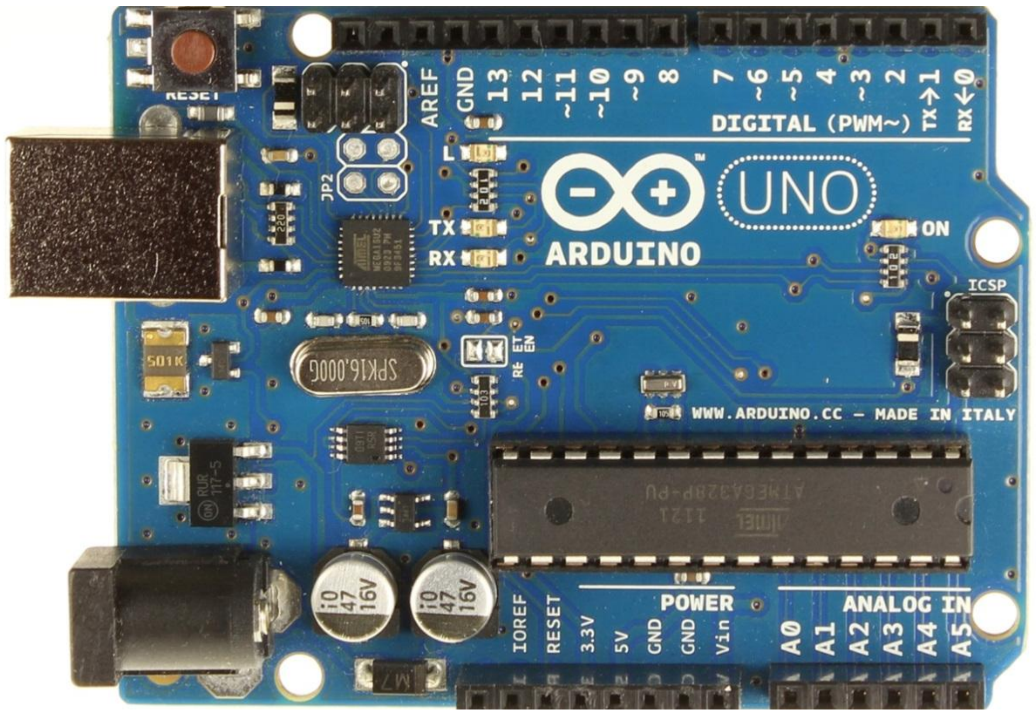
## Arduino UNO

* This is the body and the brain of our project. We use Arduino to receive signals, interpret them and control all the components in our project.

* Arduino is a tool for making smart devices that can sense and control.

* The physical world Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software.

* Arduino microcontroller is programmed using:
  * Arduino programming language (based on Wiring—C libraries)
  * Arduino development environment (based on Processing), Arduino integrated development environment (IDE)



## Ultrasonic Distance Sensor

* The ultrasonic distance sensor provides an easy method of distance measurement. This sensor is perfect for any number of applications that require you to perform measurements between moving or stationary objects.

* Interfacing to a microcontroller is a snap. A single I/O pin is used to trigger an ultrasonic burst (well above human hearing) and then "listen" for the echo return pulse. The sensor measures the time required for the echo return, and returns this value to the microcontroller as a variable-width pulse via the same I/O pin.

* We have used the ultrasonic distance sensor to detect the objects that avoid us to follow a path. If there is an object in front of the car, the sensor will detect both sides, compare both distances and will go in the direction of the bigger distance.

# Parallax Standard Servo Motor

- A servo motor is a rotary actuator that allows for precise control of angular position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback.

- The way in which the standard servomotor works in our project is easy. Once the Ultra sonic distance sensor detects that there is an object in front of the car, the servo will rotate to make the ultra sonic distance detector check right and left sides.

- This Servo can oscillate from 0 to 180 degrees. And this is all we need, since we don't have to care about back distances, we only have to turn 90 degrees to check one side, and 180 degrees from there to check the other. This is the reason because we use this servo and not Parallax Continious Rotation.

