

4/16: SysID + model-based RL

Announcements:

- HW4 due next week (4/23)
- Guest lecture: Prof. Abhishek Cauligi (4/30)

Last time:

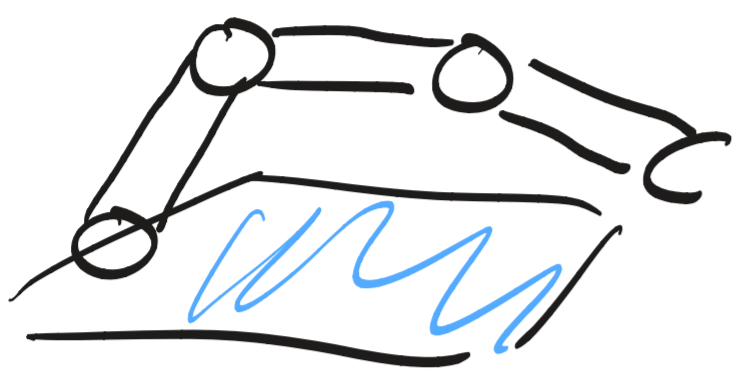
- robust losses
- SLAM on SE(3)

Today:

- system ID (traditional)
- model-based RL (non-trad'l)



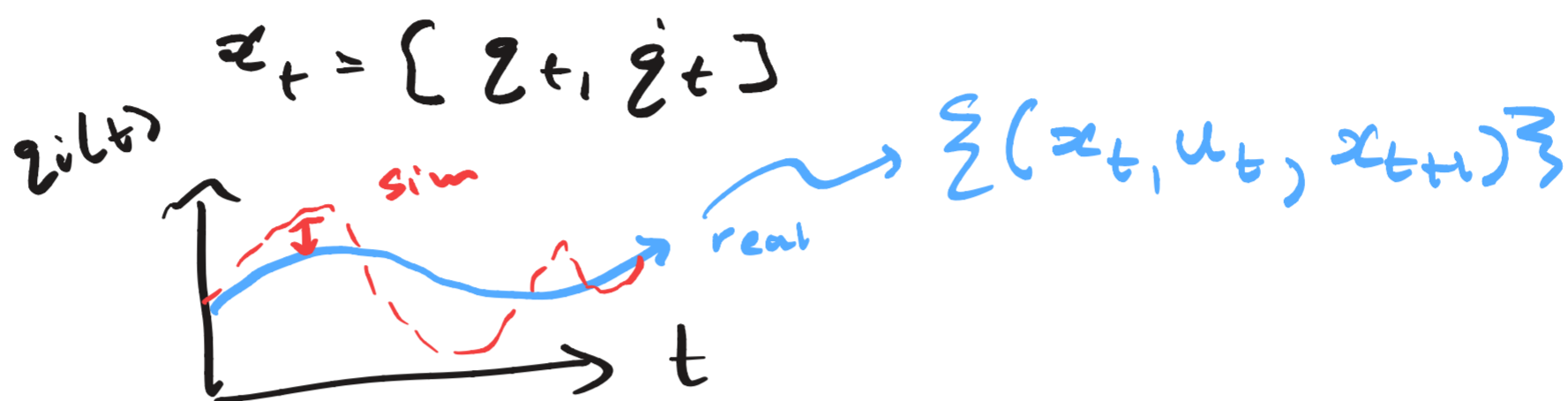
concrete example:



$$q = [\theta_1, \theta_2, \dots, \theta_n]$$

$$H(q)\ddot{q} + C(q, \dot{q})\dot{q} + g(q) = \tau$$

"URDF"
universal robot
description file



Key idea: we can use data from our system to build better models

SysID: $\min_{\theta} \sum_{t=0}^{T-1} \frac{1}{2} \|x_{t+1} - f_{\theta}(x_t, u_t)\|_2^2$

implicit assumption: the "gap" between model & reality is explained by parameters

typically: θ : mass, inertia, friction

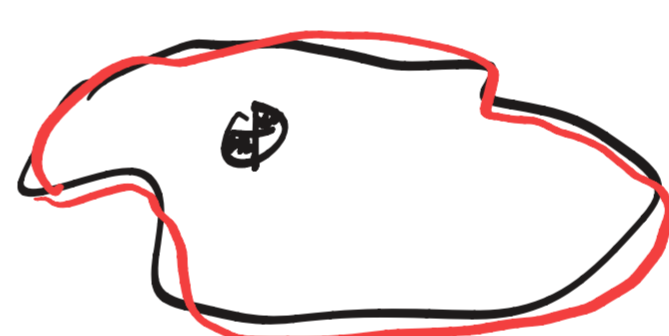
- Today:
- traditional approach
 - learning approach

Fun fact: if a system satisfies the manip. equations **impossible**

rigid body $\tau = W(q, \dot{q}, \ddot{q})\theta$

$\theta = [m^B, c^m, I^m] \in \mathbb{R}^n$

mass \uparrow c^m \uparrow Inertia



$$I^B = \begin{bmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{xy} & I_{yy} & I_{yz} \\ I_{xz} & I_{yz} & I_{zz} \end{bmatrix} \neq 0$$

Suppose: we have a dataset

$$\{(\tau_k, q_k, \dot{q}_k, \ddot{q}_k)\}$$

$$\begin{bmatrix} \tau_1 \\ \tau_2 \\ \vdots \\ \tau_T \end{bmatrix} = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_T \end{bmatrix} \theta$$

y

$$\min_{\theta} \frac{1}{2} \|y - W\theta\|_2^2 + \lambda \|\theta\|_2^2$$

regularization

$$\theta^* = W^+ y$$

- \odot : when does $\theta^* = \theta_{true}$
- + really rigid (physics) correct
 - + "persistence of excitation"
 - ($\tau(t)$ needs to have lots of frequency content)

Fun fact: you can never uniquely identify θ^*

A more modern approach: "real-to-sim"

$$f(x_t, u_t, \theta) : m_u \rightarrow c_o$$

θ : a bunch of $m_u \rightarrow c_o$ parameters

m_j -step

$$\min_{\theta} \sum \|x_{t+1} - m_{j\text{-step}}(x_t, u_t, \theta)\|_2^2$$

$$\hookrightarrow \min_{\theta} \sum_t \frac{1}{2} r_t(\theta)^2 \quad \star$$

\hookrightarrow Gauss-Newton

$$J^T J \delta\theta = -J^T r$$

1. differentiable sim
2. zero-order method