ECE110 Lab

Final Report

An Obstacle-Finding Car

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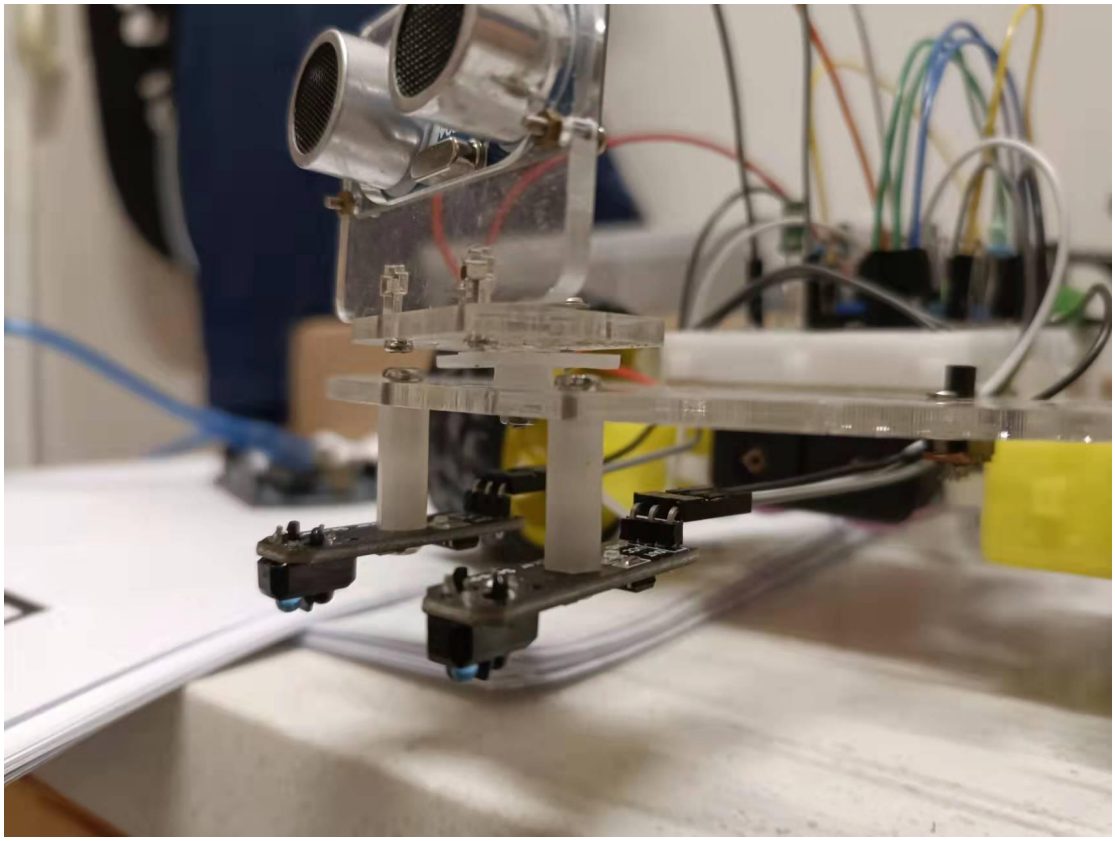


1. Introduction

1.1. Problem Description

We want to achieve three main goals.

1. Enable the car to follow a track.
2. Enable the car to stop when meets the “obstacle.”
3. Enable the car to chase the “obstacle” when the “obstacle” tries to flee away.

But what is the future application of the car? Why we build this car? What can an obstacle-finding car do?

Figure 1. Serve as a Safeguard (Picture is from the Internet)

It can serve as a safeguard robot. The robot can follow the safeguarding route at night. If the thief goes into the company, he will meet the safeguard robot, and when the thief wants to flee away, the safeguard robot will find him.

