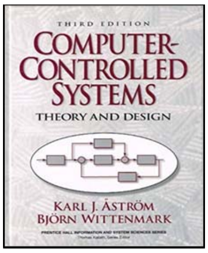
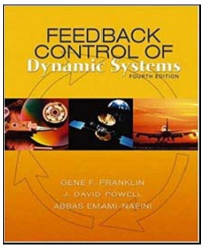
Spring 2019

數位控制系統
Digital Control Systems

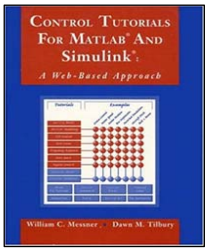
DCS-02
Project

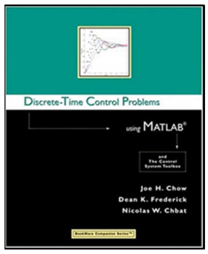




Feng-Li Lian
NTU-EE

Feb19 – Jun19





Syllabus

- **Lecture Information:**
  - Time: Fridays 1:40pm-4:30pm
  - Room: MD-225
  - Office Hours: by e-mail appointment
  - Website: http://cc.ee.ntu.edu.tw/~fengli/Teaching/DigitalControl
- **Instructor:**
  - 連豊力(Feng-Li Lian)
  - Office: MD-717
  - Email: fengli@ntu.edu.tw
  - Phone: 02-3366-3606
- **Grading:**
  - Homework (30%) bi-week
  - Midterm (30%) on x/y
  - Project (40%) on x/y
- **Textbook:**
  - Computer-Controlled Systems: Theory & Design, 3rd. Ed., (1997), by Astrom & Wittenmark
  - Discrete Time Control Problems Using Matlab and the Control System Toolbox, (2003), by Chow, Frederick & Chbat
- **References:**
  - Digital Control of Dynamic Systems, 3rd Ed., (1998), by Franklin, Powell, Workman
  - Real-Time Systems, (1997), by Krishna & Shin
  - Real-Time Computer Control: An Introduction, 2nd Ed., (1994), by Bennett
  - Control in an Information Rich World, Report of the Panel on Future Directions in Control, Dynamics, and Systems. http://www.cds.caltech.edu/~murray/cdspanel/report/cdspanel-15aug02.pdf

Grading: Term Project (40%)

- Team members:
  - About 1-3 students of different levels
  - Auditing/Visiting students are encouraged to join a team
- Subject/Title:
  - Theoretical study
    - Study any digital control theory and derive possible new results
  - Simulation study
    - Detailed and thorough simulation study of one application
  - Software package development of digital control systems
    - Develop toolkits similar to CCSDemo and Control Tutorial
- Agenda:
  - 5/3: Form a team and submit one-page proposal
  - 6/14: Progress Report
  - 6/25: Final Report

Grading: Term Project (40%)

- "Economy" Class:
  - Only 1 student
  - Simulation study of one typical control application
    - Such as flight, DVD/HD, motor, robot, etc.
    - Should include modeling, (timing) analysis, design, and simulation validation
- "Business" Class:
  - >= 2 students
  - >= 10 digital-control-related IEEE journal papers
  - Could only focus on one or two of the following areas:
    - Modeling, (system or timing) analysis, design, etc.
  - Strongly suggest to re-do the simulation results in the survey papers
- "First" Class:
  - <= 3 students
  - >= 20 digital-control-related IEEE journal papers
  - Generate good/nice (possibly new) theoretical results
  - Develop different (possibly useful) digital-control-related software package

- Agenda:
  - 5/3: Submit one-page proposal
    - > Including title, team members, affiliation, etc., and one or two paragraphs describing your ideas
  - 6/14: Progress Report
    - > Less than 5 pages including preliminary results and current status
  - 6/25: Final Report
    - > One zipped file of the related electronic files including documentation (docx) or presentation (pptx), matlab (m) files, etc.
      - » Please e-mail the link to the files of the report to fengli@ntu.edu.tw
        Deadline: By 11pm, 6/25

