2.152 Project:
Adaptive Control of 2-Link Robotic Arm

May 14th, 2018

Luke Roberto

1 Setup

The purpose of this project was to implement composite adaptive control on an interesting system while also learning to use the Julia programming language. The project code is located at: `https://github.com/Lukeroberto/2.152_project`. There are a collection of Julia Notebooks that can be viewed without actually installing the language on your system, you can also view short gifs of the results as well.

2 Adaptive Control of Double Integrator

The first steps of this project were to model a simple system. This allowed me a little time to get comfortable with the language and build intuition on how the adaptive controller worked realtime.

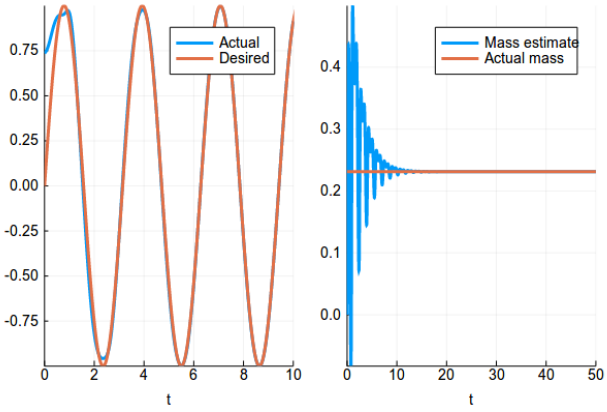

Figure 1: Tracking $sin(2t)$

The setup was easy to implement, the MRAC policy given in chapter 8, with control policy 8.3 and adaptation law 8.6, was used to track a number of trajectories. Fig. **??**

shows the controller tracking $sin(2t)$. There is nice exponential convergence as expected, although intuitively it is interesting to me how the controller has essentially zeros error around $t = 4$, yet does not learn the mass until approximately $t = 15$. I assume the nature of the controller has a good deal of robustness, especially when the mass estimate error shrinks below a sufficient threshold.

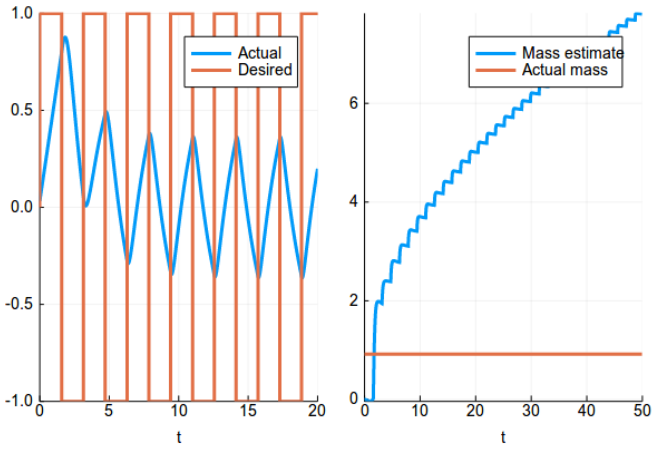

Figure 2: Tracking $sgn(sin(2t))$

After testing out the controller on a trivial set of trajectories, I decided to see what would happen if I were to break some of the assumptions that were made in the derivations of adaptive control. The most interesting one in my opinion is shown in Fig. **??**. The desired trajectory is not continuous and its derivatives are not even differentiable. The closed loop system acts behaves like a second order system trying to follow a square wave input, even though the mass estimate grows unbounded. This may be an artifact of the implementation, but an interesting observation nonetheless.

3 Adaptive Control of 2-Link Arm

Once I was able to test out the double integrator system, I then moved on to control of the 2-link arm dynamics as specified in example 9.1 of the textbook.

4 Composite Adaptive Control

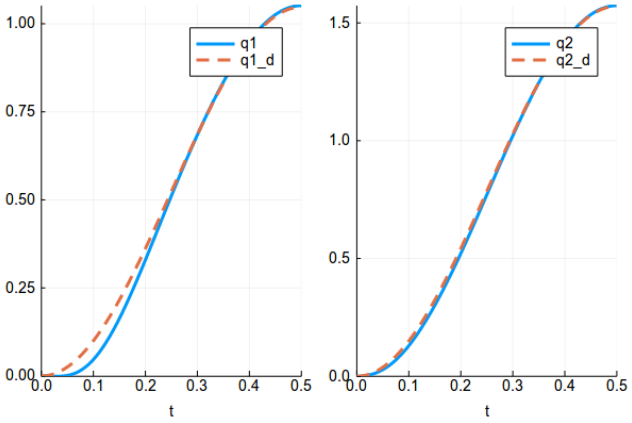

Figure 3: Tracking $sgn(sin(2t))$

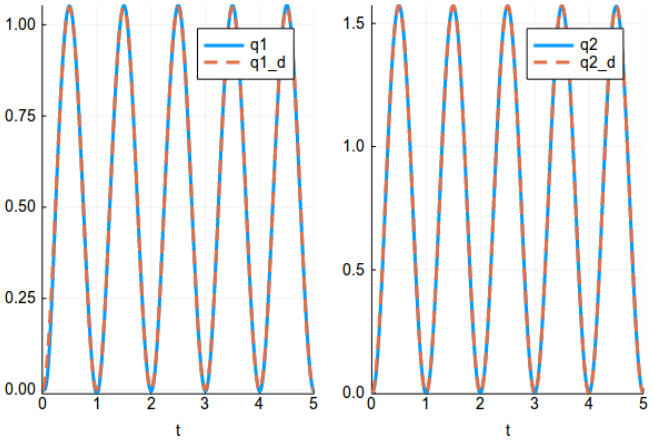

Figure 4: Tracking $sgn(sin(2t))$

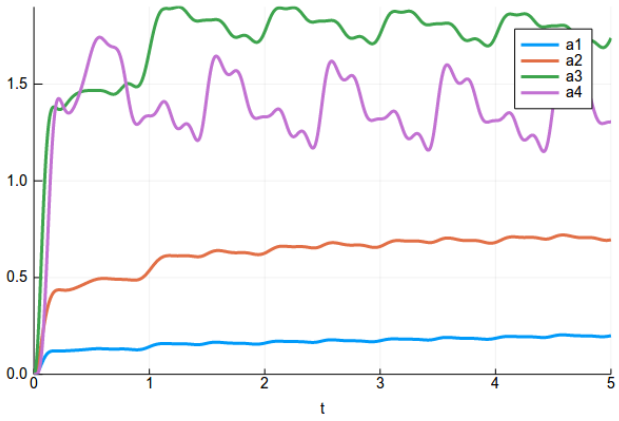

Figure 5: Tracking $sgn(sin(2t))$