## Parallax Cotinuous Rotation Servo

- It has the same characteristics as the Parallax Standard Servo Motor, with the main difference that it can rotate continuosly, whitout 180 degrees limitation.
- 0 to 50 RPM, with linear response to PWM for easy ramping
- In our mini project, the purpose of the Parallax Continuous servos is to move the Boe Bot. To move the car forward, servomotor has to move in different directions, as for moving backward, and to turn one side or the other, one of the servos has to stop turning, and the other will turn max speed, during a short amount of time.

## Parallax RF Module (Transmitter & Receiver)

- This easy-to-use module is capable of sending and receiving serial data wirelessly between microcontrollers or to a PC. Low power consumption makes it ideal for use in battery-powered applications.
- Data is sent and received by AM or CPCA modulation, thus offering a higher average output power which extends the range. This module is equipped with an RSSI feature that can be utilized to improve power efficiency by waking up circuitry only when an external signal is detected and it has a frequency band of 433 MHz.
- These transmitter and receiver are the modules that we use to communicate the Remote control with the Car. The transmitter will send the signals what we want, the receiver will receive them, and thanks to Arduino, the signal will be processed and the car will move as we like.

## Parallax tact switch

* This tact switch is a normally-open pushbutton suitable for breadboard or through-hole.
* We have used four tact switches to control the manual mode on out car. Each of the buttons will send a signal to Arduino on the remote control, and through the RF Module, the signal will be sent to the car and it will move the way that we want.

## Parallax Piezo-Speaker

- Commonly said, it’s as an inexpensive speaker.
- In the Manual mode, we have used the Piezo Speaker imitating the beeping of a car.
- In the autonomous mode, the Piezo speaker will beep when there is an obstacle in front of the car, and it will beep differently for right and left sides.
- For doing that, we should program a code, using different frequencies for each position, front, right side and left side.