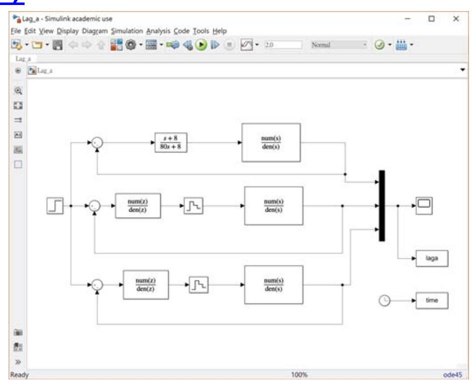
- Grading (40%):
  - Report (30% from group performance):
    - – Writing style & contents (10%)
      - > Title
        - » Does "title" actually and precisely reflect the content of this report?
      - > Introduction
        - » Does it provide enough background information about this study?
        - » Are references properly cited?
      - > Main results, including theoretical derivation or simulation study
        - » Do it explicitly and concisely describe the results?
        - » Are they good or solid enough to give readers any useful information?
      - > Discussions, summary/conclusions
        - » Does it conclude anything and provide good suggestion for the future?
      - > References
        - » Does it list enough cited papers?
    - – Technical content (20%)
      - > The contents on main result and discussions

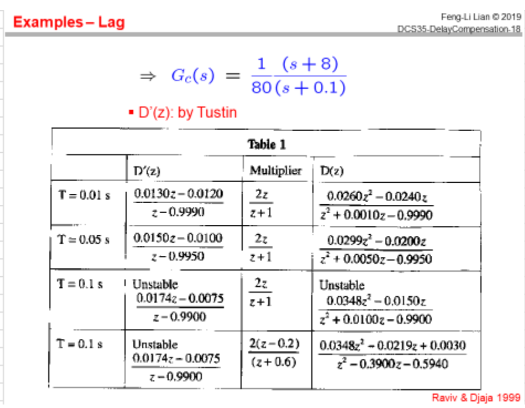
Grading: Term Project (40%)

- Grading (40%):
  - Report (30% from group performance):
    - Technical content (20%)
      - > The contents on main result and discussions, Including:
      - > Modeling:
        - » CT vs DT models, in terms of different sampling times
      - > Analysis:
        - » Stability, Controllability, Observability, in terms of different sampling times
      - > Design:
        - » Different controllers, observers, etc., vs different sampling times, performance specification
      - > Simulation studies with:
        - » Different sampling times
        - » Different design parameters
        - » Different performance specifications

Grading: Term Project (40%)

- Grading (40%):
  - Report (30% from group performance):
    - Technical content (20%)
      - > Simulation studies with:
        - » Different sampling times
        - » CT vs DT models, in terms of different sampling times





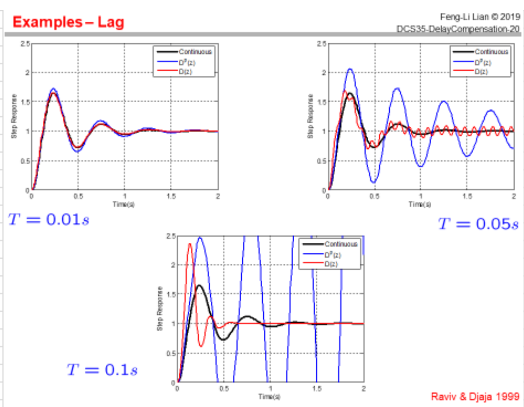
$$\Rightarrow \quad G_c(s) = \frac{1}{80}\frac{(s+8)}{(s+0.1)}$$

