MEE424 Fall 2021: Modern Control and Estimation

Course Introduction

Prof. Wei Zhang
Department of Mechanical and Energy Engineering
SUSTech Institute of Robotics
Southern University of Science and Technology

- **Course Information:**
  - **Title: Modern Control and Estimation**
  - **Location:** 2-201
  - **Time:** Monday 2pm – 3:50pm

    Wednesday (even weeks): 10:20am – 12:10pm
  - **Instructor:** Wei Zhang, zhangw3@sustc.edu.cn
  - **TAs**: Yinghan Sun, Daifeng Li, Bowen Shen

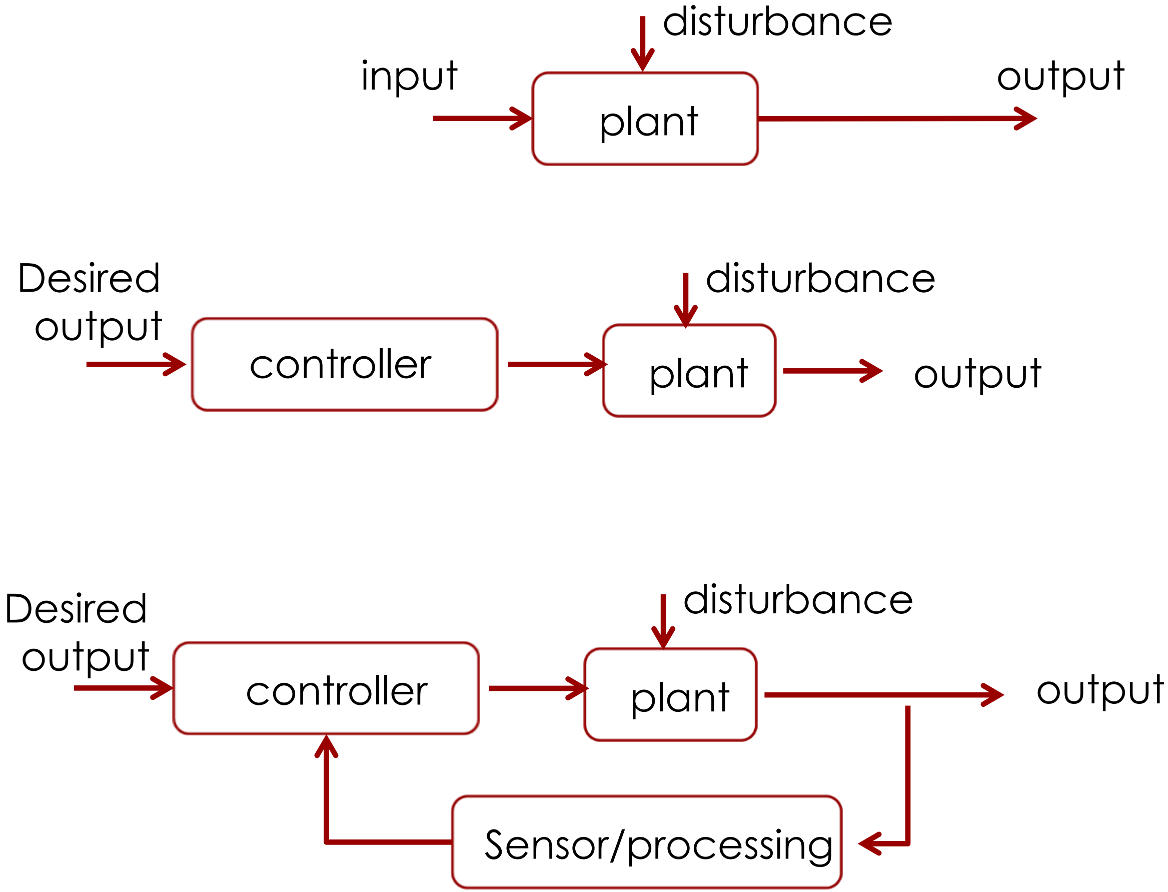


  - **Office Hours: TBD**
  - **Course website: https://www.wzhanglab.site/teaching/ModernControlEstimation**

