SPRING 2010

即時控制系統設計
Design of Real-Time Control Systems

Lecture 01
Syllabus

Feng-Li Lian

NTU-EE

Feb10 – Jun10

Syllabus

- Lecture Information:
  - Num: 921 U6200
  - Lecture Time: Tue 9:10-12:00noon
  - Discussion Time:
  - Room: MD-303
  - Office Hours: by e-mail appointment
  - http://cc.ee.ntu.edu.tw/~fengli/Teaching/RTCS
- Instructor:
  - 連豊力(Feng-Li Lian)
  - Office: MD717
  - Email: fengli@ntu.edu.tw
  - Phone: 02-3366-3606
- Grading:
  - Homework (30%)
  - Exam (30%)
  - Project (40%)
- References:
  - Feedback Control of Dynamic Systems, (Chap 8) 4th Ed., by Franklin, Powell, Emami-Naeini (2002)
  - Computer-Controlled Systems: Theory & Design, 3rd. Ed., by Amstron & Wittenmark (1997)
  - Digital Control using Digital Signal Processing, by Nekoogar & Moriarty (1999)
  - Real-Time Systems, by Krishna & Shin (1997)
  - Real-Time Systems, by Liu (2000)
  - Real-Time Computer Control: An Introduction, 2nd Ed., by Bennett (1994)
  - Digital Control Using DSP, by Nekoogar & Moriarty (1998)
  - 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

Course Topics

- Introduction + Project (2 wks)
  - 01. Syllabus
  - 02. A Brief Introduction to RTCS
  - 03. A Tutorial Paper on RTCS
- Computer Control Systems: Single Centralized Control (5~6 wks)
  - 11. Real-Time Operating Systems
  - 12. Characterizing Real-Time Systems
  - 13. Task Assignment & Scheduling
- Digital Control Systems (4 wks)
  - 21. Fundamentals of Digital Control
  - 22. Sampling
  - 23. Dynamic Analysis of Digital Control Systems
  - 24. Controller Design of Digital Control Systems
  - 25. Techniques for Enhancing the Performance of Discretized Controllers
  - 26. Timing Analysis for Control Applications
- Networked Control Systems: Multiple Distributed Control (6~7 wks)
  - 31. Real-Time Communications for Control Applications
  - 32. Industrial Networks for Control & Automation
  - 33. Introduction to Networked Control Systems
  - 34. Networked Control Methodology
  - 35. Scheduling Sampling Times of Networked Control Systems
  - 36. Design Consideration for a Networked Robot Arm

Course Schedule

- 2/28 (Sun): HW1: Research plan (.doc)
  - About your current research, including title, your information, date, description, and a list of papers you just read
- 3/07 (Sun): HW 2: Paper survey (.doc)
- 3/14 (Sun): HW 3: Define “real-time” (.doc)
- 4/06 (Tue): HW 4: Task Scheduling
- 4/18 (Sun): One-page proposal (.doc)
  - Including title, team members, affiliation, etc., and several paragraphs describing your ideas, as many references as possible
- 4/27 (Tue): HW 5: Digital control (hand writing)
- 5/19 (Sun): HW 6: Discretized controller (Matlab)
- 5/16 (Sun): Progress report (.doc) & presentation (.ppt)
  - More than 3 PPT pages including preliminary results and current status
- 5/18 (Tue): Midterm Exam (task scheduling + digital control)
- 6/15 (Tue): Project presentation (.ppt)
- 6/25 (Fri): Project report (.doc) by 5pm
  - Related electronic files including documentation and presentation files, etc.
    - > Please submit one zip file of all the electronic files by e-mail or put the zip file at some network directory such as at www.miroko.tw and e-mail the link.

Project and Report

- Team members:
  - About 2-4 students
  - Auditing/Visiting students are encouraged to join a team
- Topic/Title:
  - Theoretical study
    - Study any real-time control theory and derive possible new results
  - Simulation study
    - Detailed and thorough simulation study of control applications
  - Software package development of real-time control systems
    - Develop toolkits similar to CCSDemo and Control Tutorial

- "Economy" Class:
  - 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:
  - 1 or 2-4 students
  - >= 10 real-time-control-related technical 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:
  - (Possibly good/nice) theoretical results
  - Software package development

- 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 (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!

- Thesis:
  - Introduction:
    - > Motivation
    - > Literature Survey of Related Researches
    - > Contribution of the Thesis/Report/Paper
    - > Organization/Outline of the Thesis/Report/Paper
  - Mathematical Preliminary, Background, or Fundamental
    - » Discuss the background or fundamental information/materials related the research topics discussed in the Thesis/Report/Paper
  - Problem Formulation
    - » Formulate the problem discussed in the Thesis/Report/Paper mathematically, theoretically, academically, etc.
  - Analysis Results
  - Design Results
  - Simulation Study & Experimental Study
  - Conclusions/Summary and Future Works
  - Bibliography/References

- /R92921001/Lecture/
  - *.pdf, *.html, *.doc, *.m, etc.
- /R92921001/Lecture/Referecne/
  - *.pdf, *.html, *.doc, *.m, etc.
- /R92921001/Homework/HW1/ *.doc, *.m, *.pdf, etc.
  - /R92921001/Homework/HW2/, …/HW3/, …/HW4/, etc.
- /R92921001/Project/
  - 0225Prelim.doc
  - 0414Proposal.doc
  - 0519SlideMiterm.ppt
  - 0616SlideFinal.ppt
  - 0623FinalReport.doc
- /R92921001/Project/Reference/
  - 01ShinChou94RealTiime.pdf,
  - 02Sastry95TimeDelay.pdf, etc.
- /R92921001/Network/
  - 0512Slide.ppt
  - *.pdf, *.html, *.doc, etc.

