A robot to grip and distinguish objects: BLG456E Project Report

*By **Team Düses**:* *17.01.2017*

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Table of Contents

1. Abstract

The robot which is described in report can find the objects with distance sensors, can collect the objects and separate them according to color. We have 6 challenges for building this robot. These are hardware design, mechanical design, moving the platform, grabbing objects, color determination and separation of objects. We implemented various designs for this issues and we found most appropriate solutions.

2. Introduction

In our project, we built a robot that can detect objects and distinguish them by their colors. The robot moves in a room and using its gripper on the front side, it grabs objects which is perceived by its sensors. Then, it lifts the object and throw it into a funnel, and then it separates objects into baskets which are placed on the robot according to color of object by using its RGB sensor and contains objects with the same colors. We used Arduino platform in this project to realize.

3. Material List

Our robot will consist of an Arduino Mega as controller, a chassis, 4 wheels driven by DC motors, two batteries, 4 ultrasonic sensors, a gripper controlled by servo motors and a RGB Colour sensor. The full requirements list is given in Table 1.

No	Piece	Material Name
1	x1	Arduino Mega 2560 R3
2	x3	Dc Motor Driver L9110
3	x4	Dc Motor and Wheel kit
4	x4	Servo motor
5	x1	Dc Motor driver L298
6	x6	Ultrasonic Distance Sensor HC-SR04
7	x1	11.4V Li-Po battery
8	x1	5V Power bank
9	x4	5V Voltage Regulator
10	x1	RGB Color sensor (TCS34725)
11	x1	Jumper cable kit
12	x1	Breadboard
13	x1	Quick glue kit
14	x1	Composite material called Forex 200x100 cm

Table 1:Material List

4. Robot Connection Sketch

Entire connection scheme of the project is shown in the Figure 1.

