Data Driven Engineering II: Advaced Topics

State Space Models I

Institute of Thermal Turbomachinery
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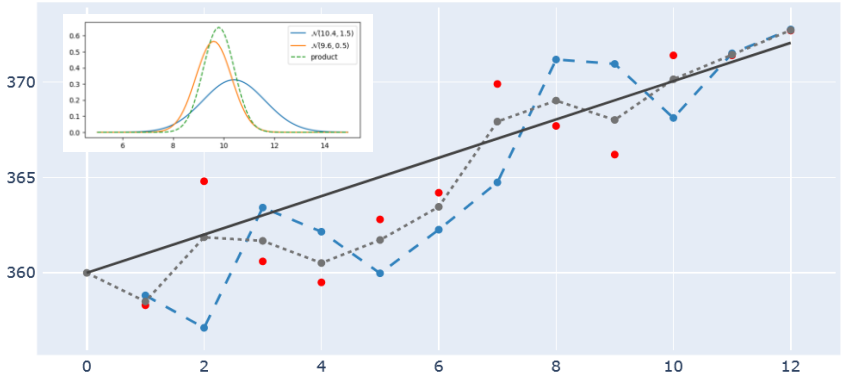

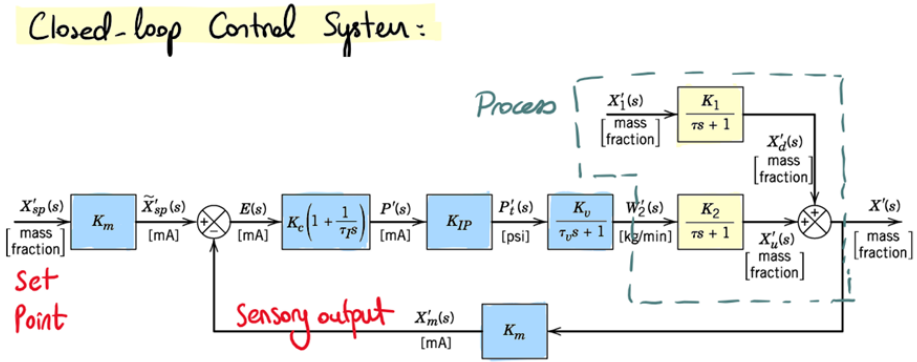

DDE: Dynamical Systems

Discovery // Characterization // Simulation

Understanding how ... works

* "Science" := interpret. of observations ... in a systematic way

* Prereq. ⇒ organized "book keeping"

* Scientific Data ⇒ Discovery ⇒ Management Optimization

"Engineering"

} interpret. as governing model eqns.

$f(x, t, \alpha, \beta, \gamma \ldots)$ — Transient; x: state; $\alpha, \beta, \gamma \ldots$: parameters

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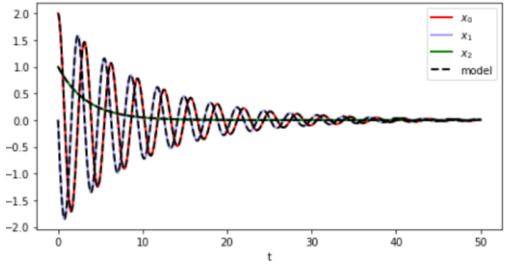
Understanding how ... works

$f(x, t, \alpha, \beta, \gamma \ldots)$ — Transient

state — parameters



modeling

observation

- Traditional approach → First Principles
- "Theory of Everything"
- Data-Driven Model Discovery

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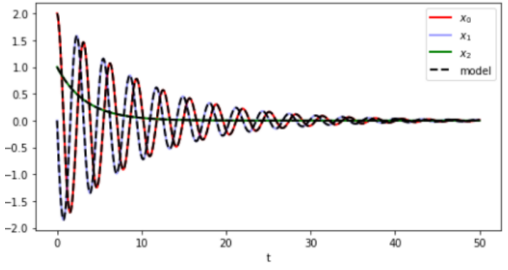
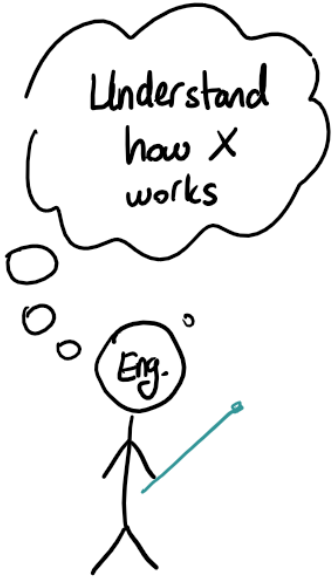
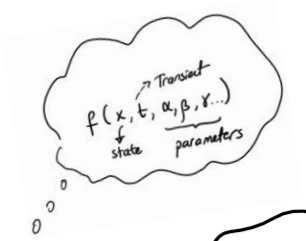
Understanding how ... works



→ Data-Driven Model Discovery





this 'model' would let me...

