Introduction to Control

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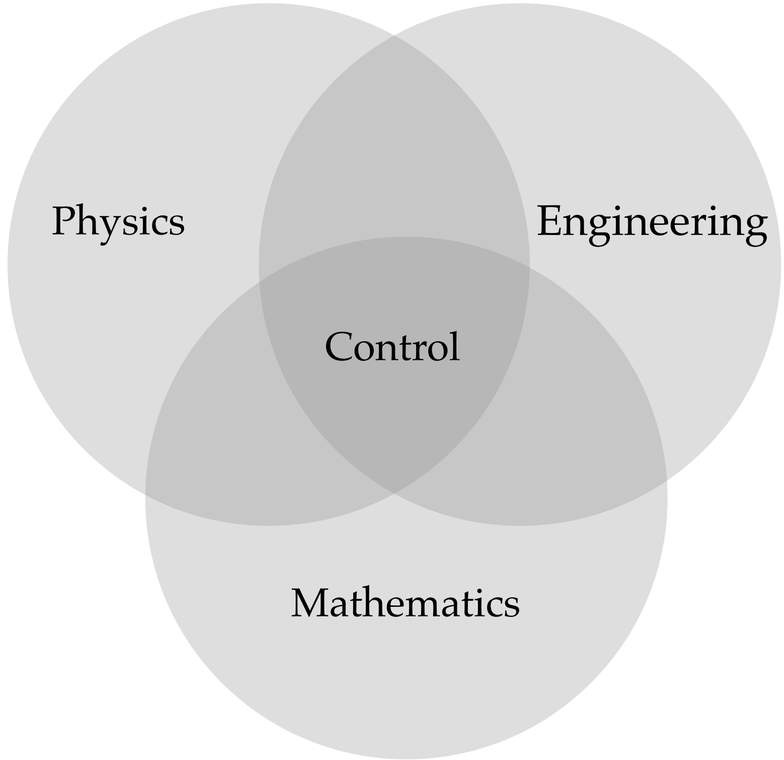
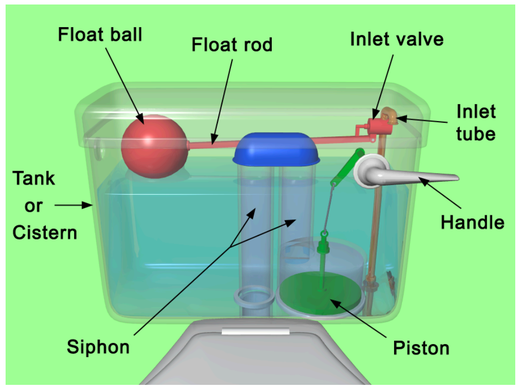
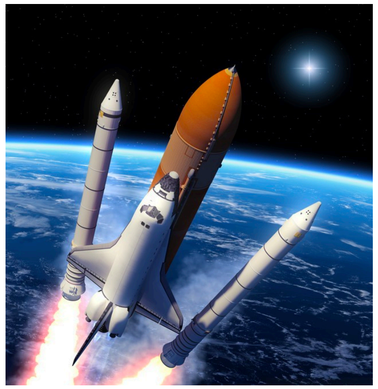
What is control?

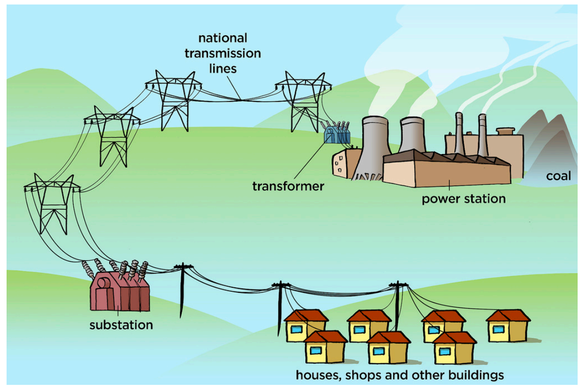
Science

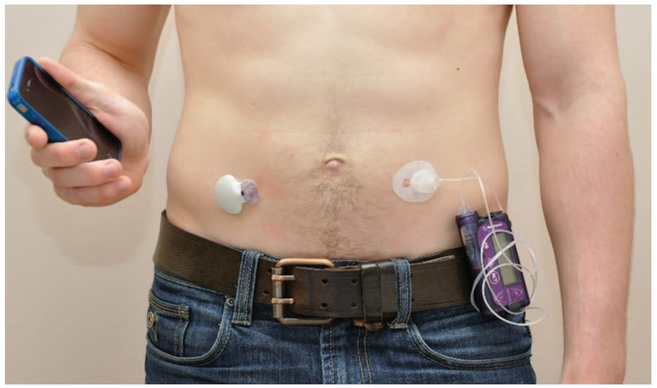
- of decision making and taking actions
- to make systems do what you want them to do
- behind all technologies