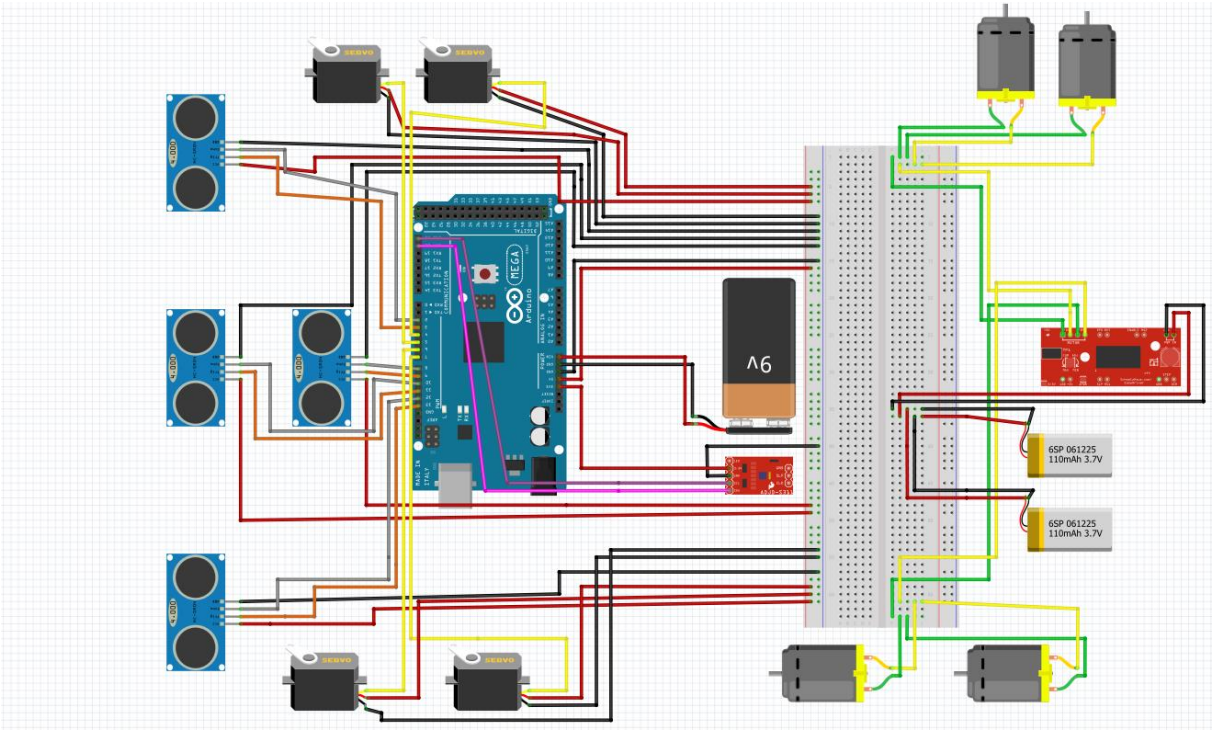

Figure 1:Hardware Connection of Full System

5. Building Robot Frame

We use material called forex as mainframe of robot. It is a plastic material that is easily cut. Firstly, we cut a piece of forex and glue wheel kits on the forex with quick glue. After that we connect dc motors cables to dc motor driver. Then we design grabber mechanism and add grabber mechanism main part of robot frame. Then we test sensors separately before using sensors on the robot.

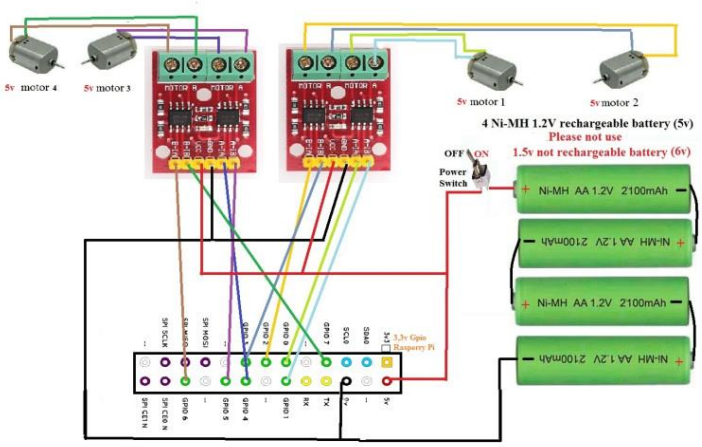

Figure 2: Motor driver example connection

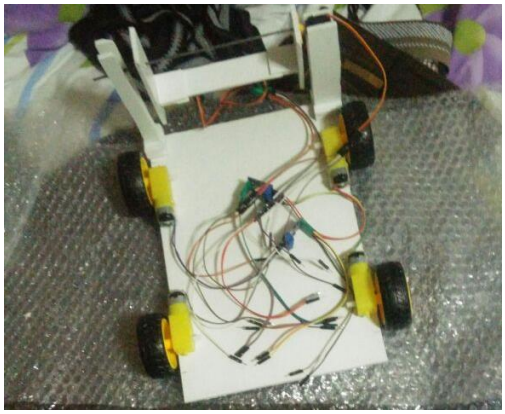

Figure 3:Motor Driver Connections

- Ultrasonic sensors are added robot frame, and then robot is able to search and grab objects.

