Thoughts about Generative Models in Control Systems

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July 3, 2024

- Control and estimation methods usually start with a dynamical system model of the form

$$x(k+1) = f(x(k), u(k), w(k)),$$

  where
  - x is what we call the *state*
  - u is what we call the *control*
  - w is what we call the *process noise*

- Usual assumptions include:
  - $x(k) \in \mathbb{R}^n,\ u(k) \in \mathbb{R}^m$, where n, m are "small" ~ 10
  - f is known, e.g., from physics
  - w is a white noise process, i.e., $w(k) \sim N(0, Q)$ and $w(k), w(\ell)$ are uncorrelated

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- Let us call this the *believed model*
  (to distinguish from other "models" that come up)

- The real system evolves *close to,* but not *exactly* according to the believed model. Examples:
- f is slightly different, e.g., has some extra terms due to simplified physics
- w is not white noise
- There are extra (hidden) states, e.g., actuator dynamics

- We are usually interested in the conditional distribution $p(x(k+1) \mid x(k), u(k))$ for designing estimators or controllers (esp. RL-based controllers)