UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

Department of Electrical and Computer Engineering
ECGR 4161/5196 Introduction to Robotics

Experiment No. 3 – Motor Control

Overview: The purpose of this experiment is to introduce the concepts of motor control and to demonstrate this by programming DaNI to complete a 2x2 meter square.

Useful Information and Equations:

NOTE: *These equations are a good starting point for deriving values needed to complete this lab; however, there are many forces that are not accounted for: friction, wheel slippage, etc. Therefore final values will need to be tweaked to make a "perfect" square.*

Gear Ratio: This is the amount of revolutions it takes the motor to complete for every 1 revolution of the wheel. The gear ratio of the daNI Robotic platform is approximately 83:1. (*This value is taking the motor gear ratio into account*)

Wheel Diameter: The diameter of one of the robots wheels must be measured to calculate correct distances.

Wheel Circumference:

$$C = \pi * d \ (m) \qquad \text{Eq. (1)}$$

Straight Away:

Revolution Distance: *(How far the robot will travel with one full rotation of the wheel)*

$$Revolution\ Distance = \frac{C}{Total\ Distance}\ (m) \qquad \text{Eq. (2)}$$

Motor Revolutions: *(How many times does the motor turn 360 degrees in* $\boldsymbol{x}$ *meters)*

$$Motor\ Revolutions = Gear\ Ratio * Revolution\ Distance \qquad \text{Eq. (3)}$$

Angular Velocity: (*Where **t** is the time the robot will take to travel **x** meters. There are two unknowns in equation 4, time (t) and angular velocity (ω). One of these values must be chosen to solve for the other.*)

$$\omega = \frac{\left(\frac{Motor\ Revolutions}{2 * \pi}\right)}{t} \left(\frac{rad}{s}\right)$$

Eq. (4)

<u>Turns</u>:

Diameter: Since the robot will be turning in place, we can think of this as a circle where the diameter is the distance between the robots two front wheels.

Circumference: Use Eq. (1) to calculate the turn circumference.

90 Degree Turn: (*Where d is the distance between the two front wheels.)*

$$90° \ Turn = \frac{\pi * d}{4} \ (m)$$

Eq. (5)

Turn Revolution Distance:

$$Turn\ Revolution\ Distance = \frac{C}{90° \ Turn} \ (m)$$

Eq. (6)

Turn Motor Revolutions:

$$Turn\ Motor\ Revolutions = Gear\ Ratio * Turn\ Revolution\ Distance$$

Eq. (7)

Angular Velocity: Since the velocity of the robot must be consistent, use the angular velocity calculated for the straight away using Eq. (4).

Turn Time:

$$t = \frac{\left(\frac{Turn\ Motor\ Revolutions}{2 * \pi}\right)}{\omega}\ Seconds$$

Eq. (8)

Pre-Lab:

1. Calculate the "straight away" time for the robot to move a distance of 1 meter if the angular velocity is 8.4 $\frac{rads}{s}$.

2. Calculate the 90 degree turn time for the robot if the angular velocity is 8.4 $\frac{rads}{s}$

3. For the robot to move forward or backwards both of the motors must be spinning in the same direction.

   True / False (circle one)

4. For the robot to turn the motors must be spinning in opposite directions.

   True / False (circle one)

Lab-Session — Motor Control Lab

2x2 Meter Square

Set up a loop that will step through the process of having the robot move in a square path and then stopping once it completes the path (instructor may ask for the program to complete multiple squares, or to run infinitely) . Ensure that the robot moves over the markings on floor during the demonstration.

Requirements:

- Req. 1 The robot will be tested on a surface decided by the course instructor.
- Req. 2 Only the motors may be used (No sensors).
- Req. 3 A LabVIEW program will be written that will use the motors to travel 2 meters, make a 90° turn, and repeat process until the robot has completed a 2x2 meter square.
- Req. 4 Robot will operate autonomously.
- Req. 5 The demonstration area where the square is marked on the ground will be available to students for testing purposes prior to the final demonstration.
- Req. 6 Robot should run in a continuous loop so that accuracy after many squares have completed may be tested. (*Optional-At request of course instructor)*
- Req. 7 The velocity of the robot throughout the loop must be consistent. *(If the robot moves forward at 5 rad/s, then it must also turn at 5 rads/s)*
- Req. 8 Solved equations must be included in the lab report. Also include tweaked values vs. theoretical values.