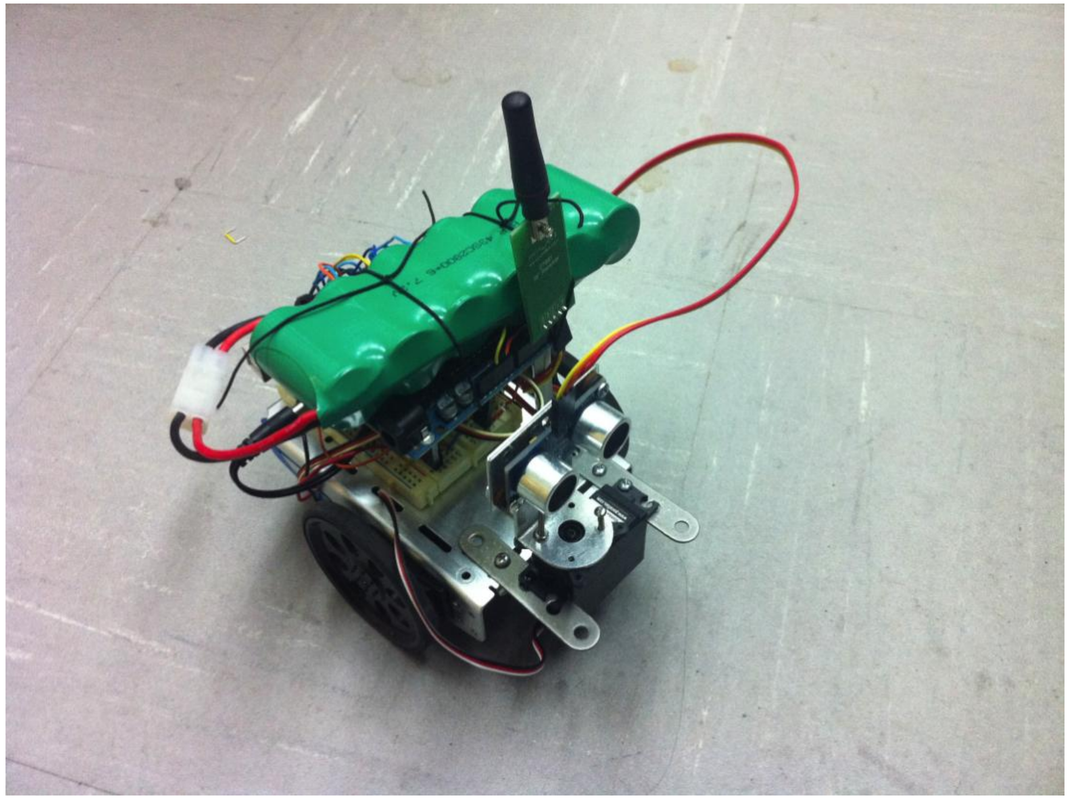
## Parallax Boe bot chasis

- This chasis is part of the Parallax Boe Bot Kit and it has been used to built out car. It comes with two wheels on the sides, a little ball on the back and a battery pack that we used to feed Arduino, Ultra Sonic Sensor and Parallax Standard Servo.

- As we will explain in the mechanical design, Arduino and the servomotors are connected to the Boe Bot, so we can use the servomotors to move the wheels and the Arduino to control them without using difficult and complex wiring.

## Car Design

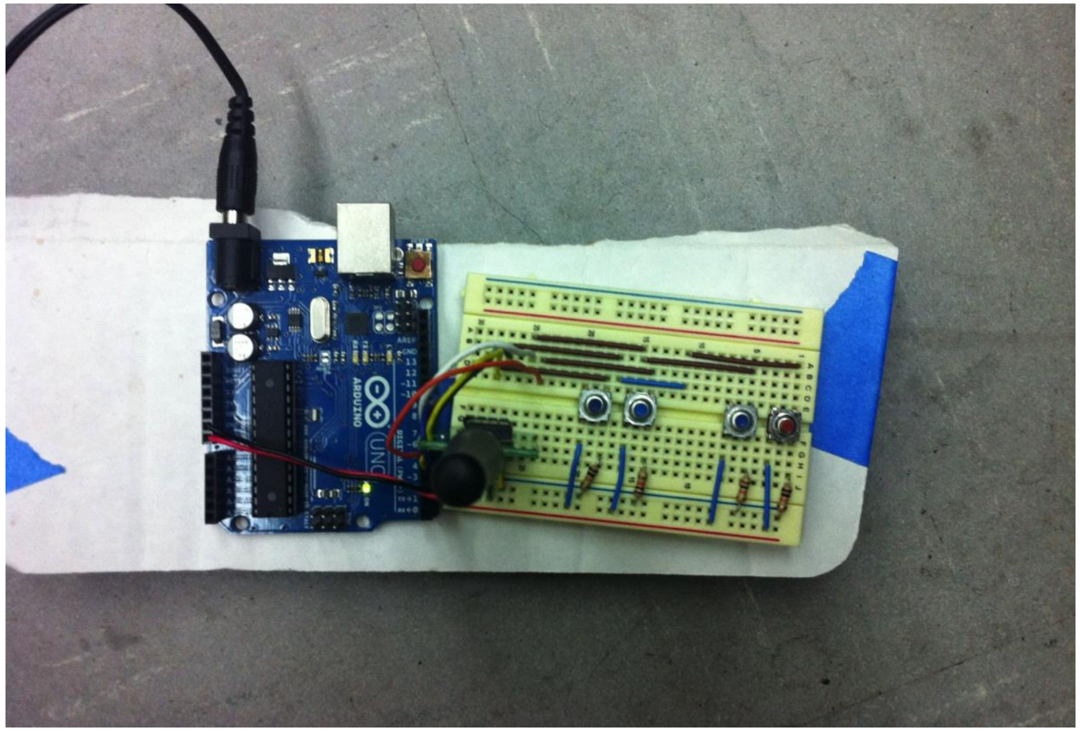
- For the mechanical design we have plugged two Arduino UNO and a breadboard into the Boe Bot Kit.
  - The first Arduino is constantly receiving data from the RF Module and sending the commands to the second Arduino, which controlls the car.
- The Parallax Standard Servo in plugged in front of the Boe Bot and the Parallax continuous rotation servos are attached to the wheels.
- The Ultrasonic Distance Sensor (used in the autonomous mode) is plugged over the Parallax Standard Servo, which will rotate when an obstacle is in front of the Boe Bot, to make the Ultrasonic Distance Sensor check the distances on the sides.



