Lab B: Modeling Robot Motors

Introduction

Single Sentence Overview

We will model how a motor allows a robot train to roll forward.

Overview of Lab

We will extend the motor model from Lab A and apply it to a simple robot that can drive in a straight line. The motor model converts electrical energy into mechanical energy. The torque that is generated at the shaft of the motor model is converted into a straight-line force that propels the robot forward. We assume that there is no slip at the wheel and that there is no lateral (sideways) movement.

In the future you will apply the same modeling process to a 2D mobile robot.

The robot is based on a locomotive example from the University of Michigan's CTMS website.

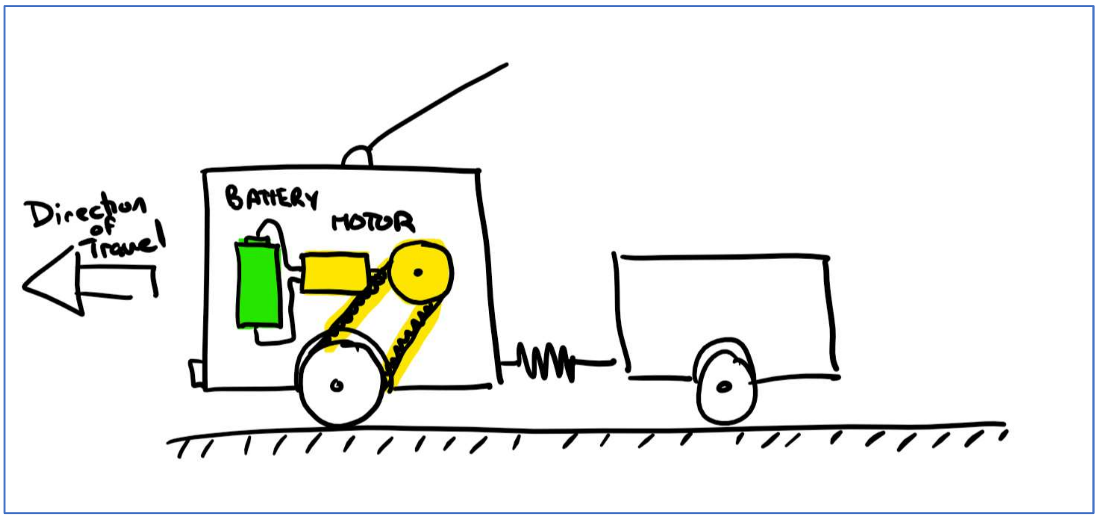

Figure 1 This mobile robot is based on the CTMS locomotive model.

Learning Outcomes

The student will know how to

1. Integrate a battery model, motor model and 1D model of a mobile robot platform
2. Control voltage of a motor in a feed-forward manner in order to drive the motor and achieve a distance goal for a mobile robot.

Grading Rubric

During the TP lab session make sure to conduct all the required demonstrations to the lab instructor. Also, submit a document with the answers to the "Stimulate" and "Explore" questions.

- *Part 1 demo: (robot + motor model)*
    - *0 pts: less than 50% of model developed and/or no demonstration attempted.*

  - *5 pts: 50% of more of model developed and/or demonstration attempted but not functional.*
  - *10 pts: Model developed and model functional*
- *Part 2 demo: (robot + motor + battery model)*
  - *0 pts: less than 50% of model developed and/or no demonstration attempted.*
  - *5 pts: 50% of more of model developed and/or demonstration attempted but not functional.*
  - *10 pts: Model developed and model functional*

Background

The motor is key interface between the electrical world and the physical world for your robot. The electrical components that need to be modeled are

- The internal resistance of the motor
- The internal inductance of the motor
- The voltage constant (for converting shaft velocity into Back-EMF)
- The torque constant (for converting electrical current into torque)
- Motor damping (e.g. shaft friction)
- Mechanical inertia experienced by the motor shaft

We are assuming that there either (a) the motor is directly connected to the wheel shaft, or that (b) it is connected via a 1:1 gearing with no losses, as shown in the illustration on the first page of this document.

In the battery lab you modeled half of the motor model (the electrical part). Now you need to complete it with the mechanical components. Assume that you are using the 90 Watt, 30 Volt RE35 from Maxon. For motor damping, assume 0.1 N*m/(rad/sec). For inertia at the shaft, assume 20 kg*m^2. Be careful when including the motor characteristics from the datasheet in your Simulink model – the units are probably not consistent with your model and you will need to convert units. Pay specific attention to the Torque and Speed constants from the datasheet.

Pro-tip: when building your model, you can insert constants (like the motor's Speed Constant) by going to:

File -> Model Properties -> Callbacks -> InitFcn* -> Model Initialization function

And then defining all the constants in the window, as you would in a Matlab script. Each time you run your Simulink model it will initialize the parameter values, allowing you to "tweak" values to see their effects from one simulation to the next.

Modify the locomotive model for use as a mobile robot. This means having a mass for the main body as 10 kg. The cart pulled by the robot should be 5 kg.

Prerequisites

You are expected to have done the previous labs, including the battery model lab.

Goal of the lab.

Demonstration 1

You are to make the robot move forward 50 meters. You will do this by creating a two-part robot model: the first part is a voltage-controlled motor and the second part is a 1D mobile robot attached to a rolling cart. You do not need to implement the battery from the previous lab in this model. Assume that you have a non-resistive "perfect" voltage source. You are to create a changing voltage profile that allows the robot to roll to a distance of 50 meters. It should not overshoot (go past) 50 meters. You are not permitted to overshoot 50 meters. You are permitted to have a final position error of up to 0.05 m. You must reach your goal within 100 seconds.

Demonstration 2

Repeat Demonstration 1, but this time by including the battery model from the last class.

References:

CTMS Tutorial on 1D Locomotive in Simulink: https://bit.ly/2UP36b5

DC motor model: there are many online and text sources for creating DC motor models. You can use the partial model from the last lab as a starting point.

Part 4: Wrap-up

Reflection on Learning

In the previous lab you created a simple battery model and connected it to a simplified motor model. This time you integrated that battery model into a more complete system which included a motor and physical properties of a 1D mobile robot. What kind of strategy will you have to pursue to create a 2D mobile robot using the components you have used to date? What modelled components will you be able to reuse? How?

Communication – Reporting

Write a two page report explaining how your model works, including illustrations of your Simulink models and list the parameters and sources for those parameters.