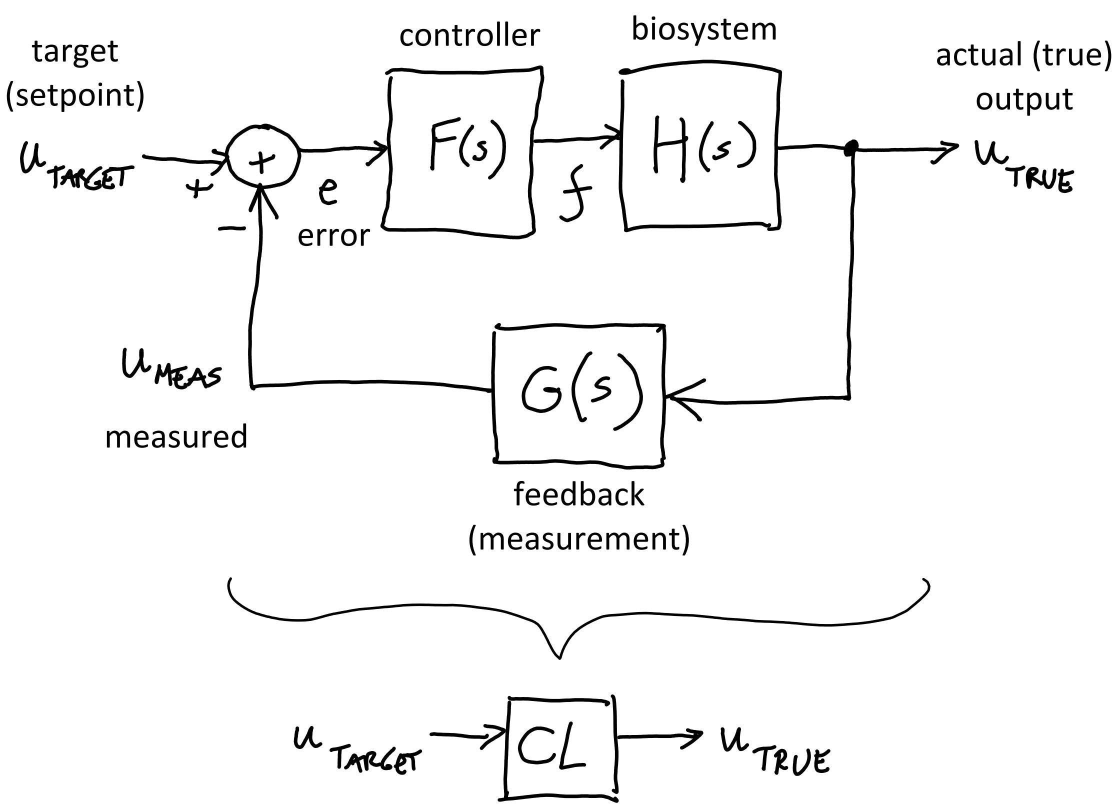
Lecture 8: Control fundamentals

Thursday, October 29, 2020   8:53 AM

References:

Tranquillo JV. *Biomedical Signals and Systems*, Morgan & Claypool Publishers, Dec. 2013. Ch. 9 (Sec. 9.1 - 9.2).

Generalized control setting (with setpoint, and measurement feedback):



$$\frac{H(s) \cdot F(s)}{1 + G(s) \cdot H(s) \cdot F(s)}$$

closed-loop
transfer function

$$u_{TRUE} = H f$$

$$f = F \cdot e = F\,(u_{TARGET} - u_{MEAS})$$

$$u_{MEAS} = G \cdot u_{TRUE}$$

$$u_{TRUE} = HF\,(u_{TARGET} - G\,u_{TRUE}) = HF\,u_{TARGET} - GHF\,u_{TRUE}$$

$$CL(s) = \frac{u_{TRUE}(s)}{u_{TARGET}(s)} = \frac{H(s).F(s)}{1 + G(s).H(s).F(s)} \longrightarrow 1$$

$$\text{as} \begin{cases} F \to \infty \\ G \to 1 \end{cases}$$

Simplistic control strategy:

1) high-gain feedback
2) accurate measurement

The problem with high-gain feedback is poor dynamics, and potential instability, due to cumulative delays through the various stages of the closed-loop system.

Careful design of the controller $F(s)$ will mitigate the effect of these delays, including any delay in the measurement, and even stabilize an otherwise intrinsically unstable biosystem $H(s)$, by adjusting just a few parameters in *proportional, integral,* and *derivative* (PID) control.

The choice of these PID parameters, and interpretation of their effect in the frequency domain (compensating phase lag with phase lead and *vice versa*), is the subject of the remaining part of the course.