ECSE 211 - Design Principles and Methods

HARDWARE DOCUMENT

GROUP 11
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Abstract

This document is intended to outline 4 hardware designs and the differences between them. It will cover the input components (ultrasonic sensors and color sensors), the output components (motors), and the ball launching mechanism. These designs have been evaluated, and ultimately a final design has been chosen, revised and refined in order to best complete the competition's task. For the final competition on *April 5th, 2017* , Group 11 has adopted **design 4** as its final hardware design.

Contents

1 EDIT HISTORY

- March 8th 2017:
  - **Ethan Lague:** Initial set up of document sections (including table of contents), completion of first draft of sections 1 through 7.
- March 9th 2017:
  - **Alex Lam:** General Re-Formating
- March 14th, 2017
  - **Durham Abric:** Updated abstract and ball launcher sections to reflect progress and design decisions the team has made.
- March 23th, 2017
  - **Ethan Lague:** Added **design 4**, the final hardware design to the document and added methodology section.
- March 29th, 2017
  - **Ethan Lague:** Added changes to **design 4**, added to methodology section, and added introduction section.
- April 8th, 2017
  - **Ethan Lague:** Modified **design 4**, reasoning, and abatract. Vectorized Figures.

2 INTRODUCTION

2.1 Purpose

Our vehicle is a fully autonomous robot that is capable of localization, navigation, obstacle avoidance, odometry, and retrieving a ball that can be shot into a target. In addition, the robot is capable of defending all the listed capabilities. The purpose of this document is to provide a detailed overview about the Hardware designs of the robot. A detailed description of the components of each of the 4 hardware designs is covered as well as the reasoning for the hardware decisions made for the final design.

2.2 Context

See requirements document included in the reference package.

2.3 Audience

This technical document is intended for parties who are interested in maintaining, testing, or extending the hardware that is included with the project. It is assumed that all readers have a sufficient understanding of the EV3 components such as ultrasonic sensors, color seonsors, motors, and the EV3 itself.

2.4 Scope

The scope of our project will be limited to only achieving the list of requirements specified by the client. Therefore, no additional features will be added.

3 ULTRASONIC SENSORS

3.1 Design 1

The robot in design 1 uses 2 ultrasonic sensors for localization and obstacle avoidance. The first ultrasonic sensor is placed static horizontally facing the front. The second ultrasonic sensor is placed vertically on a motor where it will rotate to either face the left or right side. It will only be engaged once the first motor sees an obstacle and will turn either left or right to face the obstacle. Refer to Figures 1 through 4.

3.2 Design 2

The robot in design 2 uses 3 ultrasonic sensors for localization and obstacle avoidance. The first is placed static horizontally facing the front. The two others are placed static facing the left and right sides of the robot. Similar to design 1, the two sensors facing either side will only be engaged when in the process of obstacle avoidance. Refer to Figures 5 through 8.

3.3 Design 3

The robot in design 3 uses 2 ultrasonic sensors for localization and obstacle avoidance. Both sensors are placed horizontal with an angle of 90 degrees between them on a motor. One sensor will face the front, and that will be used for localization. During obstacle avoidance, the motor will rotate the sensors so that one is facing the front while the other is facing the side that the obstacle is on. Refer to figures 9 through 12.

3.4 Design 4: Final Hardware Design

The robot in design 4 uses 1 ultrasonic sensor. The sensor is placed statically facing the front extending out from under the EV3 brick. It is used for localization and to detect obstacles. Refer to figures 13 through 16.

4 COLOR SENSORS

4.1 Design 1

The robot in design 1 uses 2 color sensors for odometry correction. The two sensors are placed adjacent to each other with respect to the robots velocity. they are placed vertically 3mm away from the ground. Refer to figures 1 through 4.

4.2 Design 2

The robot in design 2 uses 1 color sensor placed at the front of the robot facing the ground with 3mm of separation. Refer to figures 5 through 8.

4.3 Design 3

The color sensors in design 3 are placed the same as in design 1.

4.4 Design 4: Final Hardware Design

There are two color sensors in Design 4 placed laterally along the front of the robot, as close to each respective wheel as possible. Refer to figures 13 through 16.

