

# Hardware Document

## Project: LIBERTY

**Task:** Describe the design of the hardware

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**Author:** Xijun Liu

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# McGill

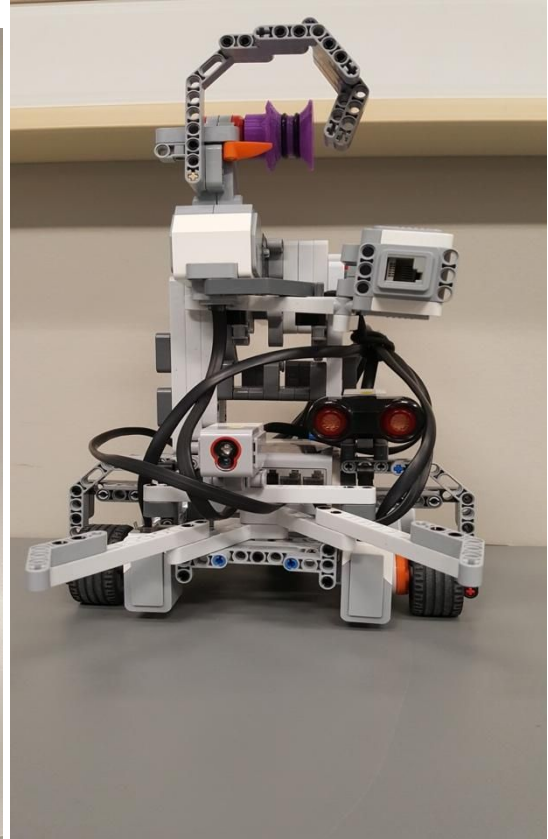
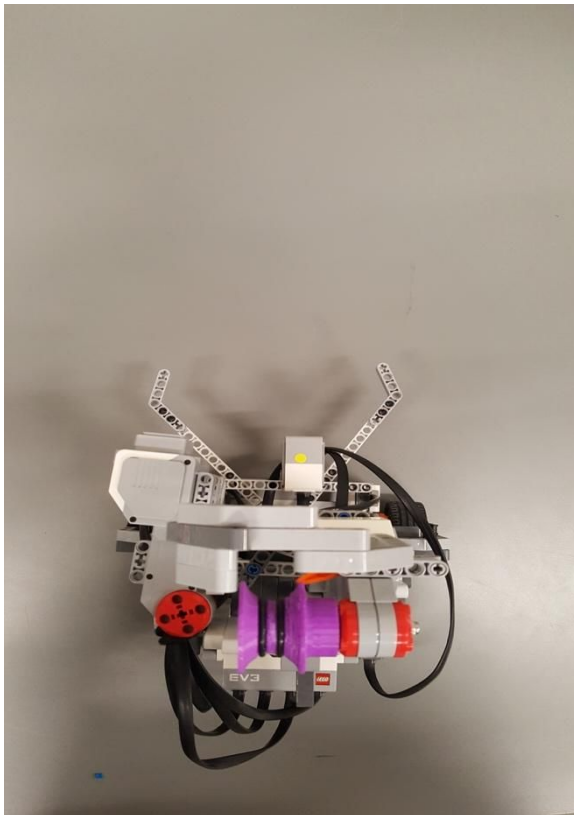
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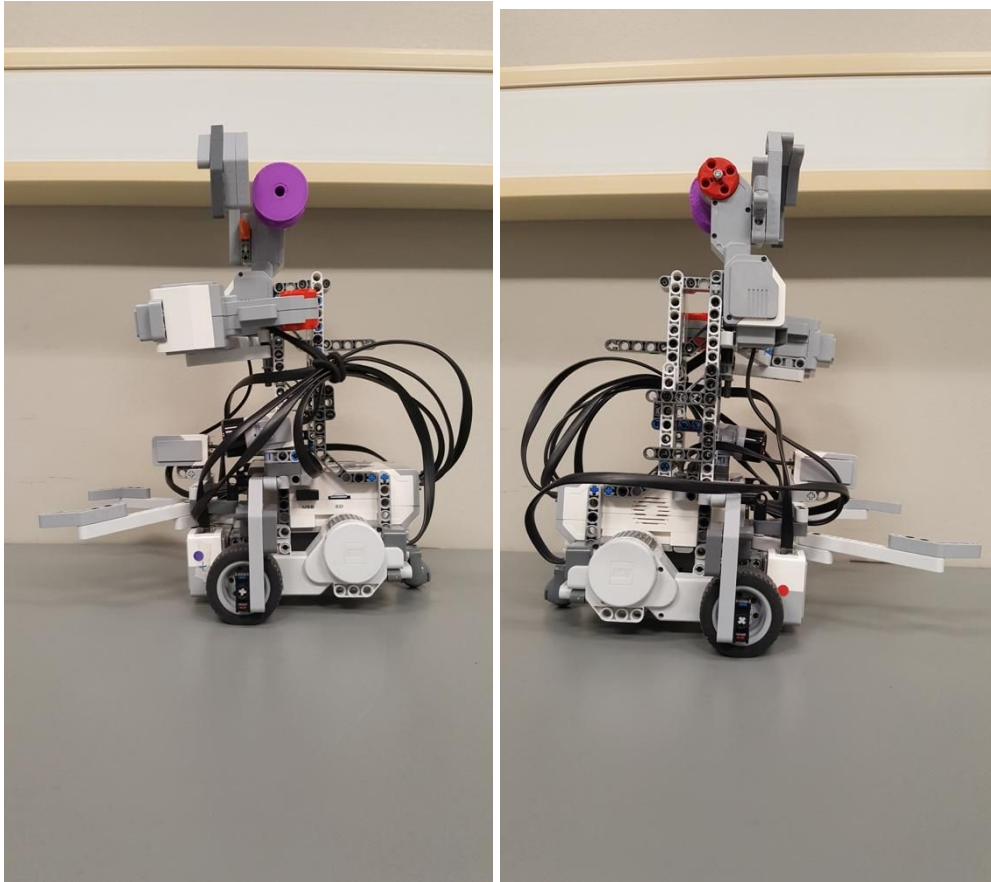
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## 2. GENERATED DESIGN