## Remote Design

* For the remote we have used a breaboard with four switches and the RF Module Transmitter.

* Depending on the switch we press, the car will move in one direction or another



## Code
## Remote

```
#include <SoftwareSerial.h>

SoftwareSerial mySerial(10, 11);                // (RX, TX) define the receive and transmit pins

volatile byte keycode=0;
volatile byte data = 0;
volatile byte flag = 0;

void setup(){
  pinMode(4, INPUT);
  pinMode(5, INPUT);
  pinMode(6, INPUT);
  pinMode(7, INPUT);
  pinMode(13, OUTPUT);

  mySerial.begin(4800);                         // set the software serial baud rate
}

void loop(){
  byte counter = B00000011;                     // how many individual information are packed in 1 byte
  unsigned int divisor = 2560;                 // CRC polynomial coefficients X^2 + 1 (101) 0000 1010 0001 0100
  unsigned int temp = divisor;
  byte cksum = 0;
  byte tx = 0;
  unsigned int ctemp = 2048;                   // B0000 1000 0000 0000
  unsigned int cksumtemp = (unsigned int) counter;
```

# Code Remote

```
// pack counter and data into a single 16-bit number
cksumtemp = cksumtemp << 8;

//check:
keycode = 0;
if(digitalRead(4)){
  digitalWrite(13, HIGH);
  delay(500);
  digitalWrite(13, LOW);
  keycode = 1;
}
if(digitalRead(5)){
  digitalWrite(13, HIGH);
  delay(500);
  digitalWrite(13, LOW);
  keycode = 2;
}
if(digitalRead(6)){
  digitalWrite(13, HIGH);
  delay(500);
  digitalWrite(13, LOW);
  keycode = 3;
}
if(digitalRead(7)){
  digitalWrite(13, HIGH);
  delay(500);
  digitalWrite(13, LOW);
  keycode = 5;
}
```

```
  data = keycode;

  cksumtemp = cksumtemp | (unsigned int) data;
  cksumtemp = cksumtemp << 2;

  // calculate CRC checksum
  while(cksumtemp & 65532){                // B1111 1111 1111 1100
    cksumtemp = cksumtemp ^ temp;
    if(!cksumtemp & ctemp){                 // check if quotient is zero
      temp = temp >> 1;
      ctemp = ctemp >> 1;
    }
  }

  temp = divisor;                      // restore the divisor value in temp
  ctemp = 2048;

  // extract only the result (3 LSBs) of the checksum (2-3 order polynomial)
  cksum = (byte) cksumtemp;
  cksum = cksum & B00000111;

  tx = (counter << 6) | (data << 3) | cksum;    // pack the counter, data and cksum in 1 byte
  //Serial.println(data, DEC);           // debug info
  mySerial.write(tx);                  //send the data
}
```

