ECE444 PROJECT PROPOSAL

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Date: 10/14/2020 Wednesday
Version: 2
Title: Investigating Methods of Discretizing Continuous Time Control System Models

PROBLEM STATEMENT

In this class ECE444, we will learn methods to convert our CT filter designs into DT, allowing us to use the methods we learned from Chapter 2 CT Analog Filters to design IIR digital filters. I would like to investigate these ideas for how one might go about taking their CT control system design to a discrete one so as to be able to implement their design on a microcontroller. For example, MATLAB has the command `c2f(sysc, Ts, method)` as part of the Control Systems Toolbox for doing such a conversion. For the `'method'` input argument, one has the following options:

`method` — Discretization method
`'zoh'` (default) | `'foh'` | `'impulse'` | `'tustin'` | `'matched'` | `'least-squares'`

Discretization method, specified as one of the following values:

- `'zoh'` — Zero-order hold (default). Assumes the control inputs are piecewise constant over the sample time `Ts`.
- `'foh'` — Triangle approximation (modified first-order hold). Assumes the control inputs are piecewise linear over the sample time `Ts`.
- `'impulse'` — Impulse invariant discretization
- `'tustin'` — Bilinear (Tustin) method. To specify this method with frequency prewarping (formerly known as the `'prewarp'` method), use the `PrewarpFrequency` option of `c2dOptions`.
- `'matched'` — Zero-pole matching method
- `'least-squares'` — Least-squares method
- `'damped'` — Damped Tustin approximation based on the `TRBDF2` formula for sparse models only.

For information about the algorithms for each conversion method, see Continuous-Discrete Conversion Methods.

In Dr. Glower's class ECE461 which I am also taking, I believe he is using the "matched" method, where we convert CT zeros and poles directly to DT and work around that. We haven't gotten to that part yet in class but looking ahead it seems that is the case.

MY IDEA

By "investigate," I mean,

1) Describe the methods.
2) Discuss how the digital control systems perspective might differ from the digital filter design perspective.
3) Compare the methods by using them for the design and realization of a control system and discussing results. Most probably, this will be the following, where I control speed as well as position of a DC motor (obviously with necessary electronics in between!):