Linebot Design

1. Microcontroller: Arduino Uno
   1. An Arduino Uno is well suiting to this project. The code will be simple enough that an Arduino Uno can perform the task. Arduino is easy to use, and I am already familiar with the platform. I already have an Uno on hand, so I won’t need to buy another microcontroller for this project.
2. Motor Driver: Dual MAX14870 Motor Driver Shield for Arduino
   1. <https://www.pololu.com/product/2511>
   2. This motor driver shield interfaces easily with Arduino Uno. The shield also has an Arduino library on GitHub, which will simplify the code on my end, allowing me to focus on the control theory.
   3. **Power**: The input voltage of the shield ranges from 1.5 V - 11 V. The shield can be powered from a 9V battery and can power the Arduino as well (by using a shorting block.) I would prefer only one compact power source, so this is desirable. WARNING: When powering the Arduino from the shield, NEVER connect a different power supply to the Arduino’s Vin or power jacks. You’ll blow everything up.
   4. **Pins**: The shield uses digital pins 6, 7, 8, 9, and 10 (right side of Arduino) and the Vin, both GNDs, and 5V pins (left side of Arduino.) This leaves me digital pins 1-5 & 11-13, and analog pins A0-A5. These will be needed to communicate with the QTR-8RC Reflectance Sensor Array.
   5. **Important specs**: 1.5 V – 11 V input voltage, continuous 1.2 A per motor
3. 210:1 Micro Metal Gearmotor MP 6V
   1. <https://www.pololu.com/product/2369>
   2. **Important Specs**:

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| Voltage | No-load speed | No-load current | Stall torque | Stall current | Power |
| 6 V | 100 RPM | 0.04 A | 1.7 kg cm / 24 oz in | .67 A | .46 W |

* 1. This motor was chosen due to its voltage, no-load speed, and stall torque specs. Being powered by a 9 V battery and assuming some voltage would be lost powering the Arduino, I decided that 6 V max voltage would be reasonable.
  2. **Speed**: Assuming constant 6 V input, a maximum of 100 RPM, and given a 60mm diameter wheel, the maximum speed of the linebot is .628 m/s, or about 2 ft/s. I am not entering this linebot into any competitions, so high top speed is not a concern for this project, as long as the linebot doesn’t move at a snail’s pace.
  3. **Torque**: I am unsure of the torque necessary to move the linebot. I made some reasonable assumptions when determining the necessary stall torque. The linebot is not going to be a heavy robot. The bot should weigh well less than a pound. Knowing this, I decided to pick a stall torque above a pound so that the it is unlikely the motors are unable to supply enough torque to move the linebot. More research needs to be done to understand how to calculate the required torque for future projects.

1. QTR-8RC Reflectance Sensor Array
   1. <https://www.pololu.com/product/961>
   2. This sensor has eight equally-spaced IR emitters and receivers. Each sensor will emit IR light, which will be reflected by the surface it hits. The brightness/darkness of the surface changes the value that is read by the IR receivers. When all eight sensors are emitting and receiving simultaneously, you can track the line by looking at the returned values of each sensor. Code is provided on GitHub which greatly simplifies how these sensors read IR values and return meaningful numbers.
   3. **Control**: The provided code contains a function that takes a weighted average of the values read by each sensor. This means that if the line was underneath IR sensor 1, the returned value of the function would be 0. Likewise, if the line was underneath IR sensor 8, the returned value of the function would be 7000. The desired behavior is that the linebot is always centered above the line. This corresponds to a return value of 3500. If the QTR-8RC Reflectance Sensor Array reads a value other than 3500, than the linebot is not centered on the line and will have to adjust accordingly.
   4. **Optimal Readings**: Best results occur when the sensors are about 1/8th inch (.125”) above the surface they are measuring. Likewise, minimal noise is achieved when the surface is a black like on a white background, or vice-versa. This linebot is unable to follow lines that do not meet these color parameters. For this project, this is an acceptable constraint.
2. Wheels, ball caster, and nylon spacers:
   1. <https://www.pololu.com/product/1420>
   2. **Wheel Diameter**: 60mm diameter wheels were chosen for two reasons: First, linebot speed. Assuming constant 6 V input, a maximum of 100 RPM, and a 60mm diameter wheel, the maximum speed of the linebot is .628 m/s, or about 2 ft/s. This speed is sufficient for this project. Second, ride height. The optimal height for the QTR-8RC Reflectance Sensor Array is .125 inches above the ground. These 60mm wheels, in combination with 15mm nylon spacers, place the QTR-8RC Reflectance Sensor Array very close to .125 inches above the ground. A greater diameter wheel would make the linebot move faster, but would increase the ride height to an undesirable level.
   3. **Ball Caster Diameter:** The 3/4" Plastic Ball Caster was chosen for two reasons: First, in combination with the nylon spacers, the 3/4" Plastic Ball Caster (.91” total height including caster) will place the QTR-8RC Reflectance Sensor Array very close to .125 inches above the ground. Second, the 3/4" Plastic Ball Caster in combination with the 60mm diameter wheels will place the linebot chassis nearly parallel to the ground.
   4. **Nylon Spacers:** 15mm Nylon Spacers were chosen to place the QTR-8RC Reflectance Sensor Array .125” from the ground, in combination with the 3/4" Plastic Ball Caster and 60mm diameter wheels.