Figure 2. Serve as a Rescue robot (Picture is from the Internet)

It can serve as a rescue robot. When we are conducting a rescue mission. Chances are that the mission is dangerous and unknown. Under this situation, we can assign the rescue robot to find the obstacles ahead. Plus, they can play an important role in the places where humans are unable to go like toxic situations.

For these reasons, we want to build a junior model for this robot----an obstacle-finding car.

1.2. Design Concept

Sensors and Inputs: ultrasonic sensor, infrared emitter/detector
Actuators and Outputs: H-Bridge-based Motor Drive, PWM
Circuit Elements: MOSFET and Oscillation
The car will get its inputs from ultrasonic sensor and infrared emitter. The ultrasonic inputs together with the H-Bridge and the oscillation will enable the car to find the obstacle and stop when meeting the obstacle while the infrared emitter, together with the MOSFET and oscillation will enable the car to follow the given black track.

2. Analysis of Components

2.1.Characterization of each sensor

Sensor 1. Ultrasonic sensor: This sensor will emit an ultrasonic wave and when the wave hit an obstacle and rebound recycle the sensor will recycle the wave and obtain the distance between the sensor and the obstacle. If it’s far away from an obstacle, the duty cycle of the

Ultrasonic sensor is small. In contrast, if it's near the obstacle, the duty cycle will be larger. In other words, the nearer from the obstacle, the larger the duty cycle. We use this characteristic to change the direction of wheel by using an H-Bridge and a Schmitt trigger.

Figure 1&2&3. Ultrasonic Sensor. The right side ("Trig" shown as the yellow) emits an ultrasonic wave, and the left side ("Echo" shown as blue) recycles it. The right upper graph shows the voltage when the sensor is away from the obstacle, while the right lower shows the opposite situation.

Sensor 2. Infrared Detector: This sensor will emit an infrared light. If the light hits a black object, chances are that the black object will absorb the infrared light, leaving scarce light to return. Vice versa. And when light is received by the black light bulb, it will output a low voltage while the light is not received by the black light bulb, it will output a high voltage. This characteristic is used to control the on/off of the motor, which enables the car to change its direction accordingly.

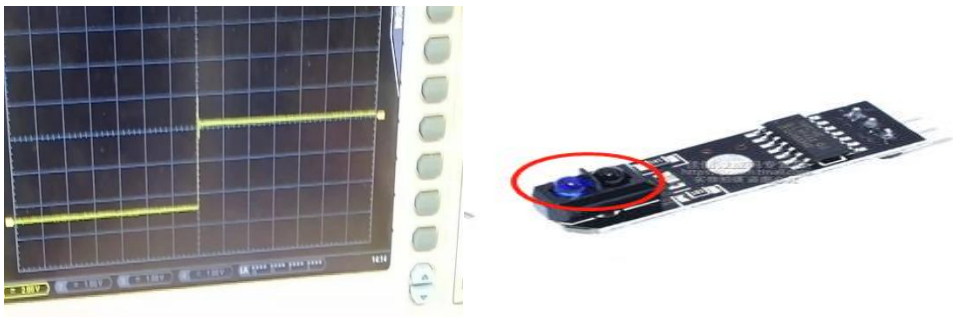


Figure 4&5. Infrared Detector. The blue light bulb will emit light, and the black light bulb will recycle it. The blue light bulb will emit light, and the black light bulb will receive it. If the black light bulb receives enough light, it will output a high voltage. If the black light bulb doesn't receive enough light, it will output a low voltage.

2.2.Design considerations

Based on the analyses of the sensors' characteristics, we made the following design decisions. We use an H-Bridge and a Schmitt trigger to control the direction of the wheel. When the car is far away from an obstacle, the duty cycle of the wheels is positively dominant, making the car move forward. However, when the car is close to an obstacle, the duty cycle is reversed, and the car will move backward. As for the ultrasonic sensor, we connect each one to a motor. When the car needs to turn a direction, one of the infrared detectors won't emit the light to the black line and manages to receive the light, outputting a low voltage, making the

MOSFET shut down, and that wheel will stop while the other one keeps turning. And as a result, the car successfully makes a turn.

