TEACHING PROCESS CONTROL IN THE TIME DOMAIN

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Abstract:

About 10 years ago I posed the question whether or not it is be possible to teach the undergraduate process control class entirely in the time. The same topics should be covered such as transfer functions (properly referred to as differential operators), delay systems, block-diagram algebra, poles zeros, stability, transient response in the time domain, frequency response, robustness with respect to model uncertainty, PID tuning and feedforward, multivariable control and RGAs. The time domain approach, it was surmised, would save time (by not introducing the Laplace domain and linearization). This would allow for the introduction of some other concepts such as nonlinear control, system identification, multivariate statisitics and model predictive control. My initial attempt was rewarded with the "What the Hell is Going On Award" at the senior banquet. However, as years progressed, the course improved. Improvements were mostly due to significant help from students and teaching assistants. The class has now evolved to a point were all classical material is handled and some additional material with a more "advanced process control" flavor is introduced. The new class is based on two key observations. The first is that the dynamics of processes we are interested in chemical engineering are constrained by systems of conservation laws. Control systems for unit processes and networks of such can therefore be developed using (passivity based) PID feedback and nonlinear feedforward control. These ideas go back to control pioneers such as Buckley and Shinskey. The second observation is that simply replacing Laplace operator s with the differential operator d/dt (as is done in Simulink) is mathematically precise and it provides a transparent and concise way of introducing the concept of a dynamical system to the students. Moreover, using the simple concepts such as output linearization, it is possible to deal directly with nonlinear systems.

The conclusion to the question posed in the first sentence of the abstract is therefore a resounding YES. The main problem is that our textbooks need to be rewritten.

Keywords: Benefits of control, distributed control, decentralized control, nonlinear control, passivity based control, model predictive control, adaptive control.