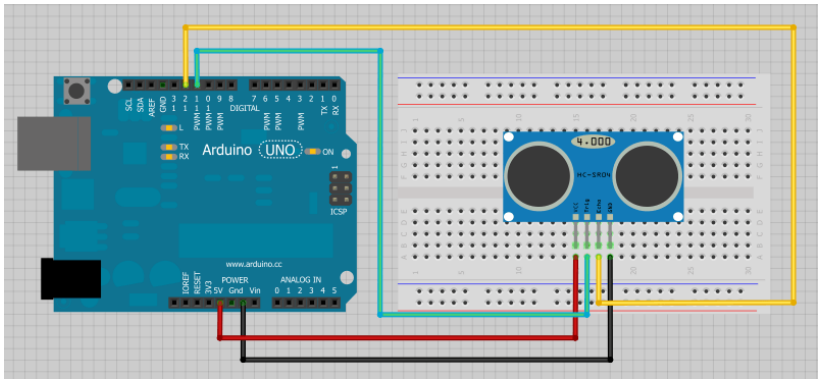

Figure 4: Ultrasonic sensor example connection

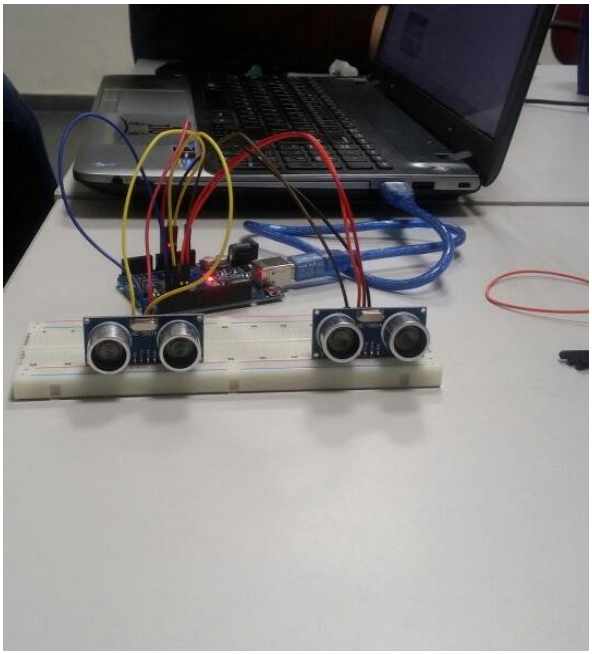

Figure 5: Ultrasonic Sensor Connections

- We built upper part of gripper mechanism and tested it by using Arduino Nano before glue mechanism on robot frame.