# Code Receiver

```
#include <SoftwareSerial.h>

SoftwareSerial mySerial(10, 11);              // (RX, TX) define the receive and transmit pins

// setup output pins and initialize the pins
void setup(){
  pinMode(7,OUTPUT);
  pinMode(8,OUTPUT);
  pinMode(12,OUTPUT);
  pinMode(9,OUTPUT);
  pinMode(13, OUTPUT);
  digitalWrite(9, LOW);
  digitalWrite(7, LOW);
  digitalWrite(8, LOW);
  digitalWrite(12, LOW);

  mySerial.begin(4800);              // set the serial baud rate
}

void loop(){
  unsigned int divisor = 2560;            // CRC polynomial coefficients X^2 + 1 (101)
  unsigned int temp = divisor;
  unsigned int ctemp = 2048;                // B0000 1000 0000 0000
  byte rx, crc;
  unsigned int cksumtemp;
```

# Code Receiver

```
if(mySerial.available()){                    // read the received data
    rx=mySerial.read();
}

// extract the counter, data, and CRC checksum from the received byte
byte counter = rx & B11000000;
counter = counter >> 6;
byte data = rx & B00111000;
data = data >> 3;
byte cksum = rx & B00000111;
rx = 0;

// pack the counter and data in unsigned 16-bit int for CRC cksum calculation
cksumtemp = (unsigned int) counter;
cksumtemp = cksumtemp << 8;
cksumtemp = cksumtemp | (unsigned int) data;
cksumtemp = cksumtemp << 2;                        // pad with zeros

// calculate CRC checksum
while(cksumtemp & 65532){                    // B1111 1111 1111 1100
   cksumtemp = cksumtemp ^ temp;
   if(!cksumtemp & ctemp){                    // check if quotient is zero
     temp = temp >> 1;
     ctemp = ctemp >> 1;
   }
}
```

```
temp = divisor;                              // restore the divisor value in temp
ctemp = 2048;

// extract only the result (3 LSBs) of the checksum (2-3 order polynomial)
crc = (byte) cksumtemp;
crc = crc & B00000111;

// verify data integrity and set or clear Boe bot arduino pins based on data
if(crc == cksum){
  if(data == 1){
    digitalWrite(13, HIGH);
    digitalWrite(9, HIGH);
    delay(250);
    digitalWrite(9, LOW);
    digitalWrite(13, LOW);
  }
  else if(data == 2){
    digitalWrite(13, HIGH);
    digitalWrite(7, HIGH);
    delay(250);
    digitalWrite(7, LOW);
    digitalWrite(13, LOW);
  }
  else if(data == 3){
    digitalWrite(13, HIGH);
    digitalWrite(8, HIGH);
    delay(250);
```

## Code Receiver

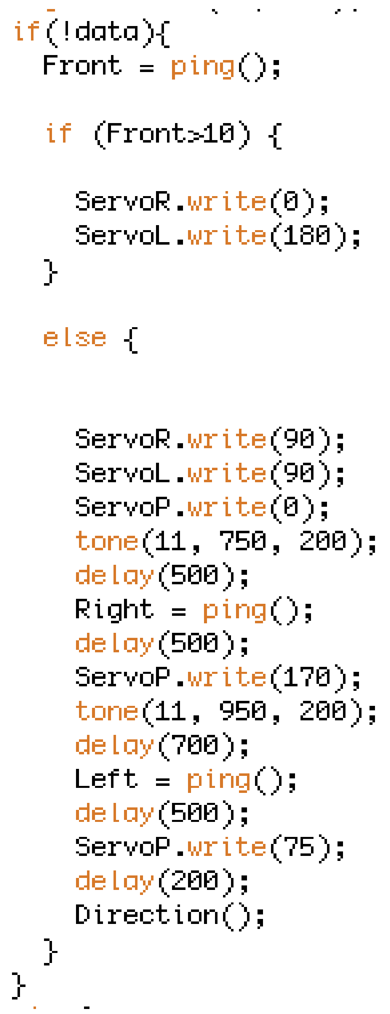
```
      digitalWrite(7, LOW);
      digitalWrite(13, LOW);
    }
    else if(data == 3){
      digitalWrite(13, HIGH);
      digitalWrite(8, HIGH);
      delay(250);
      digitalWrite(8, LOW);
      digitalWrite(13, LOW);
    }
    else if(data == 5){
      digitalWrite(13, HIGH);
      digitalWrite(12, HIGH);
      delay(250);
      digitalWrite(12, LOW);
      digitalWrite(13, LOW);
    }
    else{
      data = 0;
    }
  }
  else{
    ;
  }
}
```

