ME547: Linear Systems

Introduction

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Topic

1. Introduction of controls

2. Introduction of the course

3. Beyond the course

The power of controls

- nanometer precision control
  - information storage
  - semiconductor manufacturing
- optics and laser beam steering
- robotics for manufacturing
- laser-material interaction in additive manufacturing
- everyday life: driving, cooking, showering, to name just a few

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Course Scope: analysis and control of linear dynamic systems

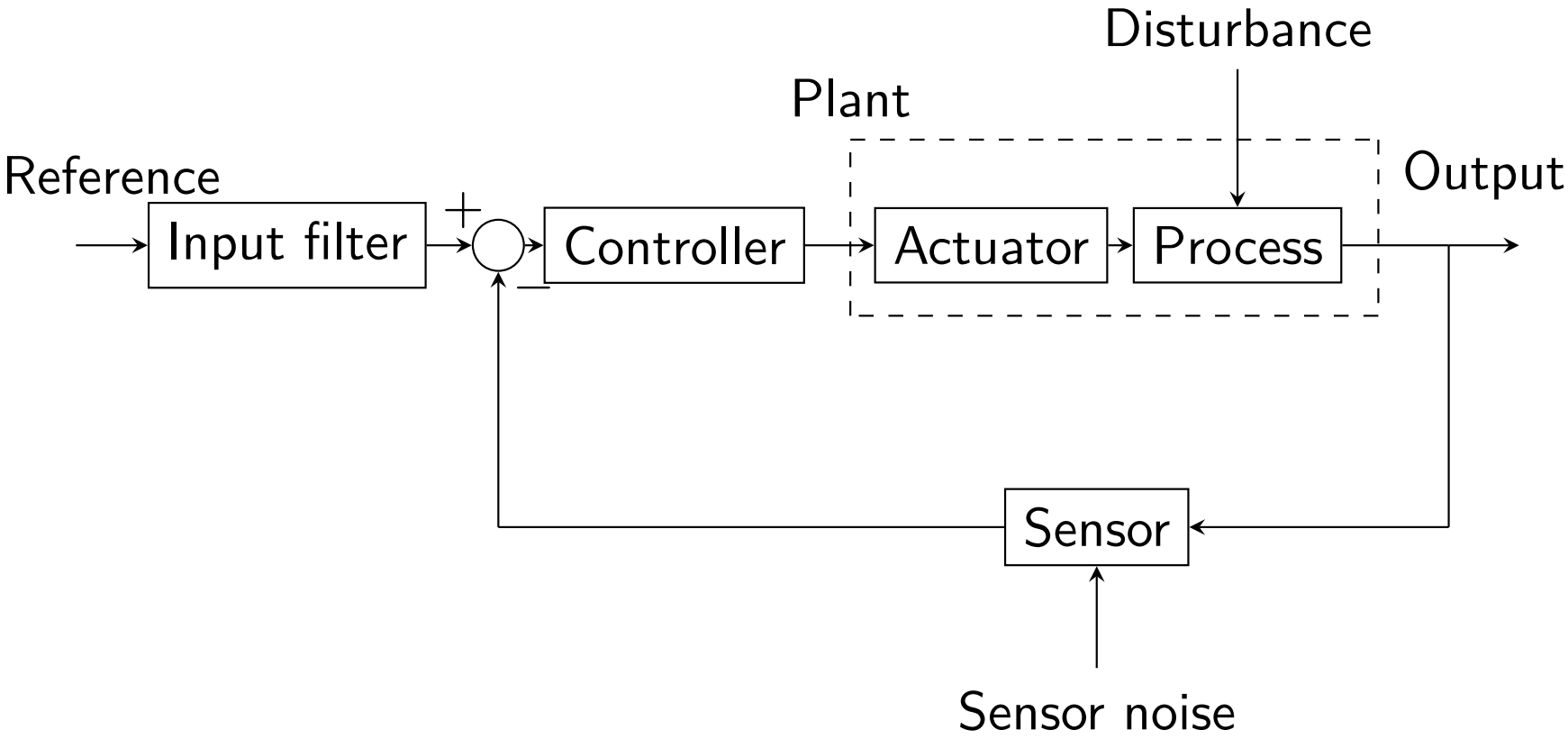
- System: an interconnection of elements and devices for a desired purpose
- Control System: an interconnection of components forming a system configuration that will provide a desired response
- Feedback: the use of information of the past or the present to influence behaviors of a system

Why automatic control?