Very strong interactions with

traditional disciplines

- Electrical engineering
- Mechanical engineering
- Civil engineering
- Aerospace engineering
- Chemical engineering
- Biomedical engineering
- Economics

interdisciplinary areas

- Machine learning
- Robotics
- Neuroscience
- Biology
- Theoretical computer science
- Statistics

Components of a control system

- **Process/plant:** system that we would like to control (e.g., car, spacecraft, glucose level in blood)
- **Sensor:** device to measure some appropriate signal (e.g., eyes for human-driven car)
- **Controller:** decision-making module/algorithm (e.g., human brain, computer)
- **Actuator:** device to force the corrective action (e.g., brake/accelerator/steering wheel in car)

Think of your favorite control system and identify these components

Block diagrams

Conceptual way to think about complex systems

What does a block diagram have?

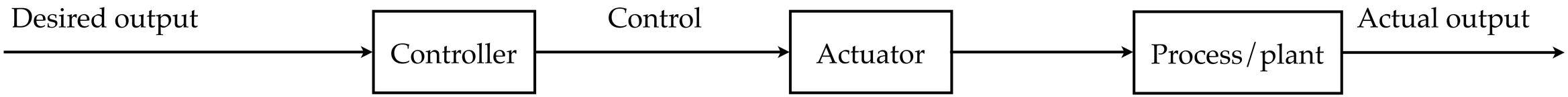
- Components **drawn as boxes**: plant + sensor + controller + actuator
- Interconnections between the components **drawn as arrows**
    - Which signal/information is going from where to where

Different types of block diagrams for different types of control systems

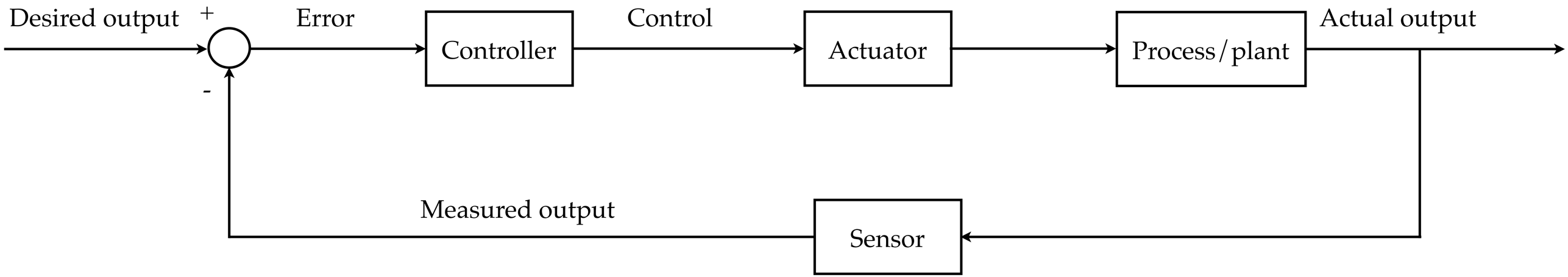
- **Open loop OR feedforward control**
- **Closed loop OR feedback control**