# Code
# Boe Bot

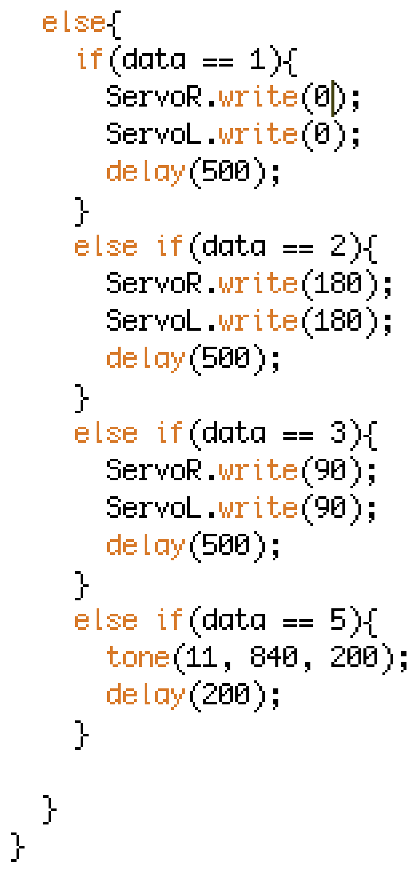
```
#include <Servo.h>

Servo ServoR;
Servo ServoL;
Servo ServoP;
const int SigPin = 4;
float rawTime, cmDist, Front, Right, Left;
byte data = 0;
const int BeepPin = 11;

void setup()
{
  pinMode(7,INPUT);
  pinMode(8,INPUT);
  pinMode(12,INPUT);
  pinMode(10,INPUT);
  pinMode(13, OUTPUT);
  ServoR.attach(5);
  ServoL.attach(6);
  ServoP.attach(3);
  ServoP.write(75);
}
```

```
void loop() {
  digitalWrite(13, HIGH);
  if(digitalRead(10)){
    data = 1;
  }
  else if(digitalRead(7)){
    data = 2;
  }
  else if(digitalRead(8)){
    data = 3;
  }
  else if(digitalRead(12)){
    data = 5;
  }
  else{
    data = 0;
  }
  digitalWrite(13, LOW);
```