At first, we only used the ultrasonic sensor, hoping that the car will move forward and backward. However, due to the large friction between the car and the ground, the car fails to move forward and then backward, it will stick to the ground at some point. Since we don't plan to use Arduino, we decided to add an infrared detector instead, making the car to achieve another goal (as described in the "Problem Description" part). To use the infrared detector, we need to carefully position the place of the detector to enable it to emit and receive light properly.

3. Design Description

3.1.Block diagram

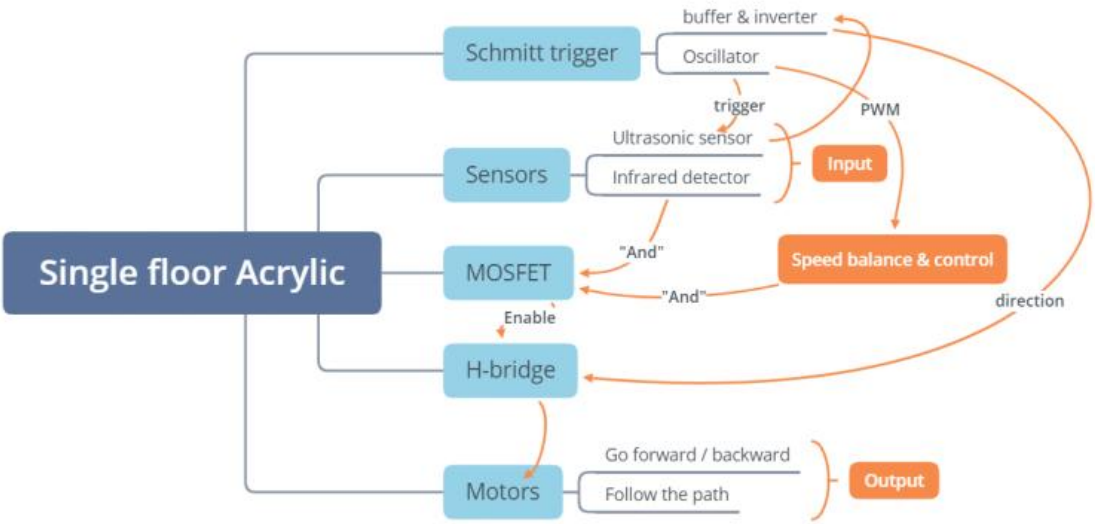
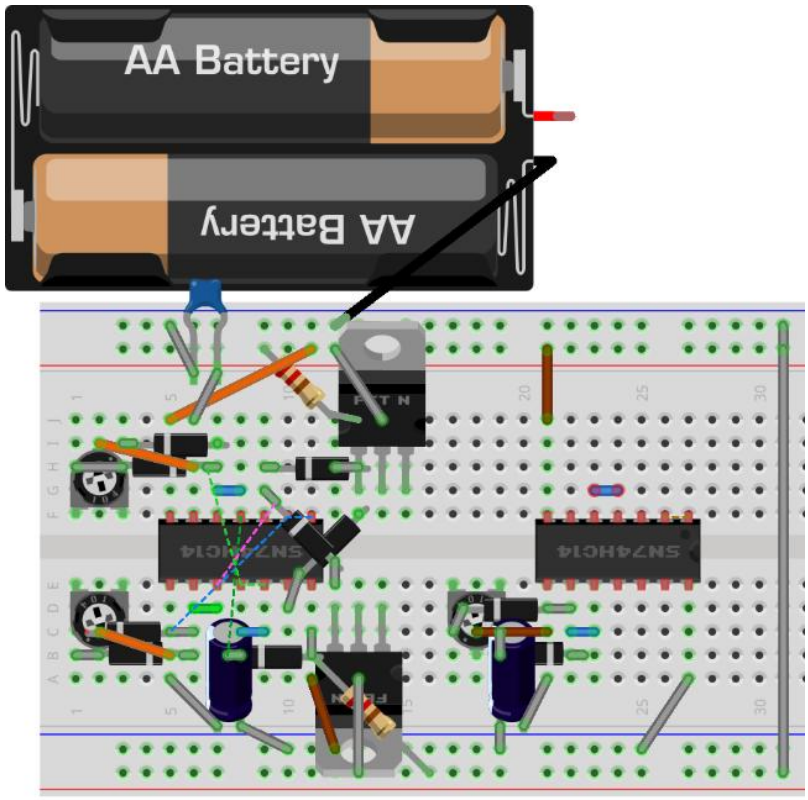


