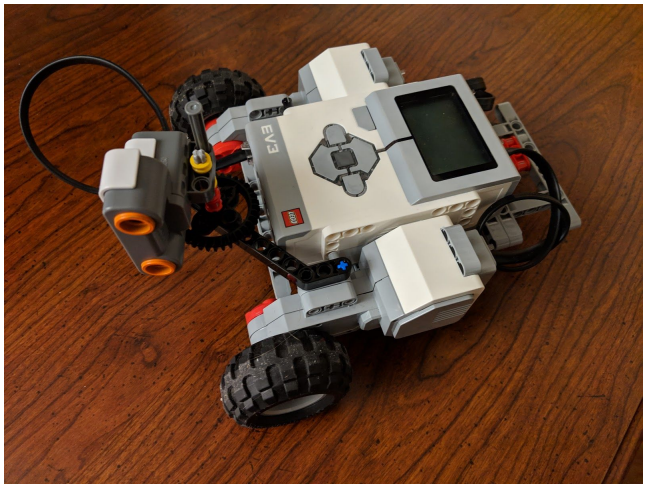
Lab 02: Smooth Navigator with PID

Due: March 6th, 2019
100 Points

Purpose: As we have discussed in class the most common type of robot control in industry is the the PID controller. The name stands for Proportional, Integral and Derivative which describe 3 mathematical functions that the controller sums together in-order to achieve our robots goals with smooth response and minimal oscillation.



We are going to apply our knowledge with an implementation of the PID controller that will solve an interesting problem, keeping our robot smoothly following walls in a room. The robot should be able to deal with changes in room layout, wall angles, and random obstacles it might encounter, without prior knowledge of the environment. It should also act in a natural and efficient manner. Moving at a good pace and not appearing to need to stop or slow necessarily to deal with obstacles.

The most difficult (and time consuming) process in PID control is discovering the right combination of constants (remember our gain) that when combined equate to a working robot with minimum oscillation. Finding the correct gain levels for Kp, Kd and Ki is by far the most difficult part of the lab. It is also the difference between a robot that looks smooth navigating it's environment and one that oscillates, looks jittery, moves and reacts slowly.

Resources:
Sensor information:
Ultrasonic NXT Sensor:
http://www.lejos.org/p_technologies/nxt/nxj/api/lejos/nxt/UltrasonicSensor.html
HiTechnic EOPD Sensor:
https://www.hitechnic.com/cgi-bin/commerce.cgi?preadd=action&key=NEO1048
http://www.lejos.org/ev3/docs/lejos/hardware/sensor/HiTechnicEOPD.html

Other sensors that can help (Advanced)
Accelerometer: http://www.hitechnic.com/cgi-bin/commerce.cgi?preadd=action&key=NAC1040
Gyro: http://www.hitechnic.com/cgi-bin/commerce.cgi?preadd=action&key=NGY1044

PID information and Tuning:

PID controllers: https://en.wikipedia.org/wiki/PID_controller
Ziegler–Nichols tuning: https://en.wikipedia.org/wiki/Ziegler%E2%80%93Nichols_method

Low pass filter: https://en.wikipedia.org/wiki/Low-pass_filter

Preparatory: You will need to have completed Lab 00 and have a working and tested development environment.

Lab Detail: Your teams robot goal will be to navigate an indoor environment (examples will be discussed in class, but final course will not be revealed until the day of the demonstration).

Points will be awarded for overall robot locomotion design, application of sensors, and accuracy of control. Your controller is required to use at least 2 components of a PID controller (but are encouraged to use all 3) to maintain course. Robots control will be evaluated on smoothness, lack of "oscillations" and "Jitters", speed and accuracy. Points will be deducted for collisions with objects / walls. 2 attempts per team will be allowed and the best run of the 2 will be graded.

The robots will have an *almost* NASCAR course to navigate, meaning they will (for the most part!) only have to turn left. This means that if you have a sensor facing 90 (or so) degrees left you can maintain a constant distance from the wall and when there is a turn it will no longer see a wall and will turn left until it does once again. A robot that that work in this condition would satisfy the most basic requirements of the lab. This robot however is useless in for a right turn as it would just crash head on into the oncoming wall or obstacle. To overcome this it is recommend to employ a second sensor (most likely the EOPD) that looks straight ahead and enables the robot to turn right to avoid an oncoming object. A robot that can do this will get a good grade, a robot that integrates the data from the 2 sensors in a smooth way gets an excellent grade.

The ultrasonic sensor is the recommended primary sensor for this project. It is also recommended that you use the EOPD sensor to avoid crashing head on into objects. (although you may choose to change which sensor points in a direction or come up with a completely different solution). Other possible sensors you can use include Accelerometer and Gyroscope sensors (or a combination using sensor fusion). They can be useful for tracking motion and angle of the robot. They are not required for this lab!

Submission: Your team will demonstrate your working robots in class by the due date and will submit its code in iLearn (best way is to zip up your project directory, but I will take the individual .java files).