# Code
# Boe Bot

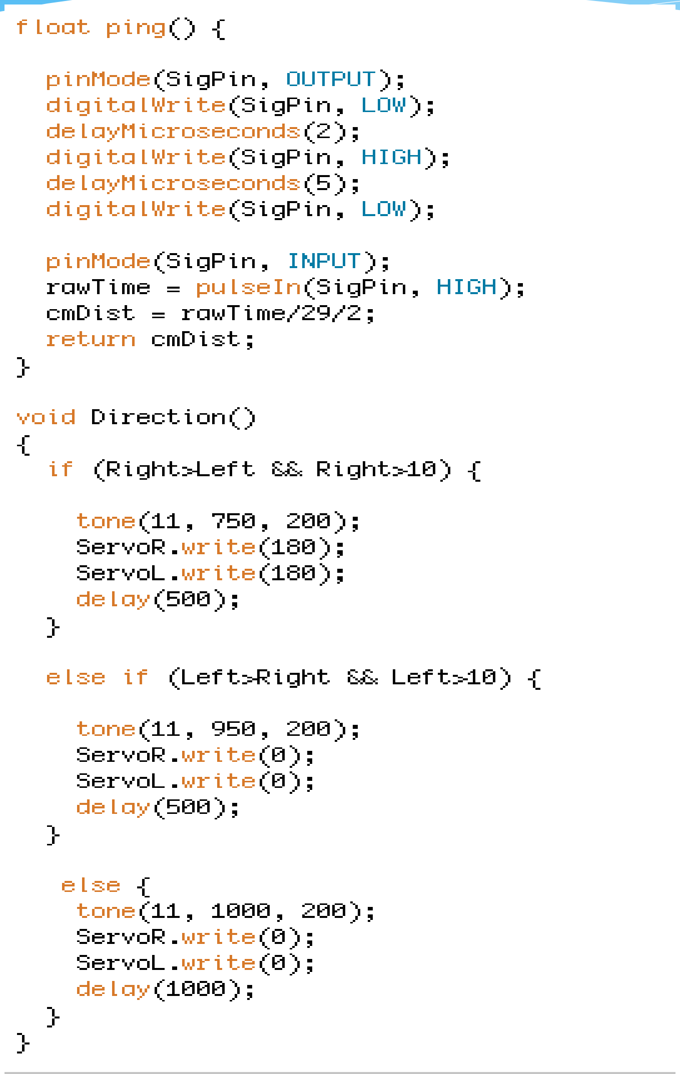


```
if(!data){
  Front = ping();

  if (Front>10) {

    ServoR.write(0);
    ServoL.write(180);
  }

  else {


    ServoR.write(90);
    ServoL.write(90);
    ServoP.write(0);
    tone(11, 750, 200);
    delay(500);
    Right = ping();
    delay(500);
    ServoP.write(170);
    tone(11, 950, 200);
    delay(700);
    Left = ping();
    delay(500);
    ServoP.write(75);
    delay(200);
    Direction();
  }
}
```



```
  else{
    if(data == 1){
      ServoR.write(0);
      ServoL.write(0);
      delay(500);
    }
    else if(data == 2){
      ServoR.write(180);
      ServoL.write(180);
      delay(500);
    }
    else if(data == 3){
      ServoR.write(90);
      ServoL.write(90);
      delay(500);
    }
    else if(data == 5){
      tone(11, 840, 200);
      delay(200);
    }

  }
}
```

# Code
# Boe Bot



```
float ping() {

  pinMode(SigPin, OUTPUT);
  digitalWrite(SigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(SigPin, HIGH);
  delayMicroseconds(5);
  digitalWrite(SigPin, LOW);

  pinMode(SigPin, INPUT);
  rawTime = pulseIn(SigPin, HIGH);
  cmDist = rawTime/29/2;
  return cmDist;
}

void Direction()
{
  if (Right>Left && Right>10) {

    tone(11, 750, 200);
    ServoR.write(180);
    ServoL.write(180);
    delay(500);
  }

  else if (Left>Right && Left>10) {

    tone(11, 950, 200);
    ServoR.write(0);
    ServoL.write(0);
    delay(500);
  }

   else {
    tone(11, 1000, 200);
    ServoR.write(0);
    ServoL.write(0);
    delay(1000);
  }
}
```

## Purpose

- The main purpose of this first miniproject was to get familiarized with Arduino and its way of programming.
- Different components as buttons, Ultrasonic distance sensor, piezo speaker, servos and RF Modules have been used in this Miniproject to have a better understanding of them in Arduino world.
- Thanks to this project we have learned how to communicate, how to program and how to use those components with Arduino.

# Budget

| Name | Units | Costs |
|---|---|---|
| Arduino UNO | 3 | $44.85 |
| Parallax Standard Servo Motor | 1 | $12.99 |
| Parallax Continuous Rotation Servo | 2 | $27.98 |
| Boe Boe Kit | 1 | $34.99 |
| Parallax tact Switches | 4 | $2 |
| Ultrasonic Distance Sensor | 1 | $29.99 |
| RF Module Transmitter and Receiver | 1 | $24.99 |
| Piezo Speaker | 1 | $2 |
| Resistors and Batteries | Various | $10 |
| **Approximate Value** | | $189.79 |