A system can be either manually or automatically controlled. Why automatic control?

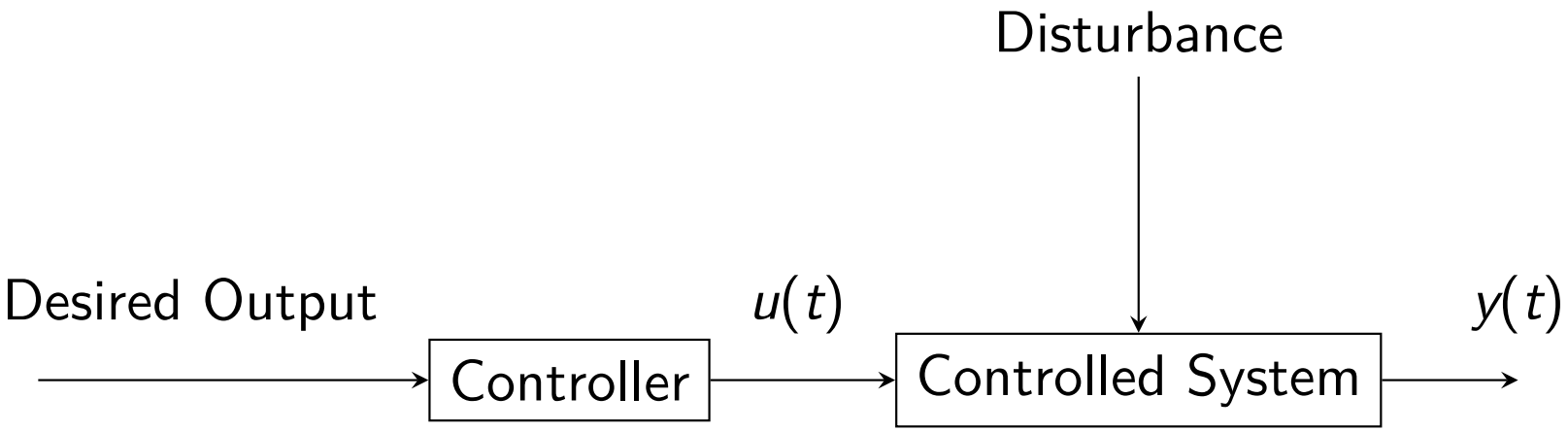
- Stability/Safety: difficult/impossible for humans to control the process or would expose humans to risk
- Performance: cannot be done "as well" by humans
- Cost: Humans are more expensive and can get bored
- Robustness: can deliver the requisite performance even if process behaves slightly differently

Terminologies



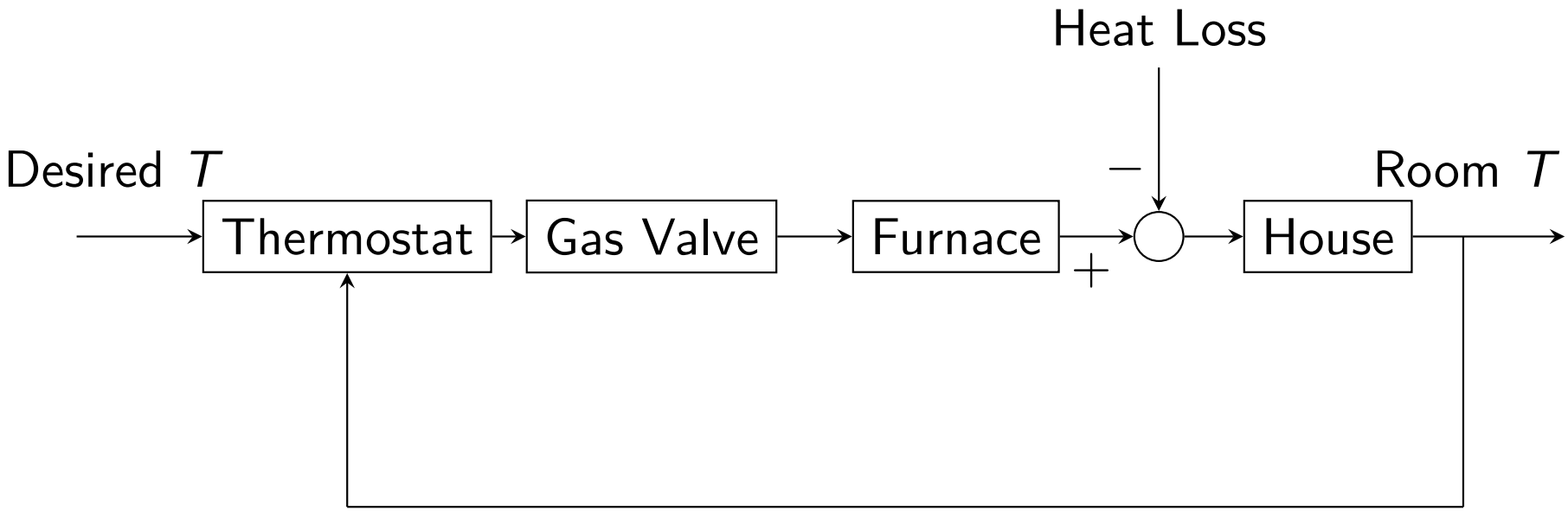
- Process: whose output(s) is/are to be controlled
- Actuator: device to influence the controlled variable of the process
- Plant: process + actuator
- Block diagram: visualizes system structure and the flow information in control systems

