Class-Project Proposal

Optimal Control Theory: EE-5630
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1. Title:

Slot Car Mania - Optimal Control of a Slot Car

2. Team Members:

This will be a solo project.

3. Background and Motivation

Connected Autonomous Vehicles (CAVs) are autonomous vehicles that have the ability to transmit information to other entities and are currently being researched in the Smart City Lab at CSULA. Currently there is a CSULA senior design team that is designing an experimental testbed for research into CAVs. This testbed consists of customized slot cars on a race track shown in Figure 1.

One of the purposes of this testbed is to simulate real-life driving conditions. Because different classes of drivers are found on the road in the real world (such as drivers who drive below, at, or above the speed limit) the customized slot cars should also mimic this driver classes as well. Therefore, this project will seek to create a class of driver that exceeds the speed limit. The way that this will be accomplished is by designing a controller such that the slot car completes a lap of the track from a full stop in the shortest amount of time as possible.

4. Description of Systems

The dynamics of the electrical and mechanical parts of the car are

$$L\frac{di(t)}{dt} = -Ri(t) - k_e\omega(t) + u(t) \tag{1}$$

$$J\frac{d\omega(t)}{dt} = -k_t i(t) - b_d\omega(t) + b_s \sin(t) \tag{2}$$

where the parameters are described in Table 1 below. This system is non-linear, but if the static friction is small enough to be ignored then the system can become linear.

Table 1: Parameter list

Parameter	Meaning
$i(t)$	current
$u(t)$	voltage
$\omega(t)$	angular velocity
R	resistance
L	inductance
J	moment of inertia
k_e	back emf
k_t	motor torque
b_s	static friction
b_d	dynamic friction

5. Proposed approach

This is a minimum time problem, therefore the cost function will be

$$J = t_f - t_0 \tag{3}$$

Most likely a variational approach will be used to solve this problem. Also, I would like to implement this on a real slot car, time permitting, but most likely this will be simulated with Python and some external libraries or Matlab.

6. Further Discussion

This problem may end up being too easy so I am aware that it may need to be modified or scrapped. This is just my proposed starting point. Perhaps a modification that can be made is to add multiple cars to the track, introduce constraints such that the cars are to not collide, and have the other cars drive at a different speed or be human controlled. This will most likely change the type of problem and thus the cost function and system-level dynamics will need to be added as well as the dynamics for the car.

As a side note, the title is a reference to the 1950 Walt Disney cartoon "Motor Mania" starring Goofy.

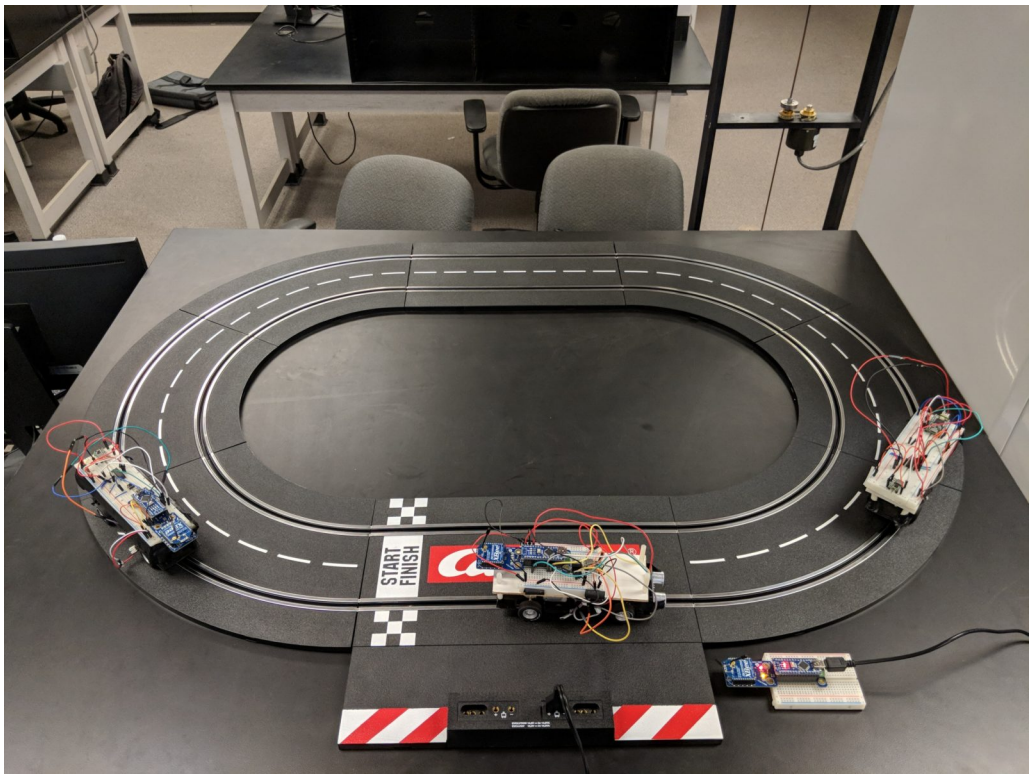

Figure 1: Experimental testbed designed for the Smart City Lab