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State-space observers 1 introduction

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Introduction

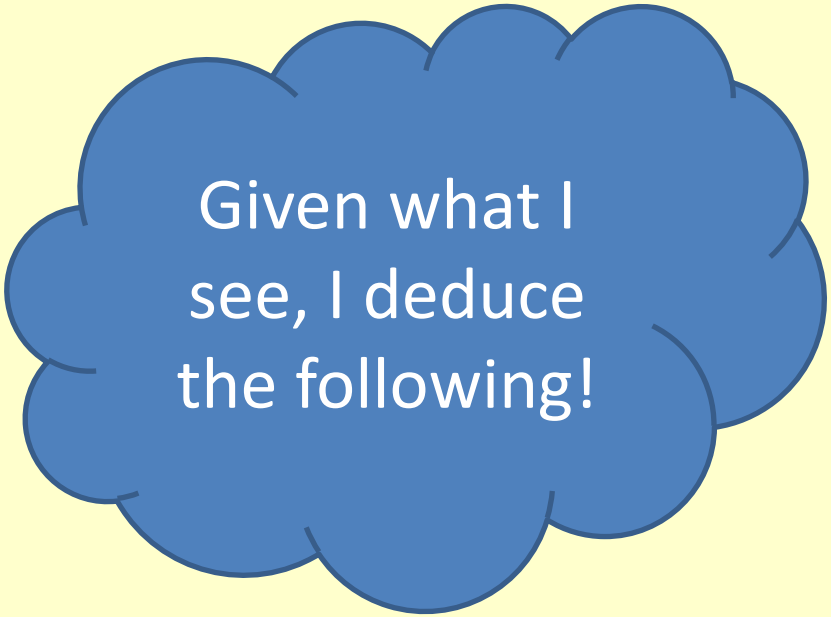
- The previous section looked at state feedback design for state space systems.

$$\dot{x} = Ax + Bu; \quad u = -Kx$$

- However, state feedback assumes the states are known by the control law whereas in practice many states cannot be measured easily.
- The next job is to consider how state values can be estimated (*or observed*) for use in the control law.

What is an observer?

An observer is an operator or system which interprets available measurements.



What knowledge is used to make these deductions?

Available knowledge

- What measurements are there?
- What is the quality of these measurements and thus how much confidence do I have in them?
- What other knowledge can I introduce which is relevant to the measurements?

The latter point is critical. Most measurements have a context. The more we understand about a context, the more reliably we can interpret the measurement.

Example of context

Muddy footprints

1. Someone walked this way since it last rained.
2. I know what size shoe they had on.
3. If the footprints are still damp, it is likely they were made recently.
4. If a limited number of people are around, I may be able to identify who made the foot prints.
5. Etc.

More context knowledge implies better inference!

Weak context

1. I do not know what the weather has been like recently so date stamping is difficult.
2. I do not know what people are around so cannot identify who might be responsible.
3. The footprints are rather messy so I cannot easily determine shoe size or even the tread pattern reliably.

Without strong context knowledge, it is difficult to make reliable deductions.

What is an observer?

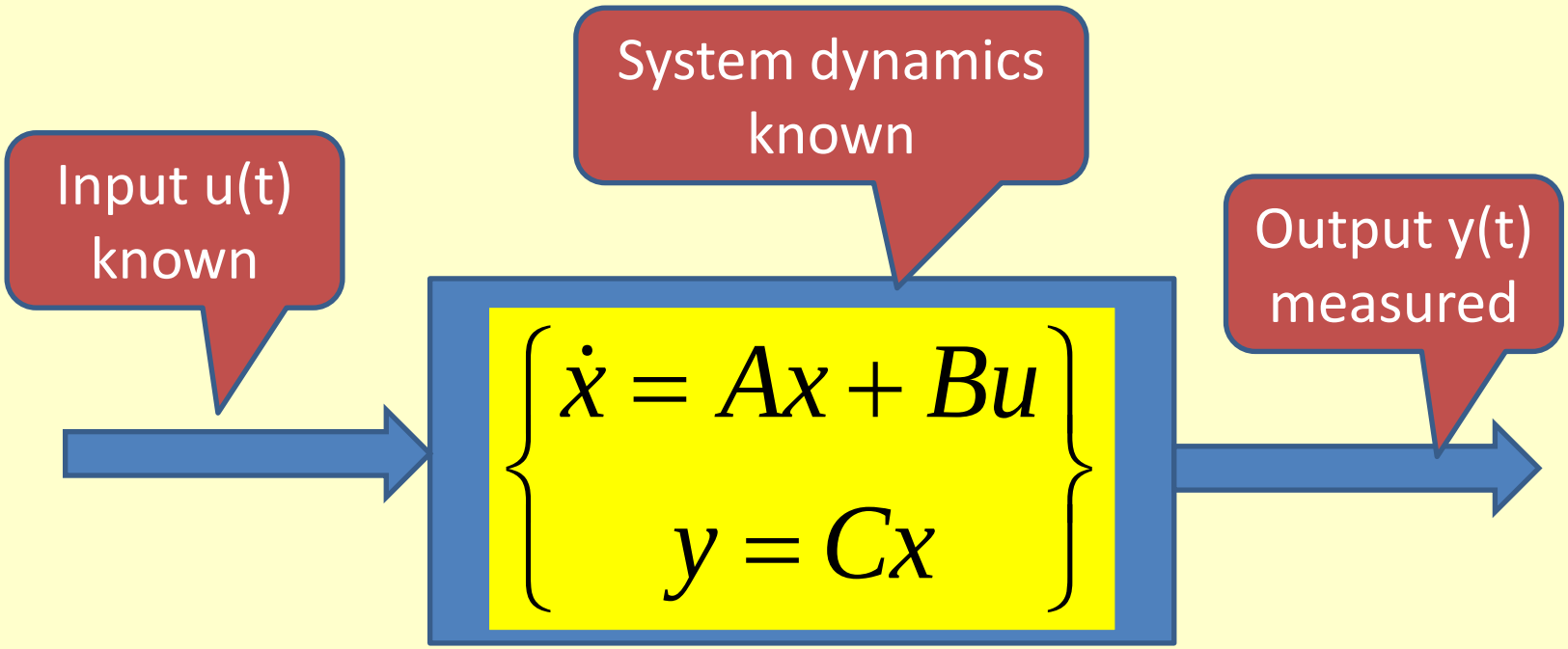
An observer is an operator or system which interprets available measurements.

Given what I see, I deduce the following!

What knowledge is used to make these deductions?

State space systems

- What measurements are available?
- What context knowledge do I have?
- Can I combine these efficiently and systematically to make reliable deductions?



Concept of state observer

- Given knowledge of u(t)
- Given measurements of y(t)
- Given knowledge of the state space model.

$$\left\{ \begin{array}{c} \dot{x} = Ax + Bu \\ y = Cx \end{array} \right\}$$

Can I determine the states x(t)?

For now assume A,B,C are known exactly and the measurements are good.

Intuitive procedure

Typically a human will do a form of back calculation.

- In order to have arrived at P with a given speed and timing, it is likely I went through M with a related speed and timing.
- This computation embeds awareness of system dynamics, so what forms of transition are feasible.

Postulate different initial conditions, simulate forward in time with the model, and select only those initial conditions which can lead to the current observed output.

Summary

Introduced concept of an observer.

1. An observer combines different forms of knowledge, facts and measurements to make inferences about a system state.
2. Typically an observer combines:
   a) Knowledge of past inputs.
   b) Available measurements of outputs.
   c) Knowledge of model parameters and thus system dynamics.
3. Next, we consider how to use this information systematically.

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