- ☑ Interpretability: What if ...
- ☑ Design & Optimization
- ☑ Future state prediction
- ☑ Active control with feedback

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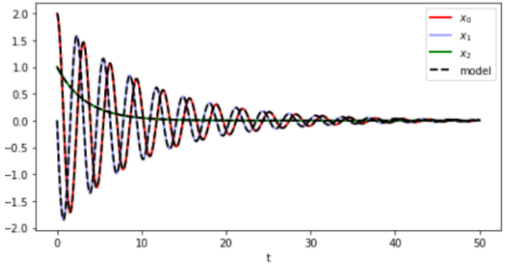

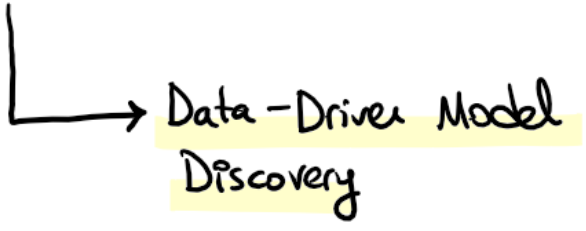

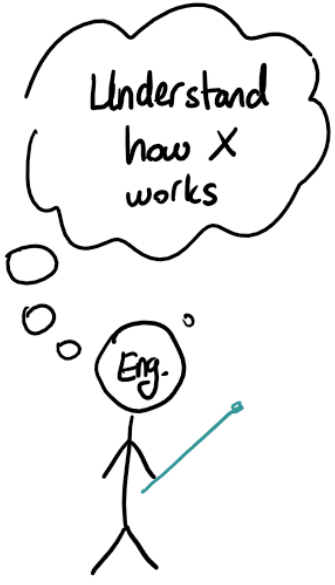

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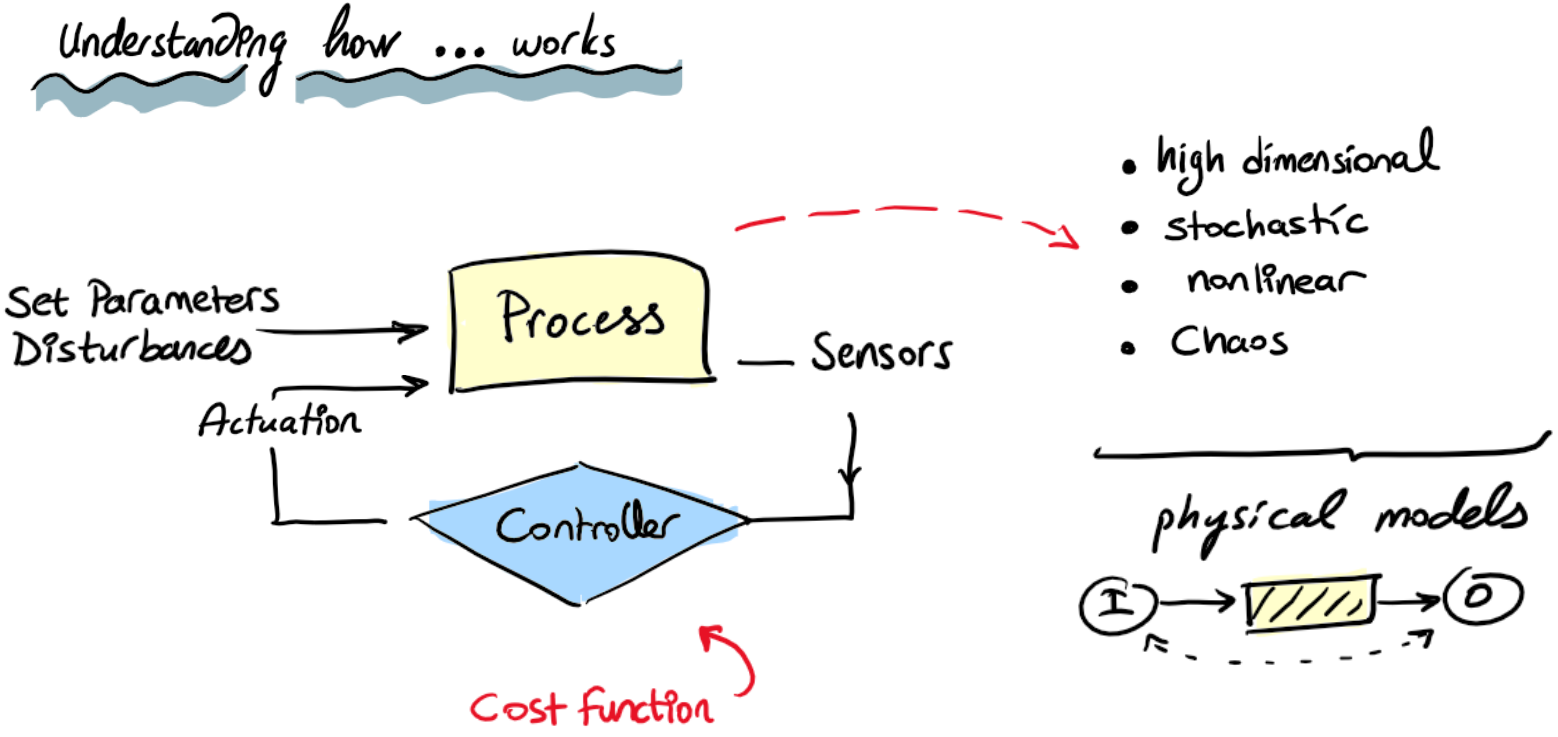