- **Course materials:**
  - Lecture notes
  - Tutorials
- **Prerequisite:**
  - Linear algebra
  - Probability
  - Introductory control systems
- **What to expect:**
  - **Math intensive course**: advanced linear algebra and probability theory
  - **Many** homework and projects: good at coding (**Python**)
  - Good training with useful materials for
    - Motivated undergraduate students who plan to pursue graduate degree in control, robotics, or related areas.
- **Outcome**:
  - Solid understanding of modern control and estimation methods
  - Your own **Python toolbox** for modern control
  - Deep understanding on linear algebra and probability
  - Training on Python and robot simulation

- **Grading Policy:**
  - Homework 20%
  - Project 20%
  - Quiz 10%
  - Midterm 20% (open book, lecture notes)
  - Final Exam 30% (open book, lecture notes)
- **Notes:**
  - Discussion is allowed for homework, but all written work turned in must be your own.
  - Projects need to be completed by small groups with 2 - 3 people.

- **What is Control?**
  - Determine proper input of a system to achieve a desired output

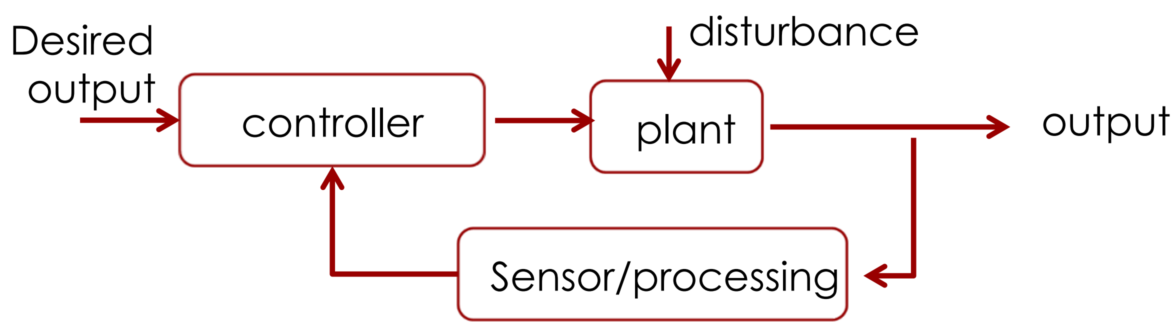


▪ Control applications

Robotics	Industrial robots, UAV control, humanoid robots, Autonomous vehicles, soft robots, underwater robots, multi-robot systems, AGVs, service robots
Medical	Medical instrumentation for monitoring and control; artificial limbs (prosthesis).
Home appliances	Home heating, refrigeration, and air conditioning via thermostatic control; humidity controllers; temperature control of ovens
Power/energy	Power system control (frequency and voltage); feedback instrumentation in oil recovery; optimal control of windmill blade and solar panel surfaces; optimal power distribution
Transportation	traffic flows control using sensors; automatic speed control devices on automobiles;
Manufacturing	Sensor-equipped robots for cutting, drilling die casting, forging, welding, packaging, and assembling; chemical process control; tension control windup processes in textile mills;
Aerospace and military	Missile guidance and control; automatic piloting; spacecraft control; tracking systems; nuclear submarine navigation and control; fire-control systems (artillery).

- Control applications

- **Control design**
  - **Modeling:** from plant to mathematical model
  - **Define control objectives:** small steady state errors, acceptable transient response, "Reject" disturbance, robust to parameter changes, small control efforts, …
  - **State estimation/observer design**: estimate system states from output measurements
  - **Controller design**: come up with a control law that maps estimated state to the control input to achieve the control objectives



- **Tentative Outline:**
  - Review of Linear Algebra (1 week)
  - State Space Models (1 week)
    - Digital control systems, transfer function model, state space model, realization theory
  - Basics of System Identification (2 weeks)
    - Least squares, system identifications
  - System properties (2.5 weeks)
    - State space model solutions, stability, controllability, observability
  - Controller Design: Pole placement (1 week)
  - Observer Design and Output Feedback (1 week)
  - Review of Probability (1 week)
  - Kalman Filtering (3 weeks)
    - Fundamentals of mean squared estimation, Kalman filter, applications
  - Advanced Control (3 weeks)
    - Optimal control and Linear quadratic regulator
    - Model Predictive Control
  - Selected Advanced Topics (if time permits)
    - Extended Kalman filter
    - Robot control applications

- More Discussions