Open loop and closed loop controls: block diagrams

Open loop or feedforward control

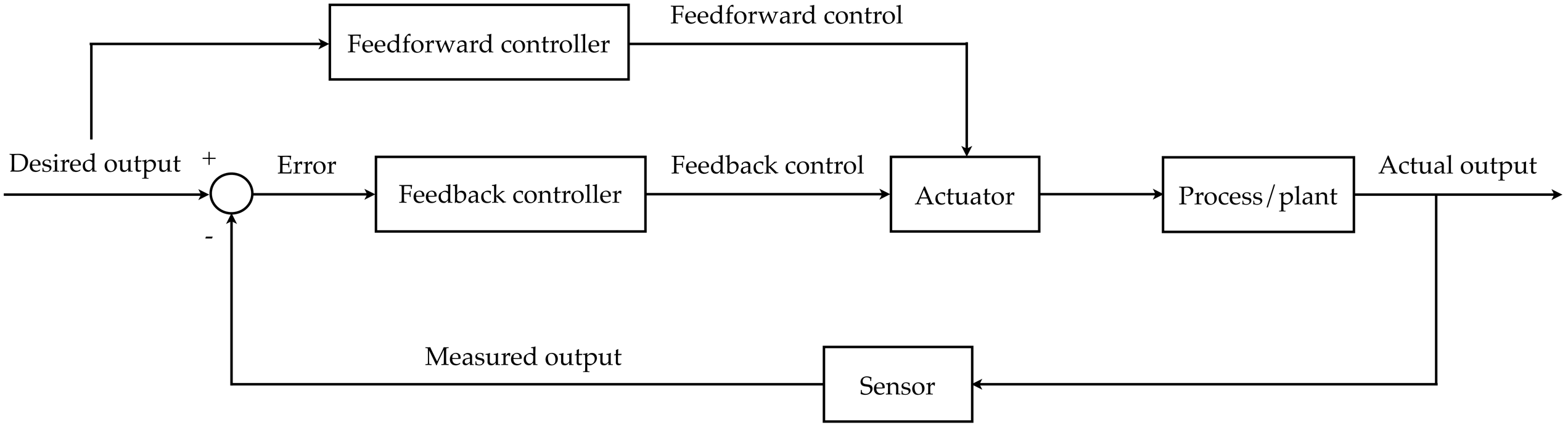


Closed loop or feedback control



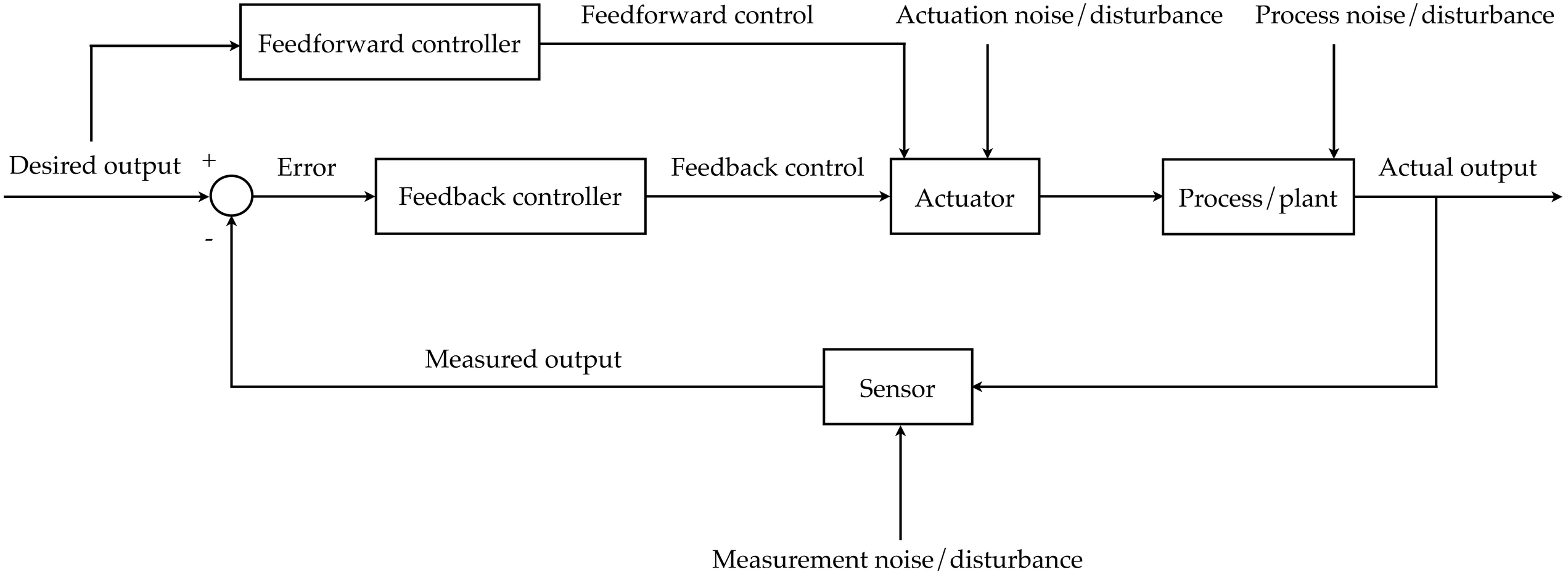
Open loop and closed loop controls: block diagrams

Mixed feedforward-feedback control



We also have noise/disturbance

Mixed feedforward-feedback control



Open loop (feedforward) versus closed loop (feedback)

Open loop (feedforward) control

- control can be designed offline
- no real-time sensing
- low implementation cost
- great if model is perfectly known
- dangerous if there are uncertainties

Closed loop (feedback) control

- good performance with uncertainties
- resilient against modeling errors
- more complex and expensive to design
- risk of destabilizing a stable process