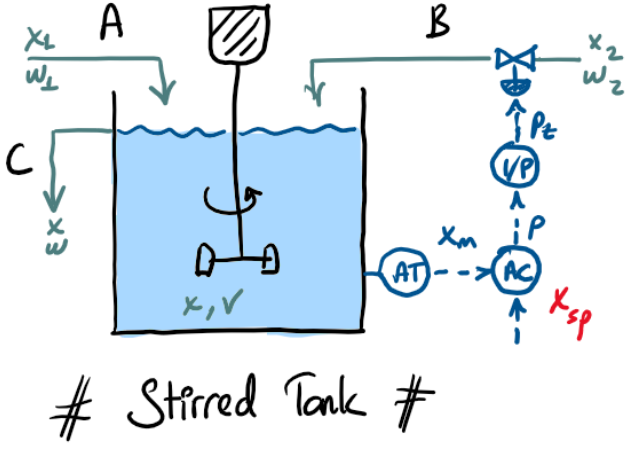
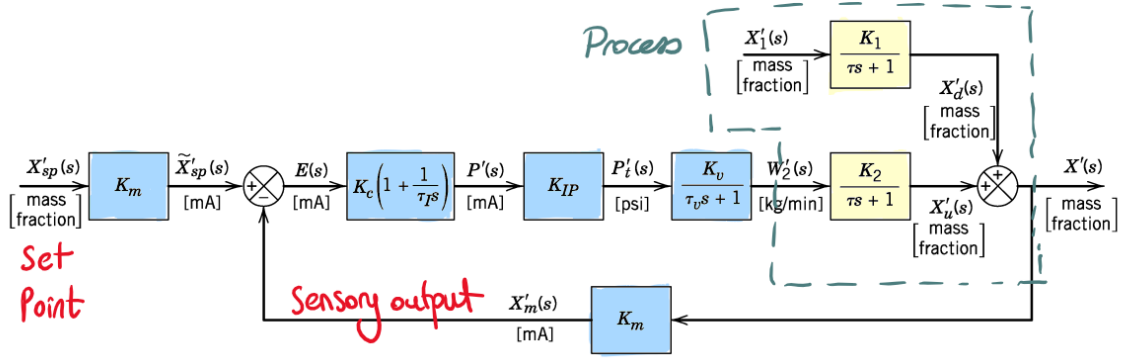


* FACT: Process ⇔ Controller
linked



Stirred Tank

Closed-loop Control System:



DDE: Dynamical Systems

Discovery // Characterization // Simulation

Karlsruhe Institute of Technology

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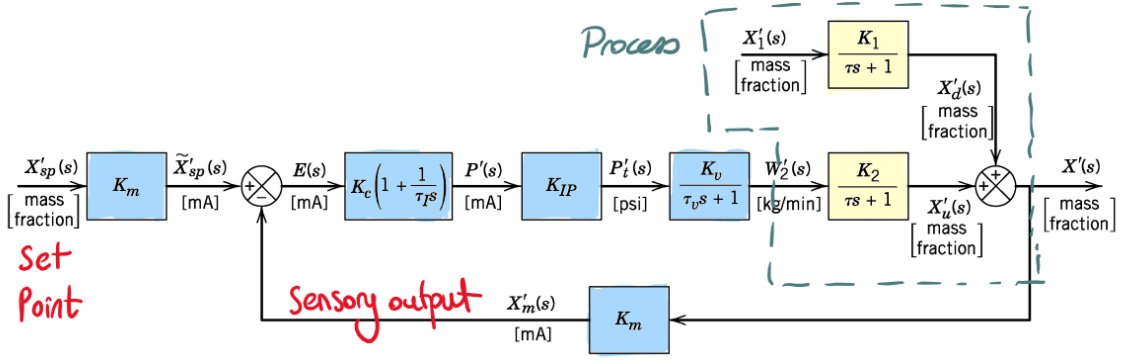
linked &