Figure 7. Block diagram

3.2.Circuit schematics



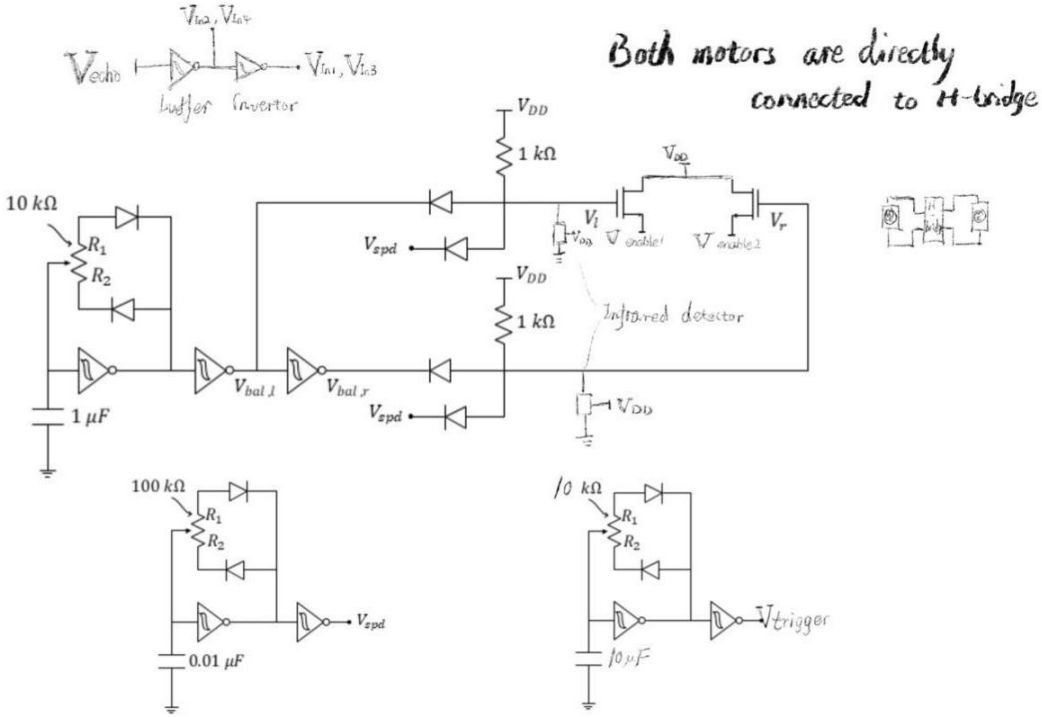
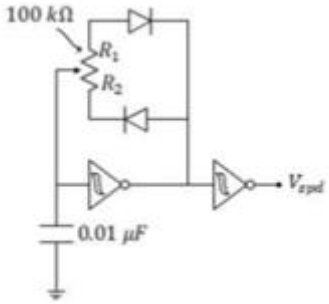


