Dynamical Systems Modeling: Opportunities and Challenges

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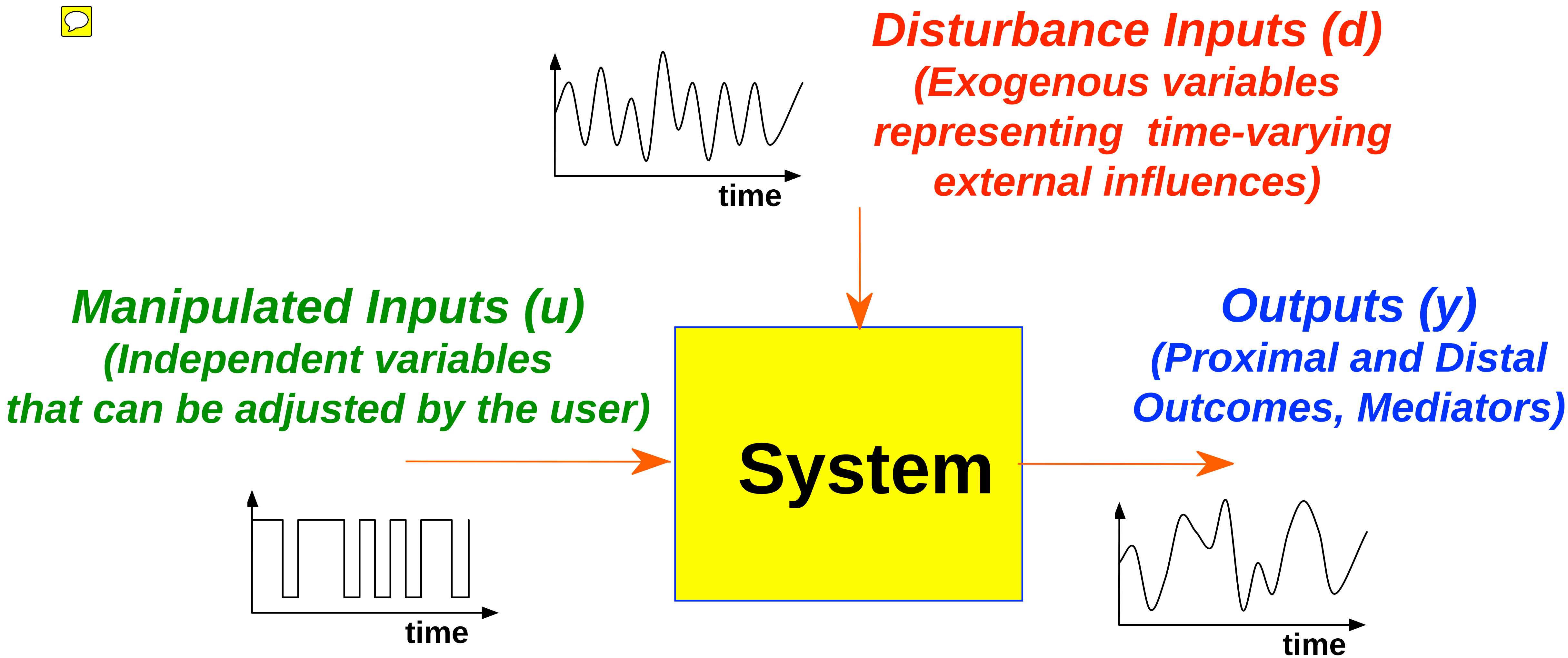