Tasks:

1. Create a phy. model | DDE-I
2. Create a controller model
3. Coupled optimization | DDE-II

Closed-loop Control System:

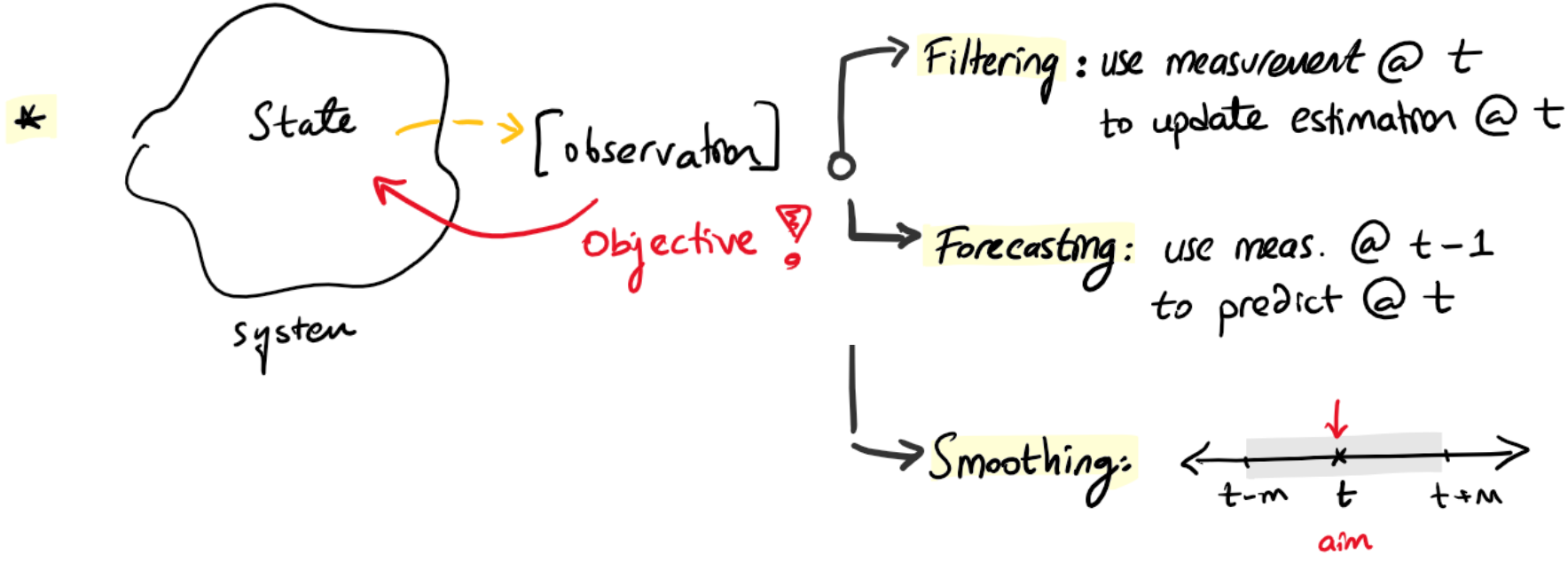


State Space Models

* Consider ⇒ True State of the system cannot be measured.
* Rely on specifying dynamics of a system
* development ⇒ mechanical automatron (mid. 20th cent.)

  ⇒ Record keeping & computation technology.

State Space Models



State Space Models

- ☑ Allows modeling dynamical systems
  - ↳ no need to be stationary
- ☑ Allows to introduce causality ⇔ "Model"
- ❗ Flexible model ⟺ more parameters to tune

Kalman Filters :

* Method for using new information from time series to estimate the hidden state of a system.

* used @ Apollo 11 mission

☑ No need to store all the past

❗ For linear systems with Gaussian errors

↘ many filters ...

KF is popular as;

* Convenient for online learning
* Sensor readings ⇒ inaccurate & noisy
  - → Robotics
* KF derivatives & versions;
  - → can handle complex systems.
* Integrated as a tool in DDE methods

Ateliers & Saveurs in Montreal

colab