5 MOTORS

5.1 Design 1

The robot in design 1 uses 4 Motors. 2 NXT motors are placed on either side of the robot each attached to a wheel for movement of the robot. 1 EV3 motor is used for the ball launcher. Another EV3 motor is placed horizontally in the middle of the robot for the rotating Ultrasonic sensor. Refer to figures 1 through 4.

5.2 Design 2

The robot in design 2 uses 3 Motors. 2 NXT motors are placed on either side of the robot each attached to a wheel for movement of the robot. 1 EV3 motor is used for the ball launcher.Refer to figures 5 through 8

5.3 Design 3

The robot in design 3 uses 4 Motors. 2 NXT motors are placed on either side of the robot each attached to a wheel for movement of the robot. 1 EV3 motor is used for the ball launcher. Another EV3 motor is placed horizontally at the front of the robot to turn the two ultrasonic sensors. Refer to figures 9 through 12.

5.4 Design 4: Final Hardware Design

The robot in design 4 uses 4 Motors. 2 NXT motors are placed on either side of the robot each attached to a wheel for movement of the robot.There are two EV3 motors placed horizontally on top of a tower built up vertically from the brick that are used in the ball launcher mechanism. Refer to section 6.2 and figures 13 though 16.

6 BALL LAUNCHER

6.1 Designs 1-3

The ball launcher is the same for the three initial designs. An EV3 motor is placed vertically towards the back of the robot. A long arm is extended from the motor with a claw like basket to hold the ball. The motor is oriented so that the arm rotates perpendicular to the robots velocity to increase the overall stability when firing. Refer to figures 1 through 12.

6.2 Design 4: Final Hardware Design

As seen in section 5.4, the ball launching mechanism uses two motors placed horizontally. A sturdy tower was built vertically from the EV3 brick which supports the two motors. The catapult arm will rotate down perpendicular to the ground along the back of the robot. There, the ball can be loaded. The robot can travel with the ball since two small lego pieces are placed on the sides of the claw where the ball is held. When launching, the motors rotate the arm to throw the ball over the top of the robot. Three rubber bands are stretched from the middle of the throwing arm to the top of the tower to add torque when throwing the ball.

7 REASONING

7.1 Ball Launcher

Designs 1, 2, and 3 were the initial designs for the robot. once we realized that the ball luncher we had in mind could not generate nearly enough torque the throw the ball the distance required, we decided to scrap those models and create an all new design for the ball launcher using two motors. Both motors are placed at the top of a tower like structure. This decision is made because being able to bring the throwing arm down so that is perpendicular to the ground allows it to swing the ball from there enabling it t release the ball at a more optimal angle and throw it farther. We chose to design a very simple claw-type mechanism where the ball sits while being transported. This is because too many excess pieces can inhibit the release of the ball while launching.

7.2 Color sensors

After testing the odometry without correction, we realized that using two color sensors was optimal for navigation. We put the color sensors just in front of the wheels so that whenever one sensor passes over a line, the corresponding wheel stops until the other sensor passes over the same line. Since the hardware is faulty and every so often one of the color sensors misses a line, we implemented a correction where if 1 second passes after the first light sensor hits a line and the second sensor has still not passed the line, the wheel corresponding to the second light sensor will stop and travel back to where it was when the first light sensor hit the line and then the robot will continue forward. The color sensors are also used in ball retrieval and in the aiming process for the shooting of the ball. For both cases the robot will line up to two perpendicular lines using the light sensors so that its odometry is as accurate as possible. This will allow us to be precise when retrieving and shooting the ball.