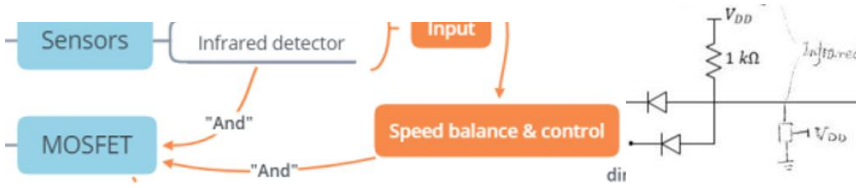
Figure 8&9. Circuit Schematics

Reactions that the vehicle produces corresponding to environmental conditions it detects that is, the output of the vehicle, mainly appears through the behavior of motors, which is directly controlled by H-Bridge-based Motor Drive with full authority. Overall, the H-Bridge-based Motor Drive receives signals for each motor with two categories, one of which is enabling signal, determining whether a motor works or not, as the other one is direction signal, determining which direction the motor runs in if it's enabled.

Enabling signal is produced by the power source, two oscillators (controlling both balance and speed of motors), and outputs of two infrared detectors.



The figure on the left shows one example of oscillator in circuit. An input terminal of Schmitt trigger is connected to the ground through a capacitor and to the corresponding output terminal through a resistor. At the very beginning, the input terminal is at low electrical potential so that a high electrical potential is produced at the output terminal, charging the capacitor, until the electrical potential of input terminal, connected to the capacitor, is high enough. Then the output terminal would be at low electrical potential, and thus the capacitor would begin to discharge itself, until its potential is low enough for it to get back to the beginning of the cycle. In this circuit, resistors are replaced with potentiometers and diodes so that the rate of charging and discharging can be modified easily and thus duty cycles can be modified easily. For the speed-balancing oscillator, an invertor is added to produce two PWM signals with opposite duty cycles.



The three sections are connected, through an "And" logic node on the Gate of a MOSFET for each motor. If and only if all of the four sources (V_{DD}, V_{spd}, V_{bal} and V_{infra}) are offering signals, the node would offer a signal. Oscillators, producing PWM signals, determine the speed of motors, while the output of an infrared detector determines on/off of a motor. When an infrared detector meets the black path, it will stop supplying the signal and thus the motor on its side would stop working at all.

Direction signals are produced by the ultrasonic sensor, a buffer, and an inverter (Schmitt trigger). The original signal of the ultrasonic sensor is firstly buffered, and then supplied to In 2 for a motor and In 4 for another motor on H-Bridge-based Motor Drive. The buffered signal is secondly inverted and supplied to In 1 and In 3. Therefore, normally, when there is no object detected by the ultrasonic detector, the original signal provided by the detector is relatively low. Input is low for In 2, In 4 and conversely, high for In 1, In 3. Motors row forward. If an object is detected, the original signal gets relatively high. Input is high for In 2, In 4 and low for In 1, In 3. Motors row backward.

(In 1, In 2, In 3, In 4 terminals are all on the H-bridge. In 1 and In 2 control one motor, while In 3 and In 4 control another.)

Overall, the input signals can be modified through three ways. Turning knobs of the two potentiometers alters speed level and speed balance of motors. Infrared detector meeting the black path disables the motor on the corresponding side. Ultrasonic sensor detecting an object in front of the vehicle drives motors to row backwards if they are not disabled.