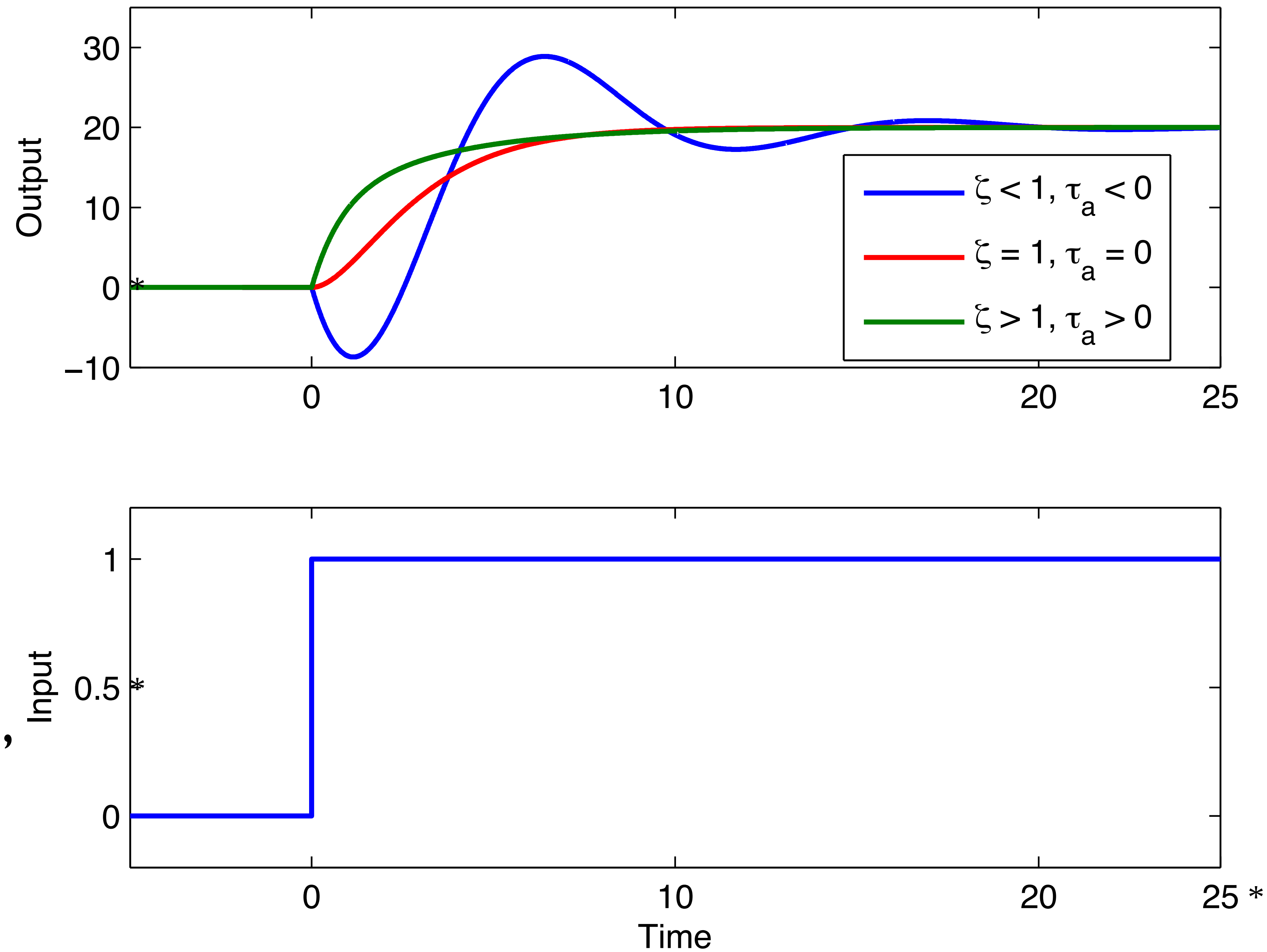
- Dynamical systems thinking considers how to characterize the transient response resulting from changes in manipulated inputs (e.g., intervention component dosages) and disturbance inputs (e.g., external influences) on outputs (e.g., proximal or distal outcomes, mediators).

General Second-Order System

$$\tau^2 \frac{d^2y}{dt^2} + 2\xi\tau \frac{dy}{dt} + y(t) = K\left(u(t) + \tau_a \frac{du}{dt}\right)$$

Output *y(t)*
(e.g., Craving, Cigarettes Smoked)

Input *u(t)*
(e.g., Quitting, Dosage Change, Stress)



- The general second-order differential equation, enhanced with numerator dynamics, can represent a wide variety of dynamical system responses.

Why dynamical systems for modeling behavioral change?

- Serves to better understand the concepts of *change* and *effect* in behavioral systems; this includes characterizing the *speed*, *shape*, and *magnitude* of response, both within and between participants.
- Enables more efficient use of intensive longitudinal data.
- Ultimately allows the application of *control engineering principles* for achieving *just-in-time* adaptive interventions.

Dynamical Systems Modeling: Topics of Interest

- The interplay between dynamical systems modeling and behavioral theory.
- System identification (i.e., estimating dynamical systems models from data).
- Control systems engineering: applying dynamical models to achieve *just-in-time* adaptive interventions.

Big DATA, little information?

- Industrial applications teach us that it is easy to be *data rich* yet *information poor*.
- Technology by itself does not provide a solution.
- To facilitate dynamical systems modeling:
  - data must display "persistence of excitation."
  - components must be introduced in an orthogonal / statistically-independent fashion over time
  - feedback relationships from self-regulation complicate matters, so these should be recognized *a priori*

Experimental Design

- Represents both a major challenge and a great opportunity.
- Increasing interest in single subject designs facilitates the use of system identification principles from engineering in experiment design; however, this approach may not be feasible in all cases.

- We know that a better understanding of context and location can provide insights into behavior, how do we best proceed?

Controller design

- achieving *just-in-time* adaptive interventions becomes the ultimate end use of estimated dynamical models from well-designed experiments.
- determining appropriate model adequacy for these interventions can lead to better, simpler models ("control-relevancy" in engineering terminology).

Thank you for your attention!

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http://csel.asu.edu/AdaptiveIntervention