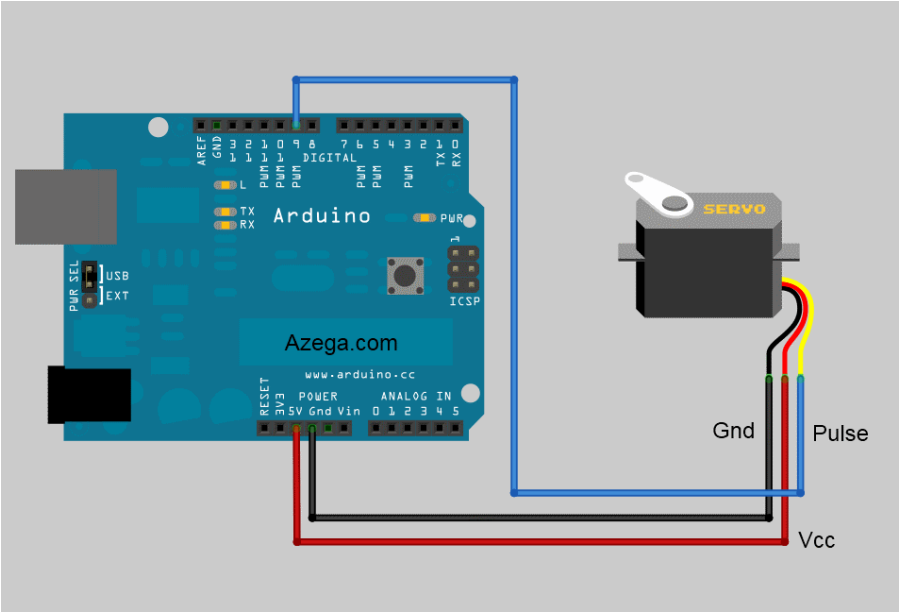

Figure 6: Servo motors example connection

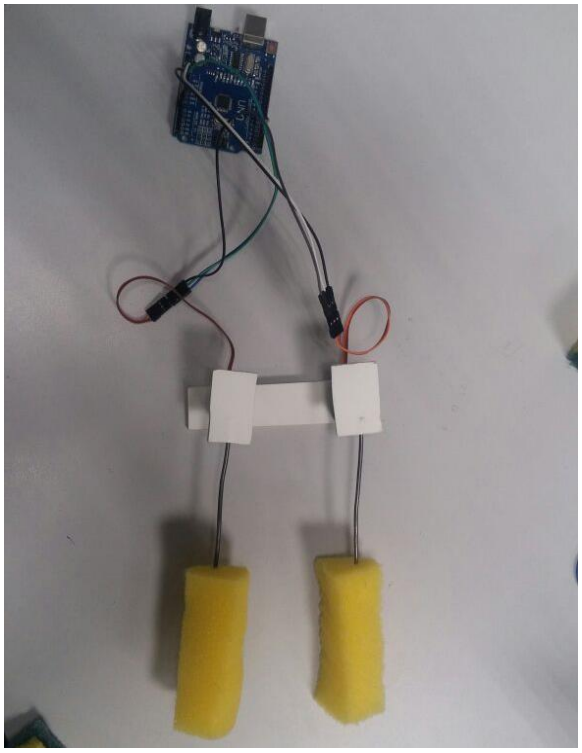

Figure 7: Gripper Connections

- In final stage we add robot's object collector box and color sensor for classifying objects for their color.

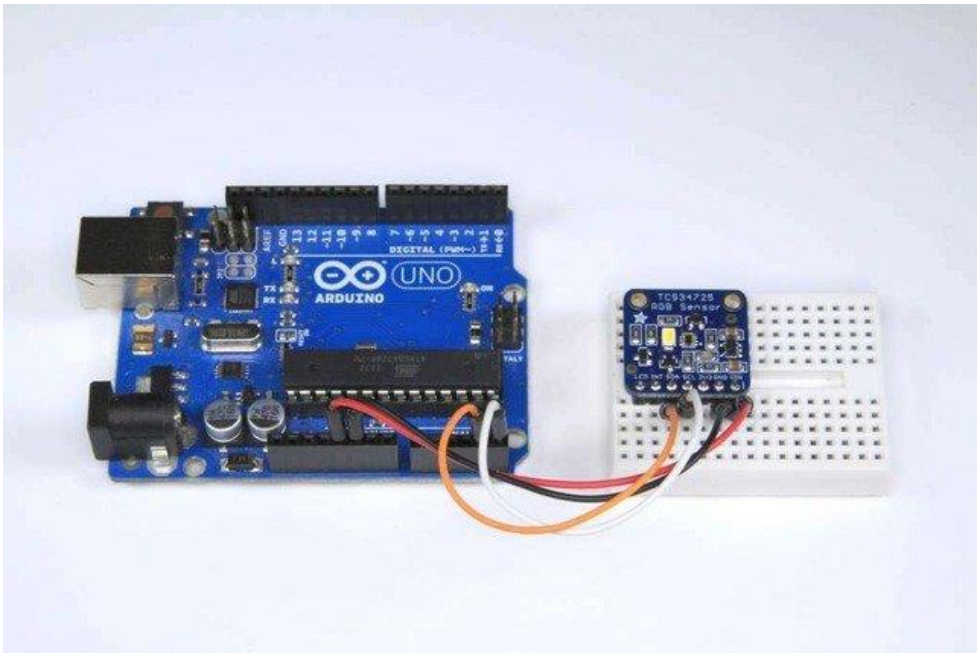

Figure 8: RGB color sensor example connections

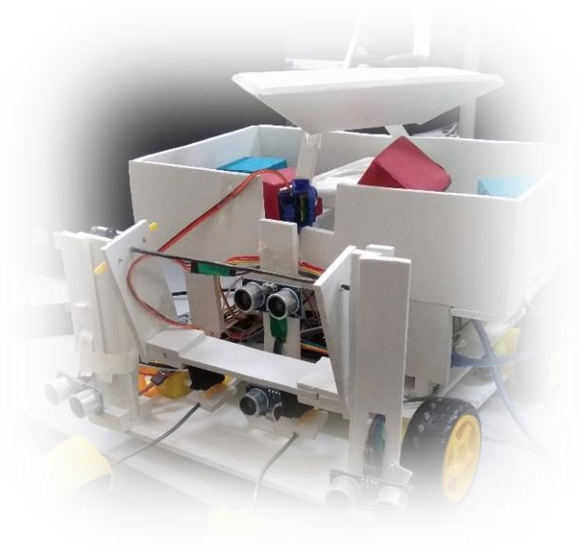

Figure 9:Collector Box and Color Sensor Implementation

6. Challenges and Solutions of Implementation

6.1. Hardware Design

In our project, we had serious problems about the hardware components of the robot.