### 2.1 DESIGN CHOICES

**Figure 1:** Image of the final iteration of the robot (top, front, right, left)





## 2.2 SPECIFICATIONS

The robot is built with three color sensors, an ultrasonic sensor, a 3-D printed pulley and 3 motors. The US sensor is set on the robot and facing straight, in order to detect obstacles and provide rough angle correction for localization. In addition, two of the color sensors are placed in

front of the two wheels separately and downward. Design like this will improve the performance of localization and odometry correction. There is another color sensor placed in front of the robot and facing forward. The functionality of it is to complement the US sensor to detect the object in the way, as well as detect the targets' color, which will be used in the future project. Moreover, two motors are used to drive the wheel and the other one is connected to the pulley, providing power when the robot is on the zip-line.

Additionally, we added a motor to balance the robot while it is traveling over the zip line, a guide for the block to have it face the color sensor directly (see **Figure 5**) and a guide for the zip line to allow for a greater error tolerance (see **Figure 6**).

In short, the robot possesses the following parts:

- 1 Ultrasonic sensor, place towards the front
- 3 Color sensors (two to the sides of the front wheels and one towards the front)
- 4 Motors (2 NXT motors to control the movement of the system, 1 EV3 Motor to control the movement on the zipline and 1 EV3 Motor to balance the robot on the zip line)
- 1 EV3 Brick
- 1 Rechargeable Battery

## 2.3 ACCURACY

The ultrasonic sensor (or US) has:

- A detection range of [0,250] cm<sup>[1]</sup>
- An accuracy to within +/- 1cm (in imperial: +/- 0.394 inch)<sup>[1]</sup>

The color sensor on the other hand has:

- a detection range of eight colors. It can tell the difference between color or black and white, or between blue, green, yellow, red, white and brown.<sup>[2]</sup>

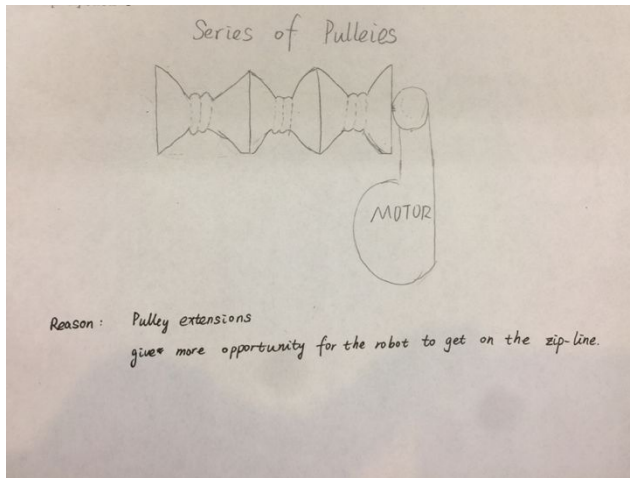
## 2.4 FACILITIES USED

The playing field was used in the design of the system to determine the appropriate height and to test if the system could withstand the load under its own weight (see **REQ - ZIP; 2.2.2**).