Open-loop control v.s. closed-loop control



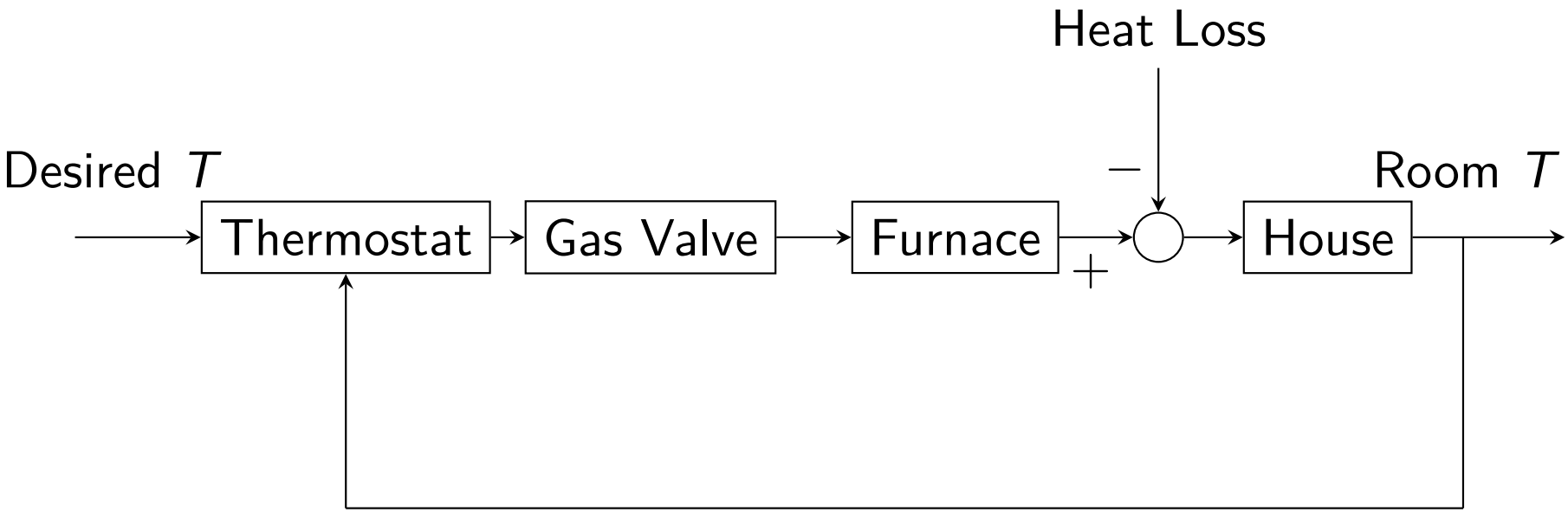
- the output of the plant does not influence the input to the controller
- input and output as *signals*: functions of time, e.g., speed of a car, temperature in a room, voltage applied to a motor, price of a stock, electrical-cardiograph, all as functions of time.