3.3.Physical/mechanical construction

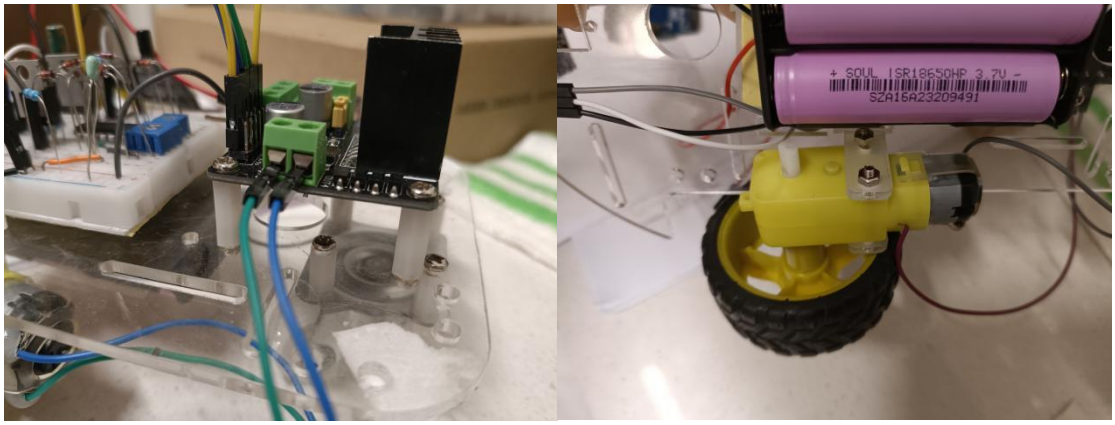


Figure 10&11. H Bridge

H-bridge is connected to the acrylic board with four plastic sticks. Each motor is pinched by two pieces of plastic flakes.

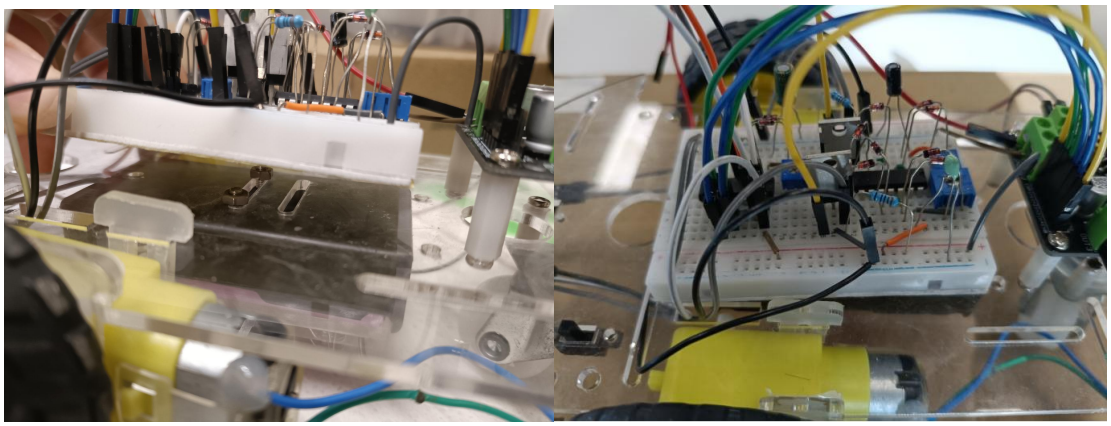


Figure 12&13. Overall circuit

Batteries are attached to the acrylic board with screws and nuts. The bread board is set to the acrylic board with multiple wires.

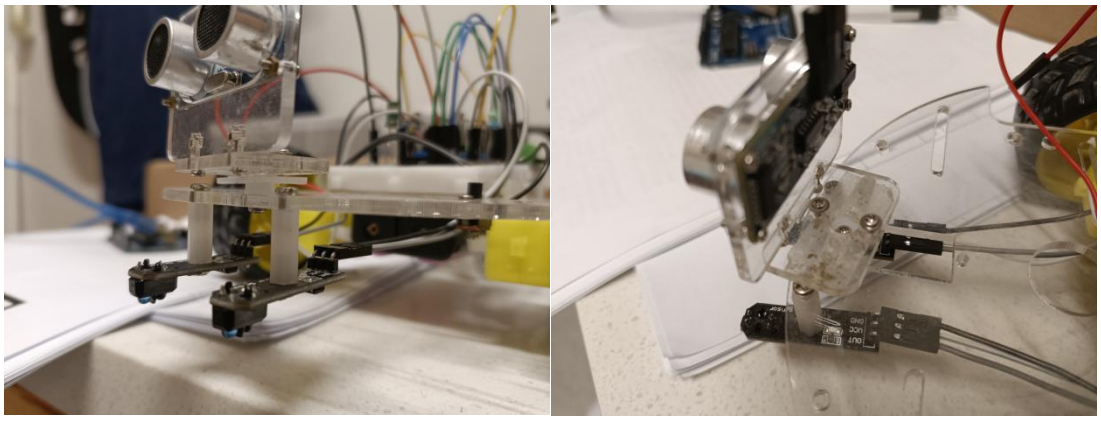


Figure 14&15. Ultrasonic Sensor and Infrared Detector

Ultrasonic sensor is fixed to a cloud platform. To leave space for screws fixing infrared detectors, we applied the cloud platform to an extra mini platform so that a gap is created for the screws.

