ESS101- Modeling and Simulation

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Today (**Chapters 1 and 2**)

- Course organization
- What is a model?
- How to use a model?
- Why do we study modeling and simulation?
- How to build a model?
- How to verify a model?
- Types of mathematical models
- Course overview
- Learning outcomes

Course organization

- Course memo
- Homepage with news
- Literature and course material
  - ✓ "Modeling and Simulation of Dynamical Systems". L. Ljung and T. Glad
  - ✓ "Numerical Methods for Ordinary Differential Equations", Griffiths, Higham, Springer, 2010.
  - ✓ "Feedback Systems: An Introduction for Scientists and Engineers". K. J. Åstrom and R. M. Murray (available here)
  - ✓ Collection of exercises and results
  - ✓ Handouts
- Lab assignment
  - ✓ Covering most of the course topics
  - ✓ Final report
- Course evaluation
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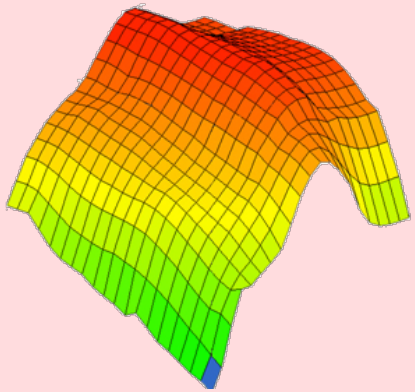
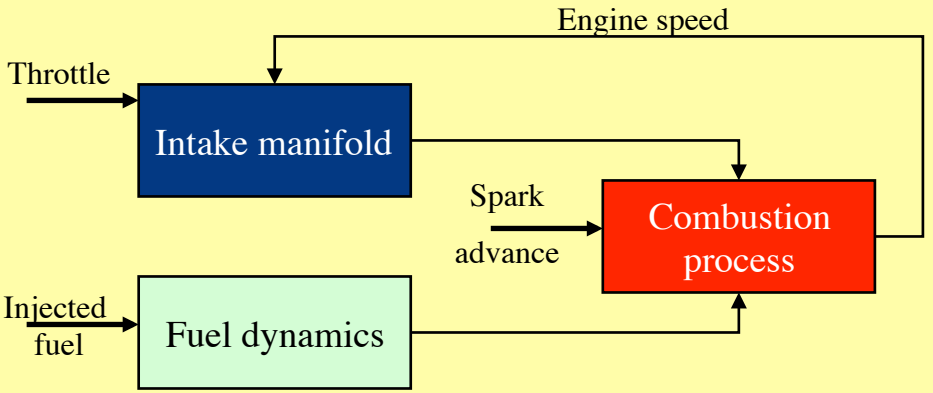
What is a model?

*A model is a **tool** for describing the behavior of a system*

Static map



Block diagram



Mathematical models

$$\frac{dx}{dt} = f(x,u)$$

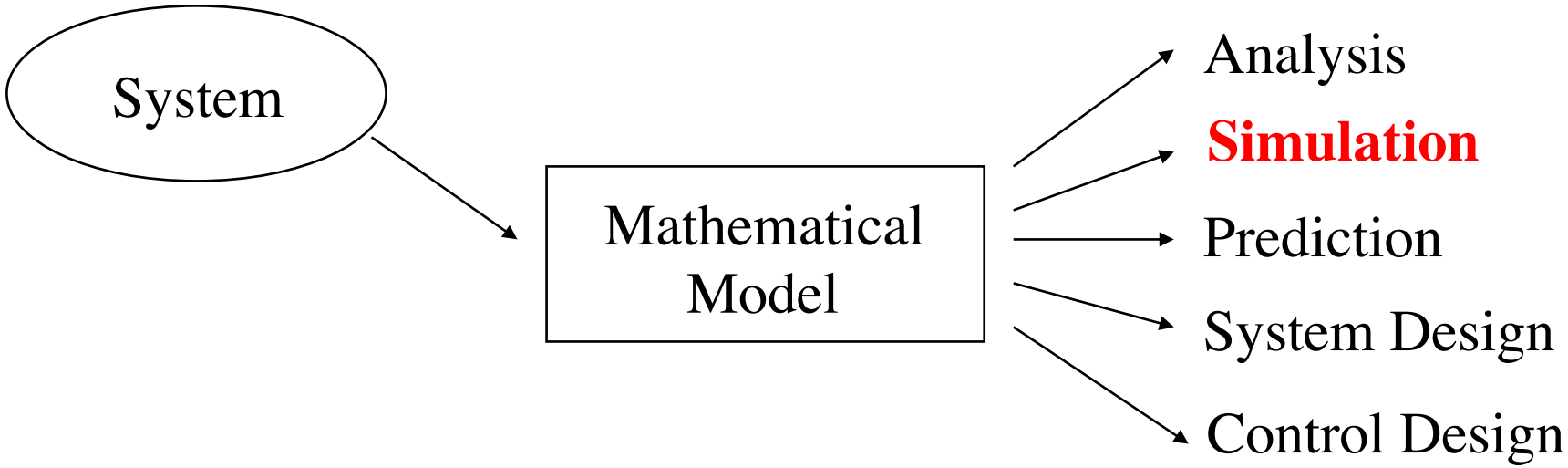
$$y = g(x,u)$$

Propositions

If x<y then…

If event 1 then…

How do we use a model?



In this course, starting from a *system*, we will formulate a *mathematical model* for *simulation* purposes

What do we simulate?

Why do we study modeling and simulation?

- **Costs.** Making experiments on the actual plant might be expensive
- **Simpler.** The experimental setup might be complex
- **Safety.** Improper use of the plant might be unsafe. E.g., training
- No other alternative, the system might not exist (not implemented yet)
- **Control design.** Required for model-based control design

Example. Chalmers Vehicle Simulator

How to build a model?

- From physics law (Physical modeling)
  1. Braking down the system into simpler subsystems with known behaviors
  2. Modeling each subsystem applying fundamental laws (energy conservation, Ohm's laws)
  3. Integrating the the models of the single subsystems
- From data (System identification)
  1. Observing the system, e.g., collecting input-output data
  2. Fitting the model properties to those of the systems

Often the *Identification* methods are complementary to the *Physical modeling*

Overview of the course