- D'(z): by Tustin

Table 1

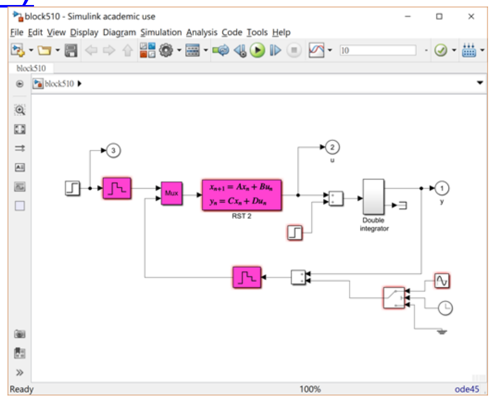
	D'(z)	Multiplier	D(z)
T = 0.01 s	$\frac{0.0130z - 0.0120}{z - 0.9990}$	$\frac{2z}{z+1}$	$\frac{0.0260z^2 - 0.0240z}{z^2 + 0.0010z - 0.9990}$
T = 0.05 s	$\frac{0.0150z - 0.0100}{z - 0.9950}$	$\frac{2z}{z+1}$	$\frac{0.0299z^2 - 0.0200z}{z^2 + 0.0050z - 0.9950}$
T = 0.1 s	Unstable $\frac{0.0174z - 0.0075}{z - 0.9900}$	$\frac{2z}{z+1}$	Unstable $\frac{0.0348z^2 - 0.0150z}{z^2 + 0.0100z - 0.9900}$
T = 0.1 s	Unstable $\frac{0.0174z - 0.0075}{z - 0.9900}$	$\frac{2(z-0.2)}{(z+0.6)}$	$\frac{0.0348z^2 - 0.0219z + 0.0030}{z^2 - 0.3900z - 0.5940}$

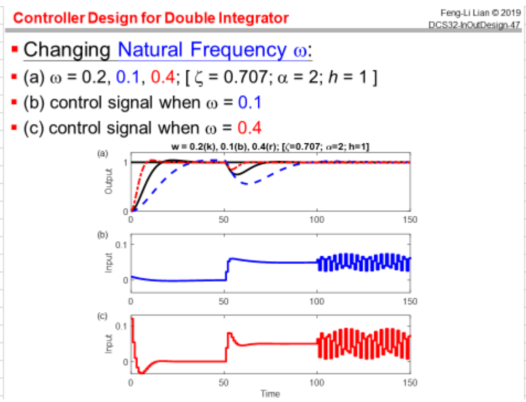
Raviv & Djaja 1999

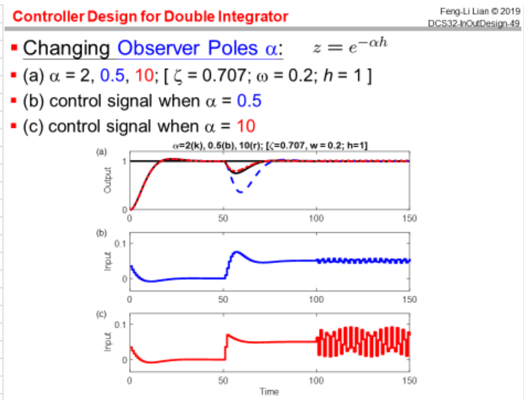


Grading: Term Project (40%)

- Grading (40%):
  - Report (30% from group performance):
    - – Technical content (20%)
      - > Simulation studies with:
        - » Different performance specifications
        - » Different controllers, observers, etc., vs different sampling times, performance specification







Grading: Term Project (40%)

- Grading (40%):
  - Presentation (10% from individual performance):
    - – Evaluation by instructor (5%)
    - – Evaluation by other students (5%)
    - – Suggested Format:
      - > Each group should use PowerPoint to give a formal presentation.
      - > Every group member should provide at least 7-min talk.
      - > After everyone's presentation, we will have Question-&-Answer session!