The first difficulty was to control the speed of the wheels because we have used digital pins and we could not assign intermediate values to DC motors. We have solved that problem by driving the wheels with lower voltage, using a LiPo battery. While we are using LiPo battery, we tried running Arduino and wheels with different voltages, and used a 5V regulator and connected its output to Vin pin of Arduino. After some time, that regulator burnt and we had to find a different way for supplying energy to motor drivers and Arduino. Moreover, the battery could not supply energy for a long time and we found the solution by brazing a USB cable to the driver and using a powerbank which has 5V output. After a while, one of our motor drivers burnt and we had difficulties in driving the robot, but we solved that problem by driving left and right wheels using a single motor driver instead of separate drivers, since the wheels on the same side will work coordinated. Then, we ordered another motor driver to be able to replace it if we need to. As we completed all other parts and working on the coordination of all elements, the last motor driver we had burnt one day before the demo session. We tried hard to find another motor driver and finally we have found another type of motor driver and connected it to the wheels. By using this motor driver, we could give intermediate values for the speed but we were out of PWM pins, so we separated the echo and trigger pins of the ultrasonic sensors and used digital output for trigger. By doing that, we got some extra PWM pins and used them for the motor driver.

Another difficulty was about the ultrasonic sensors. At the beginning of the project, we have ordered 6 ultrasonic sensors although we need 4 of them, in case some of them burn. As we go some steps further in the project, ultrasonic sensors began returning inconsistent, or sometimes arbitrary values. Since we do all of our work like driving, turning and grabbing the objects according to the distance values we obtained from these sensors, our robot was not able to work properly. It was a bit hard to find whether the sensors or the cables we use causing that problem, or which one of the

sensors has problems and in which conditions it gives those wrong numbers, but we managed to find it after a while and replaced that sensor with a new one. After some time, we had the same problem with another sensor and replaced it again. Until the last day of the project, sensors were working well but we began getting wrong distance values from the lower-middle and left sensors. Because of that wrong values (most of the time it was 10, 11 or greater than 3000), in demo session, our robot failed to do most of the actions that we have intended.

6.2. Moving

In order to move the robot, we use 4 dc motors connected to 4 wheels. Due to controlling the synchronously we planned to user 2 motor drivers (1 for left hand side wheels and 1 for right hand side wheels). However, one day before the demo one of our motor driver was burned so we use 1 motor driver for moving the wheels synchronously. After that, two left wheels are connected a single input and two right wheels are connected another single input, instead of connected them separately. For voltage supply, it is used a 5V power bank.

Our robot has 3 main motions which are forward, left and right. As it is seen on the code, for moving the robot forward *back_right* and *back_left* pins are assigned to HIGH Boolean value. It is in reverse order because if the dc motors turn backward the robot goes forward. Also, forward_right and forward_left are assigned to LOW. Furthermore, if robot needs to turn right or left it turns without any linear velocity (only angular velocity). So, for instance while turning left, left hand side wheels go backwards and right hand side wheels go forward. For turning right, it is vice versa.

In order to move robot cleverly, we use 4 ultrasonic sensors. There are two important motion for robot. Firstly, it has to avoid the walls. For avoiding the walls in every motion function, robot checks the return value of is_wall() function. If it is true, robot turns back (turns right with 0.75 second delay). Secondly, robot needs to move towards the obstacles. For doing that, robot checks the left and right sensors. If measures any desired value, turn to the object, moves and grabs it.