4. Conclusion

4.1.Lessons Learned

We planned to make the car move forward until it meets an obstacle and then move backward. However, when we managed to build up our circuit and put it into a test, we regretfully found that the car was unable to move backward. Instead, it will stick to some place and can't move forward nor backward. We analyze this it is because the friction between the wheel and the ground was large. Since the car move forward and slow down due to the smaller positive duty-cycle, the car is unable to move forward to reverse the duty cycle. Therefore, it sticks to some place. This was the unexpected obstacle we encountered during our design process. Luckily, we find out this outcome have some real-life function if we add a infrared detector to the car, which will enable the car to find an obstacle and even follow the obstacle. In other words, we "utilize" this outcome to make the present car. Through this experience, our group learned that, even misfunctioning can turn out to be a good start if we can see the outcome in a different angle.

Another difficulty we met was that we failed to add LEDs and a buzzer into our design. We planned to add LEDs and a buzzer into our design. However, when we tried adding them into our circuit, the light didn't illuminate as we expected. It worked rather weirdly. To make the matter worse, when we changed the position of the LED, the car even failed to function properly. Due to the limited knowledge, we were unable to analyze the disfunction of the LED. At last, we had to give up this design.

Although it's not required to write about our knowledge and experience gained from this class. We think it of necessity to retrospect what we have learned to make a good conclusion to the end of this course.

Needless to say, we have gained much knowledge of electronics. We learned how to use

H-Bridge, Schmitt Trigger, Potentiometer, Ultrasonic Sensor, Buzzer, Infrared Detector, and so on. This is a good compliment of the ECE110 classes, which we can know the practical application of electronic devices.

We have gained much knowledge of experiment. We learnt how to use oscilloscope. And we have acquired the precious knowledge of trouble shooting by using the oscilloscope.

And we have realized the importance of cooperation. Apart from the normal class, we will meet on Friday to do some extra work like learning modules and building our cars. It's at that time we learnt to use H-Bridge as well as Ultrasonic Sensor, which contributed to our final project.

4.2.Self-Assessment

Bingjun Guo:

I feel great to see our car accomplishes the three goals we set previously. Even if our car cannot turn backward when meeting an obstacle, we thought of a way to solve this problem by Arduino. But since we don't plan to use Arduino, therefore, we didn't carry that out, instead, we utilized our misfunctioning car to achieve other goals. Honestly speaking, the car is not perfect, though. Due to the poor condition, the ultrasonic sensor does not work properly considering it will receive a variety of echo. Therefore, our car does not go smoothly when putting into the track. This needs future improvement.

Plus, since using Arduino isn't required in this course, we didn't include it into our design. We planned to use Arduino to make more functions to the car like turning to another direction, changing speed and so on. And maybe we can include other sensors like photosensors or thermosensors into our car.

Feiyu Tang:

Although we failed to accomplish our proposal, we managed to make use of our failures to build a different car. It can follow the given track; it can find out the obstacle; and it can chase the "obstacle" when the obstacle wants to leave away. However, there still needs some improvement. For example, we might need other outputs like LED or Mosquito Buzzer to indicate the exact place of the car.

Still, there is a long way from our junior model to the safeguard robot and the rescue robot. We need to add sound and light output to indicate where the obstacle is. And we also need to write program to tell the robot to leave the obstacle and find another way. This is our future improvement of the car. And step by step, we can build up the safeguard robot and the rescue robot.