7.3 Ultrasonic sensors

Since two motors were used for the ball launcher and two color sensors we were used for odometry correction, we were limited in our design for ultrasonic sensors due to the limited number of ports in the EV3. Since there were no output ports available we could not manipulate the ultrasonic sensors with a motor in any way and since there were only two input ports available we were restricted to maximum two static ultrasonic sensors. We decided to use only one front-facing sensor to minimize the number of threads since the EV3 brick can only run so many. The sensor is used for localization and obstacle avoidance. We decided to place the sensor under the EV3 brick in this design for two reasons. First, it allows the sensor to see obstacles that are much lower to the ground than it could if the sensor was above like in designs 1, 2 or 3. Second, it allowed us to attach a ball bearing beneath it touching the ground so that when the robot launches the ball the bearing touches the ground stopping the whole robot from swinging forward. This allows the robot to throw the ball much farther, and reduces the error in odometry after every shot.

8 FIGURES

Figure 1: Design 1 front

Figure 2: Design 1 side 1

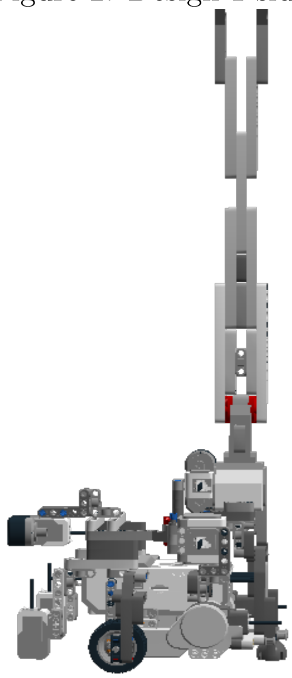


Figure 3: Design 1 side 2

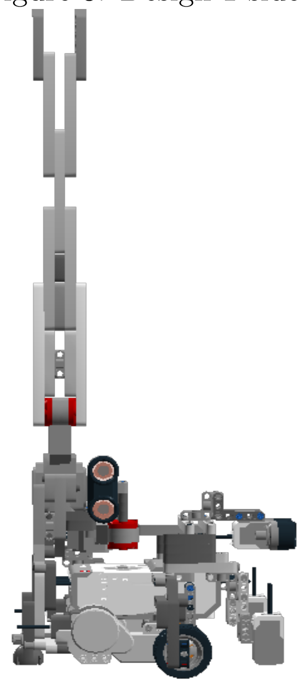


Figure 4: Design 1 back

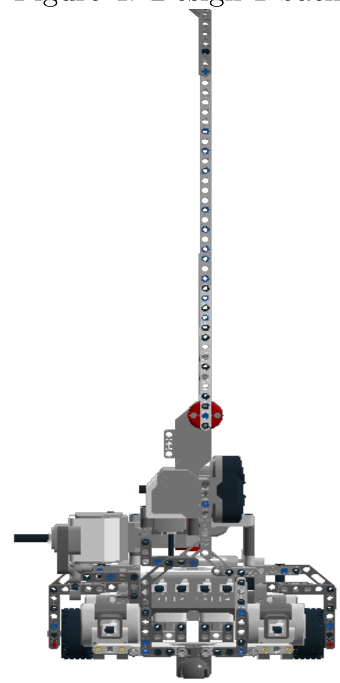


Figure 5: Design 2 front

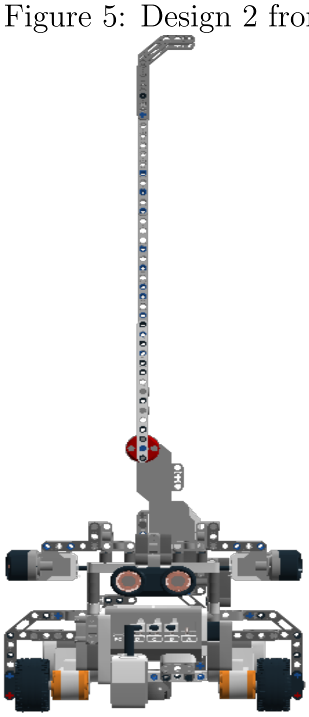


Figure 6: Design 2 side 1

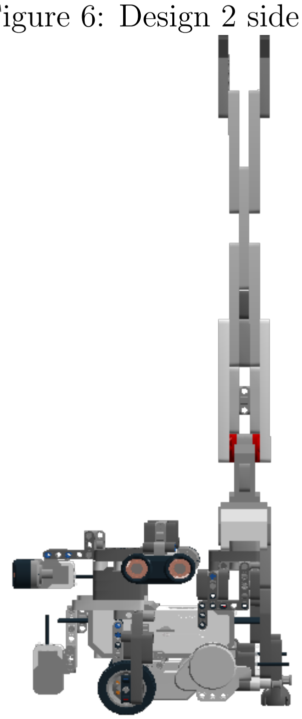


Figure 7: Design 2 side 2

Figure 8: Design 2 back

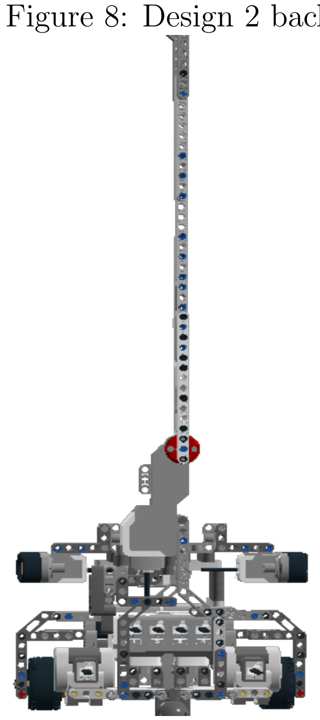


Figure 9: Design 3 front

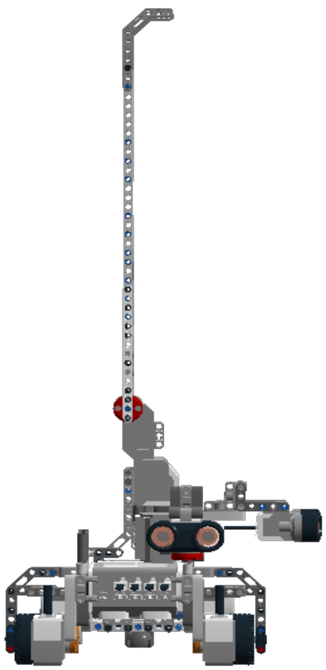