6.3. Gripper

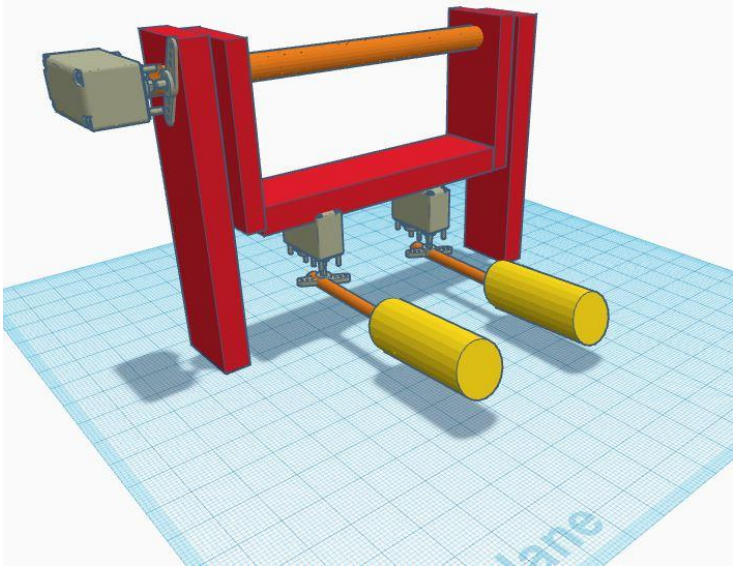

Figure 10: Sketch of Gripper

We used 3 servo motors for gripper as you can see figure above. Two of these are for horizontal axis and other is for vertical axis. We connected the iron rod to moving part of the servo motors and we attached dish sponge to end of the iron rod for increasing power of friction. Because we tried it without dish sponge but power of motors is not insufficient for lifting objects and we decided to implement this way. Robot could hold object with using these rods after we attached sponge. Another faced problem is that servo motor which is responsible for vertical movement is not suitable for lifting entire system and object. We have added a supporting column in front of column with engine. We added a rod between two columns for supporting balance of gripper system.

When robot travels, gripper system is positioned above of robot. Because distance sensors should not see the gripper system while robot are traveling. After robot recognize an object and has reached the proper position to grip the object, the distance sensors are disable at this point, gripper can work for taking an object. At this point firstly vertical servo motor works and it makes its arms are down. Secondly, horizontal servo motors work and hold object with compressing. After this step, vertical servo motor works again and it makes its arms are up again. Lastly, horizontal motors work again and leave the object to bucket [1].

6.4. Colour Determination and Separation of Objects

In the colour determination part, we have faced a design problem due to range of RGB Colour sensor. Range of our RGB Colour sensor (TCS34725) to get data from the object in front of it is about 2-3 cm. Therefore, we had to place the colour sensor very close to the object which is caught. We designed a structure by using forex. This structure looks like a funnel to keep collected object on the RGB sensor, because the RGB sensor was implemented under this structure.

After colour determination, the next problem was to create a design to collect objects which have different colours in different baskets. To solve it, we added a new 2 baskets both sides of funnel, and the plane of the RGB sensor is connected to moving part of a servo motor. By this way, when colour of an object is determined, the plane below the object is turned to one side and object is collected in the basket according to its colour.

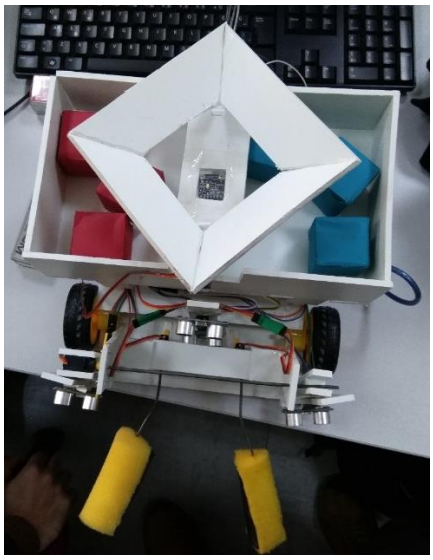

Figure 11: Impelementation of RGB sensor and Baskets

In the code part we checked 3 times of an object to get correct data from RGB sensor. It also solves another problem. For instance, if an object is stuck between funnel and plane while dropping to basket, it tries again and provides to drop the object into basket.