Introduction: Course Outline

- **Digital Control Systems**
  - From Analog to Digital World
  - Design Consideration
  - Z-transform
  - Controller Design
- **Computer Control Systems (Single Centralized Control)**
  - Real-Time Operation Systems
  - Analog to Digital
  - Digital to Analog
- **Networked Control Systems (Multiple Distributed Control)**
  - Control Networks Protocols
  - Networked Controllers & Managers
  - Networked Sensors
  - Networked Actuators

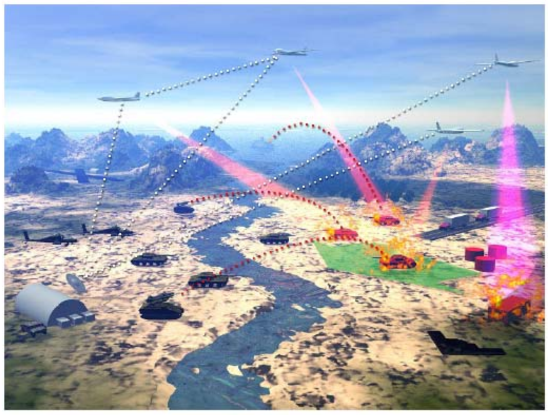
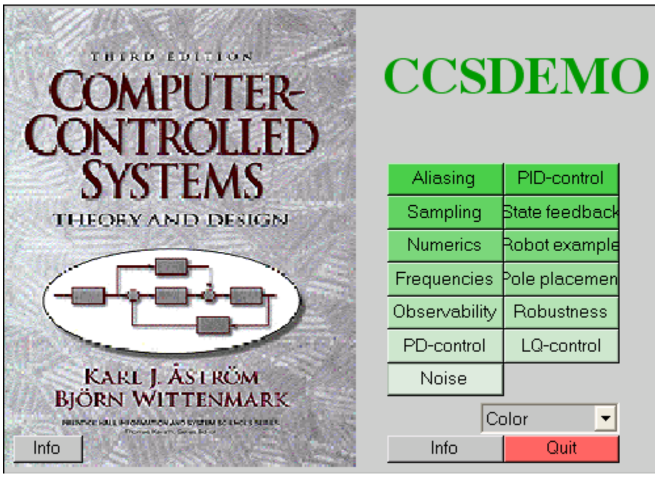
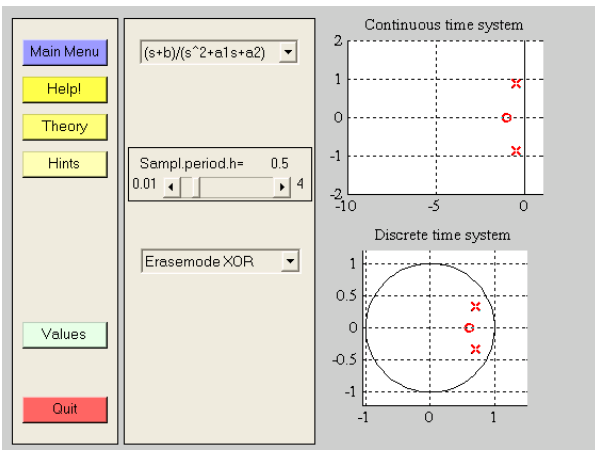


Figure 3.2. *Battle space management scenario illustrating distributed command and control between heterogeneous air and ground assets. Figure courtesy of DARPA.*

Introduction: Computer Aided Tools

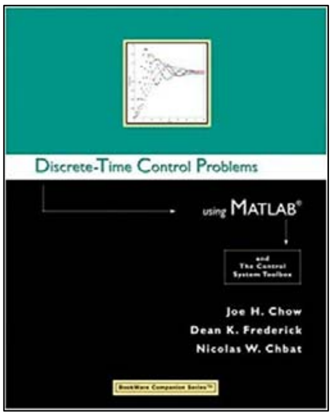
- **CCSDEMO** by Astrom & Wittnemark of Lund





Introduction: Computer Aided Tools

- Discrete Time Control Problems
  Using Matlab and the Control System Toolbox, (2003)
  - by Joe H. Chow, Dean K. Frederick, Nicholas W. Chbat
- Table of Content:



Introduction: Computer Aided Tools

- Control Tutorial for Matlab & Simulink

  by Tilbury of UMich & Messner of CMU

  http://ctms.engin.umich.edu/CTMS/