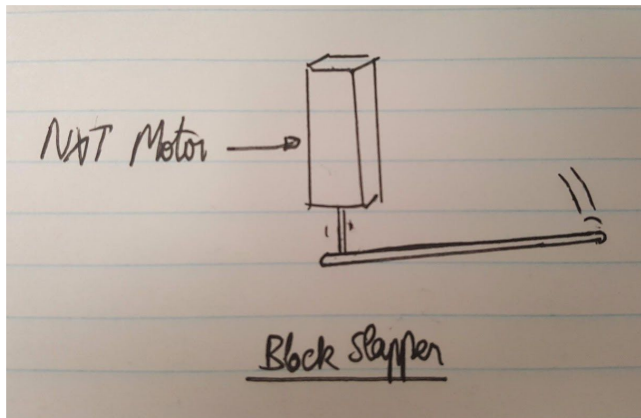
# 3. ALTERNATIVE DESIGNS

Apart from the design proposed above, our team has also established two alternative solutions in regards to the design of the hardware.

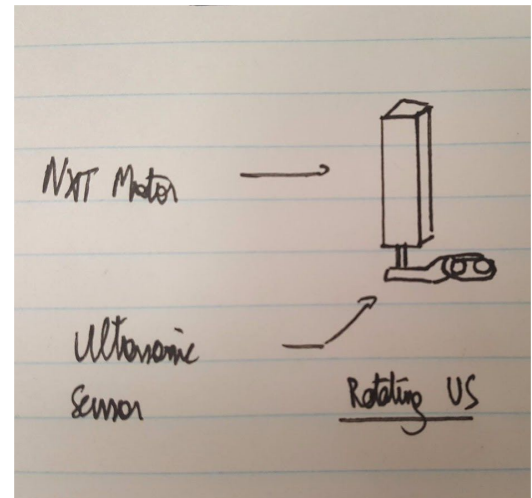
- Assuming that the amount of sensors remains unchanged, two ultrasonic sensors and two color sensors could be used. Two US sensors could be placed in parallel at the front of the robot which would be used to improve the accuracy of the data from the US sensors and would allow to better filter out outliers. Meanwhile, the extra US sensor will make it possible to detect the obstacles from the other side. One of the color sensors would be placed on the back of the robot facing downward. It would be used to finish the accurate localization and the odometer correction. While the other color sensor would still be set in front of the robot and facing forward, with the same role as the current prototype. See **Figure 5**.
- An additional motor could be used for the rotating US sensor. In this way, the robot will detect the obstacles from the all directions which is considered as “forward”. See **Figure 4**.
- Using an addition motor, we could implement a “block slapper” that would move blocks that are of the wrong color outside of the search area. This would prevent looking at the same block multiple times. See **Figure 3**.
- A series of pulley could be placed instead of a single one. Design like this will increase the rate of zip-line mounting success. However, the structure might not be robust enough to support the robot when traversing the zip-line. See **Figure 2**.



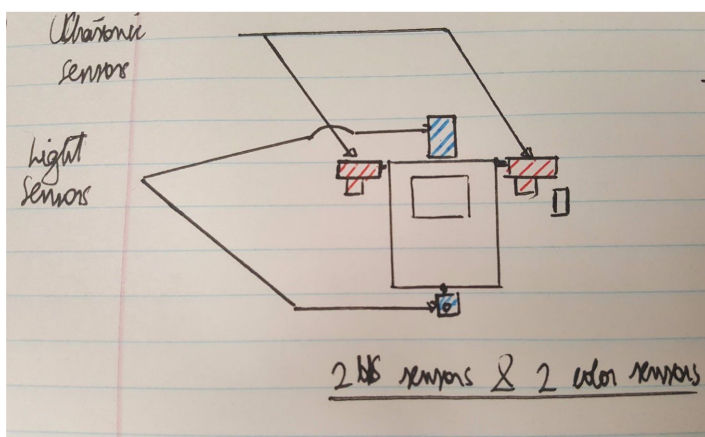
**Figure 2 Pulley extension**



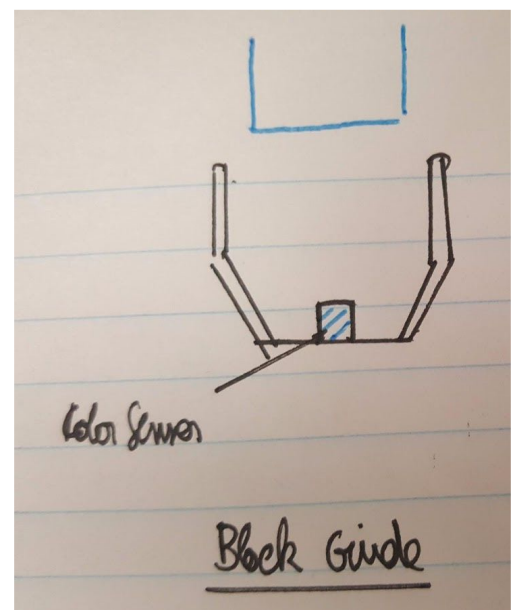
**Figure 3 :** Diagram of the Block Slapper