7. Analysis

During the implementation of the robot, we had a lot of serious and unplanned problems. Since we had some issues, we had to change some plans while making the robots. As it is mentioned in the project proposal, it is supposed to be used a 11,4 V Lipo battery with a 5V regulator but the regulator is burnt so we had to use a powerbank with 5V output. Besides, it is planned to drive the dc motors with two separate drivers, however after one of them was burnt it is used a single motor driver with connected the left side wheels in a single input and right side wheels in the other single input.

Driving the motors was not only problem during the implementation but also design of the gripper and bucket for objects. First, it is planned to put two different baskets back to back one after another and according the angle of the top servo motor robot puts the object in the corresponding bucket however, the length of the gripper should have been too long in that case and the power of the servo motors were not high enough. That's why, we used two bucket side by side and above the middle wall which divides two bucket, there is a cover that connected to a servo motor and according to the colour it turns left or right.

Finally, position of the RGB colour sensor was another issue during the implementation because the measure range of the sensor is maximum around 3 cm. Firstly, it is planned to put the sensor in front of the robot however it was impossible to measures the colour because the length of the grippers is more than 3 cm. After that, it is planned to put the RGB sensor above the cover which is on the buckets. Thus, gripper takes the object without knowing the colour and then it releases it into the cover. Finally, the colour of the object is found and the cover turns to corresponding position according to the colour of the object.

It is made a lot of minor changes during the process because there were a lot of unexpected issues. Eventually, all these issues are handled.

You can see differences between planned robot design and last design on Figure 12 and Figure 13.