Open-loop control v.s. closed-loop control

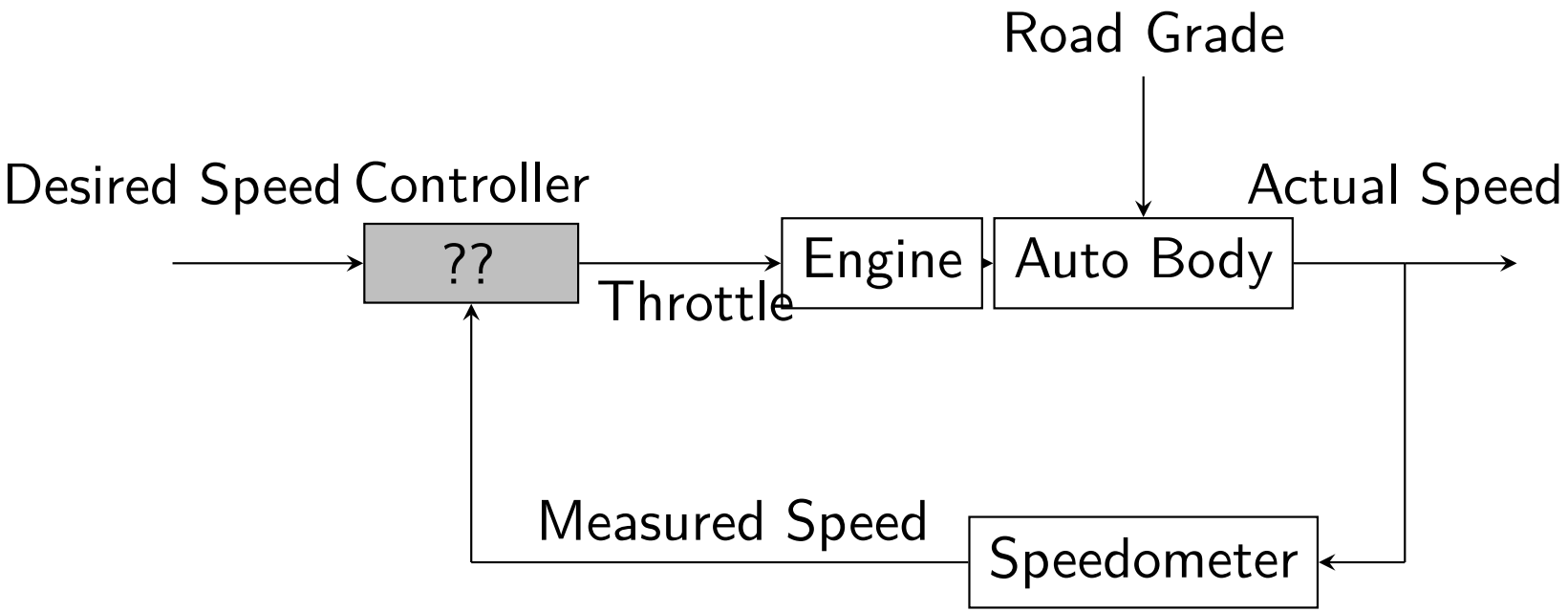


- multiple components (plant, controller, etc) have a closed interconnection
- there is always feedback in a closed-loop system

Closed-loop control: regulation example



Regulation control example: automobile cruise control



- What is the control objective?
- What are the process, process output, actuator, sensor, reference, and disturbance?

Control objectives

- Better stability
- Improved response characteristics
- *Regulation* of output in the presence of disturbances and noises
- Robustness to plant uncertainties
- *Tracking* time varying desired output

There are some aspects of control objectives that are universal. For example, we would always want our control system to result in closed-loop dynamics that are insensitive to disturbances. This is the disturbance rejection problem. Also, as pointed out previously, we would want the controller to be robust to plant modeling errors.

Means to achieve the control objectives

- Model the controlled plant
- Analyze the characteristics of the plant
- Design control algorithms (controllers)
- Analyze performance and robustness of the control system
- Implement the controller

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Resources for control education: societies

- AIAA (American Institute of Aeronautics and Astronautics)
  - Publications: AIAA Journal of Guidance, Control and Navigation
- ASME (American Society of Mechanical Engineers)
  - Publications: ASME Journal of Dynamic Systems, Measurement and Control[1]
- IEEE (Institute of Electrical and Electronics Engineers)
  - www.ieee.org
  - Control System Society
  - Publications:
    - IEEE Control Systems Magazine[1]
    - IEEE Transactions on Control Technology
    - IEEE Transactions on Automatic Control
- IFAC (International Federation of Automatic Control)
  - Publications: Automatica, Control Engineering Practice

[1] start looking at these, online or at library

IEEE Control Systems Magazine