**Figure 4 :** Diagram of the rotating ultrasonic sensor

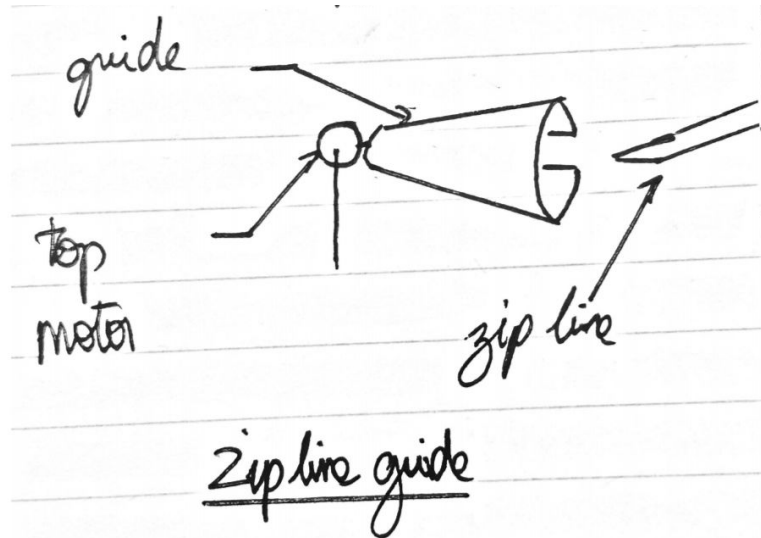


**Figure 5 :** 2 US Sensor & 2 Color sensors



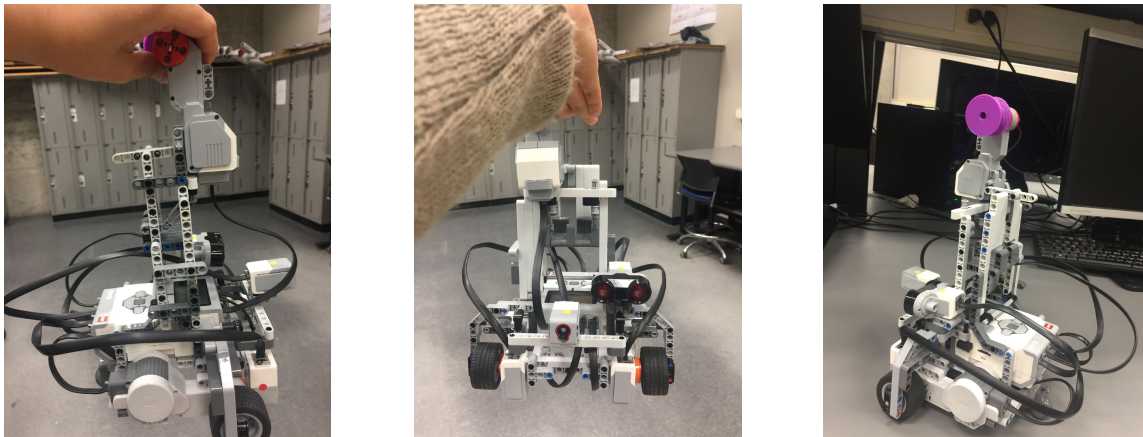
**Figure 6 :** Diagram of the block guider





**Figure 7 :** Diagram of the zip line guide

## 4. EVOLUTION OF DESIGN



**Figure 7:** Image of the prototype used for the research and development of zip line navigation

According to the test of localization run by Edward Son on 11.3, the forward-facing color sensor affects the data from the US. Thus, we move the color sensor towards the right by one slot of the LEGO piece. By test (testing documentation of localization by Claire Liu on 11/14), the US is not influenced anymore. In addition, the extra motor with the purpose of countering weight is fixed with two connectors instead of two.

## 5. GLOSSARY OF TERMS

US: ultrasonic sensor.

## 6. REFERENCES

- [1] Sensor, E., ACCURATE, I., stuff!, R. and specification, N. (2017). *EV3 Ultrasonic Sensor - 45504* | MINDSTORMS® | LEGO Shop. [online] Shop.lego.com. Available at: <https://shop.lego.com/en-CA/EV3-Ultrasonic-Sensor-45504> [Accessed 23 Oct. 2017].
- [2] Sensor, E. and sum-obots....., G. (2017). *EV3 Color Sensor - 45506* | MINDSTORMS® | LEGO Shop. [online] Shop.lego.com. Available at: <https://shop.lego.com/en-CA/EV3-Color-Sensor-45506> [Accessed 23 Oct. 2017].