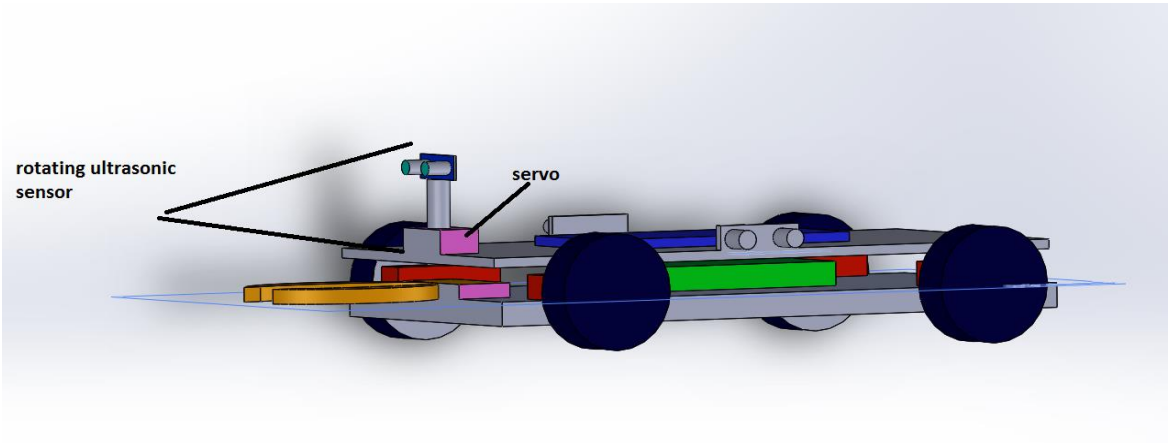

Figure 12: Planned Robot Sketch on Proposal Document

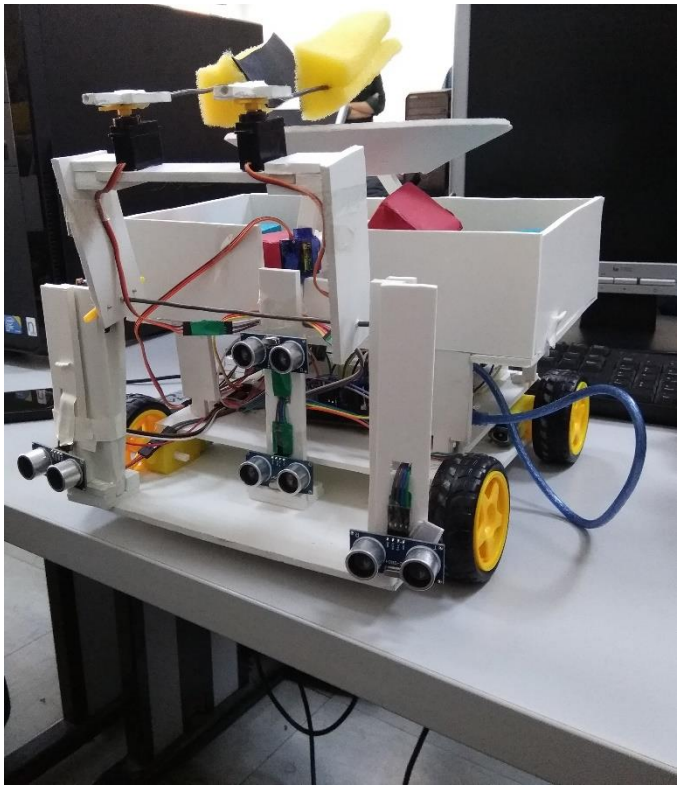

Figure 13: Last Version of Robot

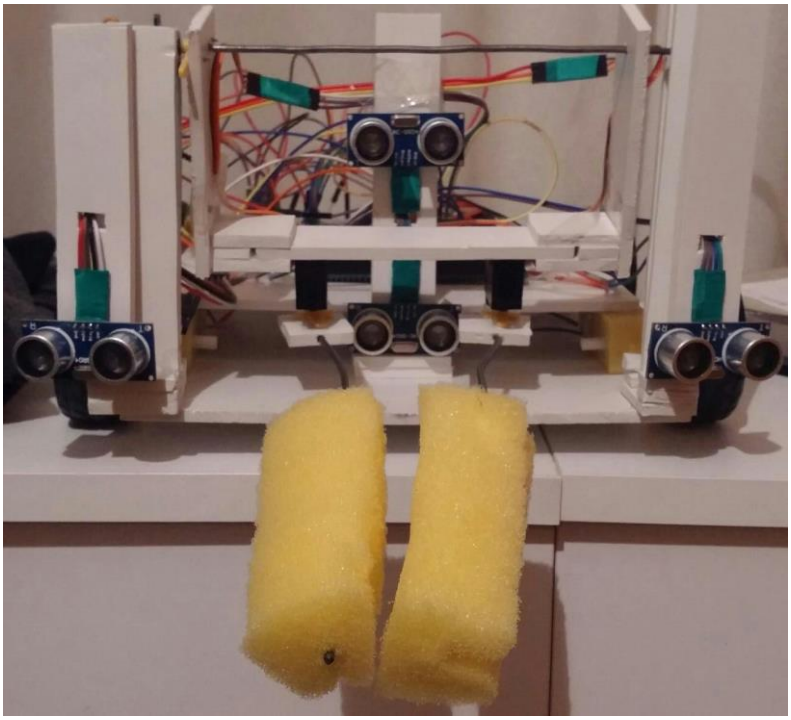

Figure 14: Robot 217

8. References

- [1] A.M. Al-Busaidi, “Development of an Educational Environment for Online Control of a Biped Robot using MATLAB and Arduino”, Mechatronics-REM, 2012.
- Figure 2 https://nvhs.wordpress.com/project/catspberry-2/
- Figure 4 http://randomnerdtutorials.com/complete-guide-for-ultrasonic-sensor-hc-sr04/
- Figure 6 http://www.azega.com/arduino-servo-motor-part-1/
- Figure 7 https://learn.adafruit.com/adafruit-color-sensors?view=all,

Robot demonstration video link is given below:

https://www.youtube.com/watch?v=FG66yUn1h1o