Figure 10: Design 3 side 1

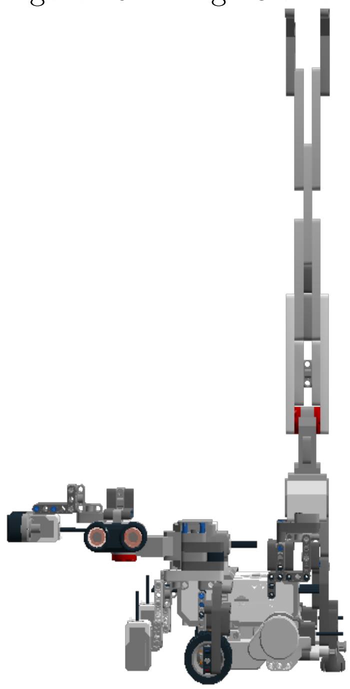


Figure 11: Design 3 side 2

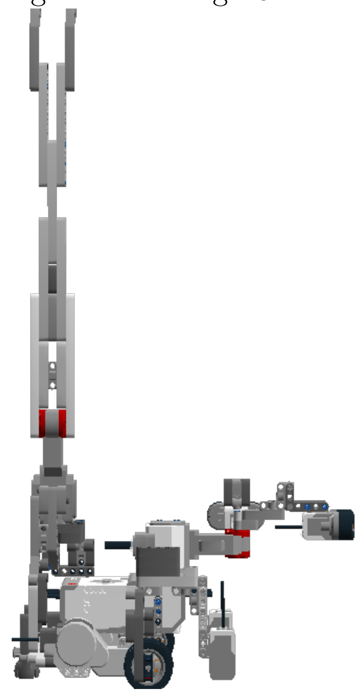


Figure 12: Design 3 back

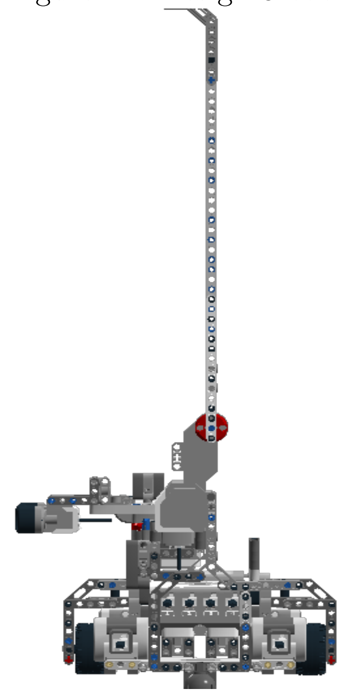


Figure 13: Design 2 front

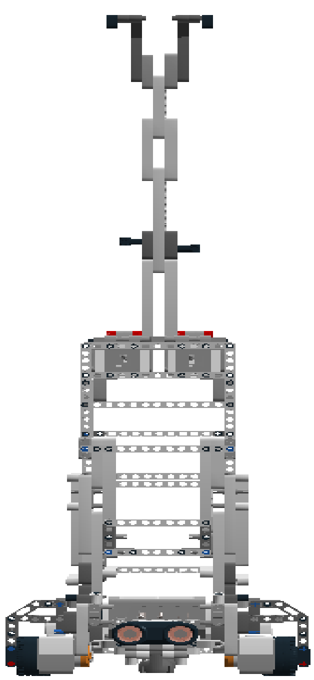


Figure 14: Design 2 side 1

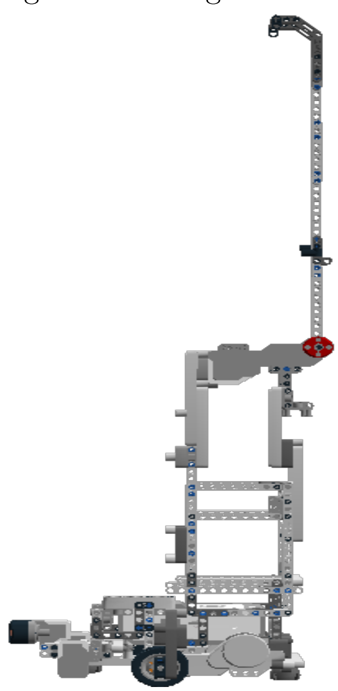


Figure 15: Design 2 side 2

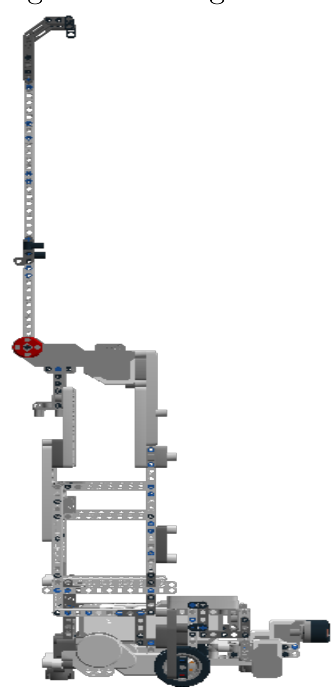
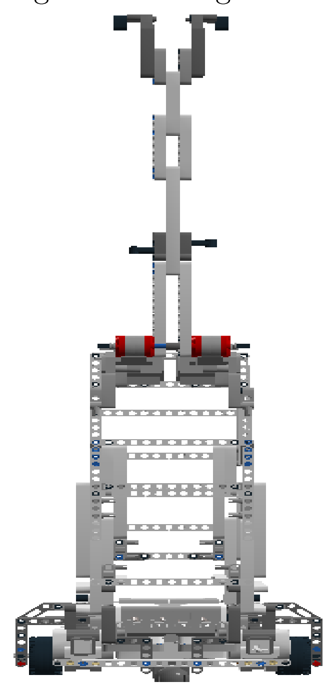


Figure 16: Design 2 back



9 GLOSSARY OF TERMS

- Ultrasonic sensor: A sensor which emits sound waves to pick up its proximity to an object.
- Color Sensor: A sensor which picks up on the color of an object which given the black lines on the field can help the robot know where it is.
- "The client" in this document refers to Professors Lowther and Giannacopoulos giving this course.