Lab 3. Omnibot introduction and data collection.

Deliverables: **Each group should write a *short* report that includes data and plots from both Labs 3 and 4, due November 20 at 5pm.**

Overview

The goal of this lab is to control the omnibot to accurately follow each of two desired paths:

1. A square (about 1 meter on a side, with exact scaling to be indicated by the TAs in lab)
2. A circle (about 1 meter in diameter, with exact scaling to be indicated by the TAs in lab)

As always, you are encouraged to explore various solutions, depending on your personal knowledge, interests, curiosity, and persistence.

The assignment requires that you have completed the tasks listed below. The exact lab report format style is (as always) flexible, but you must include relevant presentations of data, such as MATLAB plots (e.g., both desired and actual motor position over time), along with an understandable summary of the methodology and calculations required.). *Please be concise and efficient in your presentation; well-labeled plots are always appreciated – and often can be much more effective in communicating details than excessive text.*

Your tasks in this lab include:

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1. Design trajectories for both the square and circle paths. You should have done most if not all of the required work for the square in Prelab 3. The robot should not rotate during each path: keep φ_b constant. Ensure the paths are "smooth" functions of time, such that the requested accelerations and velocities will be achievable for the Lego motors. Also, modify your simulink model (if/as needed) to be sure you are playing back trajectories at the desired speed.

2. Implement a proportional controller to follow each path; be sure the feedforward in the model is turned off here. You must (1) log and save data for each run and (2) record the final position of the robot, measuring (x,y, phi) position and orientation by hand, using a tape measure and geometric calculations of angle. At home (or at the end of lab), use your saved data to generate a plot of predicted the motion of the robot, based on the recorded actual motor encoder positions over time.

3. Repeat part 2, but follow only half the path, so you can accurately record the robot position and orientation (x,y, and phi) midway through the trajectory. These data will allow you to estimate how close the size of your shape is both to what was planned and to what you predict based on encoder data.

4. Modify your simulink model to improve performance. Turn on and "tune" the nonlinear feedforward already provided in the model, and also do one or more of the following: (a) improve feedforward control by also including a linear part that "inverts the plant" (e.g., pre-compute feedforward terms to add in, based on plant and particular trajectories), (b) modify trajectories (adjusting maximum speeds, correcting or improving kinematic models, etc.), (c) include integral control (PI or PID), (d) re-shaping (or "pre-warping") trajectories based on observed omnibot motion (e.g., if square is "too small", re-scale shape). Keep track of changes you make, to document these (and their effects) in your Lab Report.

Note: The more smoothly and accurately your robot moves this week, the more likely you will do well in the omnibot CONTEST during Lab 4 next week. Good luck!

EXTRA CREDIT 5. Now, plan a more interesting trajectory, in which the vehicle turns as it is moving. For example, turn while tracing the square, or draw a circle with the same wheel always pointing inward.

Lab 3 Requirements for the "Lab 3/4" Report (due Nov. 20):

1. Include trajectories you calculated for the three motors for both the square and circle paths. Indicate the maximum magnitude of velocity and acceleration, showing where these occur on your plots. (You are encouraged to put all 3 motor trajectories for a given shape on a single set of axes, to save space.)
2. Use your saved log data to determine the expected motion of the robot for each recorded trial. Compare the planned end point (x,y,phi), the measured end point, and the end point predicted by simulating recorded encoder data.). (Note: since you are commanding closed paths, the planned end point should simply be your start position and orientation.)
3. Repeat this comparison for the "mid-point" of the trajectory, from step 3 of the lab.
4. Describe the improvements you implemented to satisfy part 4 of the lab. Comment on accuracy, sources of error, and why you tried what you did to reduce errors. Provide data that demonstrate that the motors followed trajectories more accurately and/or that the resulting motion of the omnibot was closer to the requested shapes.