Homeworks

Homework 1

- By 11pm, 2/28/10 (Sunday) by e-mail to fengli@ntu.edu.tw
- Use MS-Word to edit your Research Plan
- Content:
  - Homework 1: Research Plan
  - Title of your research topics
  - Name:
  - Registration Number:
  - Department, University, etc.
  - Date

  - A brief description about your research with several paragraphs
  - Describe why you want/need to know real-time control systems
  - Describe what your expectation from taking this course is
  - Write down any further suggestions, ideas, thoughts for the instructor

Homework 2

- By 11pm, 3/7/09 (Sunday) by e-mail to fengli@ntu.edu.tw
- Use MS-Word to edit your paper survey
- Content:
  - Homework 2: Paper Survey
  - Name:
  - Registration Number:
  - Department, University, etc.
  - Date

  - Go to some searchable database such as IEE/IEEE, EI etc. to search for related research papers.
  - Use keywords such as “real time control” + “your research topics” etc.
  - List 10 of them which interest you most.
  - Read the abstracts of the first 3 papers.
  - Summarize their ideas

  - Also, please estimate the time (in minute) you spend on each of the following:
    - 1. keyword searching; 2. abstract reading; 3. homework writing

Homework 3

- By 11pm, 3/21/09 (Sunday) by e-mail to fengli@ntu.edu.tw
- Use MS-Word to edit your document
- Content:
  - Homework 3: Define “real-time”
  - Name:
  - Registration Number:
  - Department, University, etc.
  - Date

  - Re-read the three or more papers you just obtained.
  - Look for the definition of “real-time”.
  - Identify how the authors define “real-time” or “real-time control” in the paper
  - Re-think again if the title or content without “real-time”.
  - Are the papers classified as real-time-related papers?

Homework 4

- Due on 4/6/09 (Tuesday) in class

- Content:
  - Homework 4: Task scheduling
  - Name:
  - Registration Number:
  - Department, University, etc.
  - Date:

Homework 5

- Due on 4/20/08 (Tuesday) in class
- Content:
  - Homework 5: Analysis and Design of Digital Control Systems
  - Name:
  - Registration Number:
  - Department, University, etc.
  - Date:

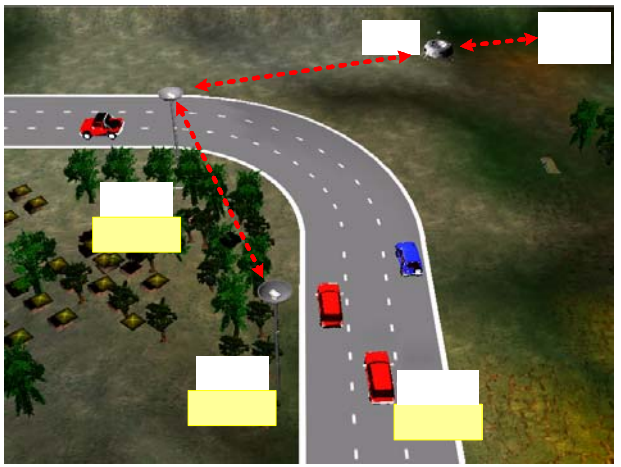
Homework 6

- By 11pm, 5/2/09 (Sunday) by e-mail to fengli@ntu.edu.tw
- Content:
  - Homework 6 (Discretized Controller)
  - Perform your simulation study of the four examples discussed in the paper by Raviv & Djaja, 1999
  - Submit R93921XXX.m of Matlab program
    - Name, Registration Number, Department, University, etc.
    - Date:
  - Submit R93921XXX.doc of Word file
    - Name, Registration Number, Department, University, etc.
    - Date:
    - From Matlab/Figure, use Edit/Copy Figure to copy every figure generated by the Matlab program
    - When copying figures, set up the following options:
      - Edit/Copy Options
        - Clipboard format -> Preserve information
        - Figure background color -> Transparent background
        - Size -> Match figure screen size
    - Discuss in detail how do you set up your simulation
    - Provide any possible description or explanation for each figure
    - Further discussions if possible

Ongoing Projects

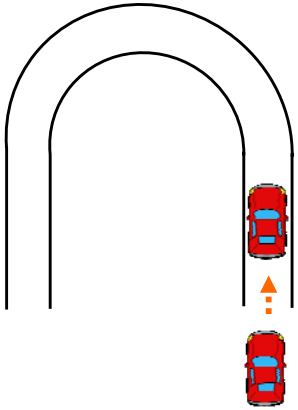
Ongoing Projects

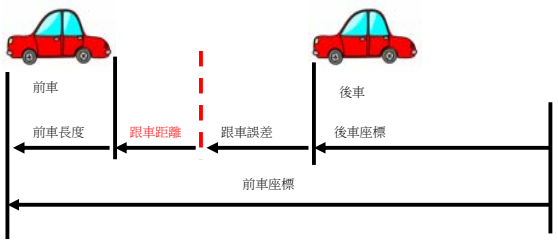
Ongoing Project: Smart Driving



Ongoing Project: Car Following

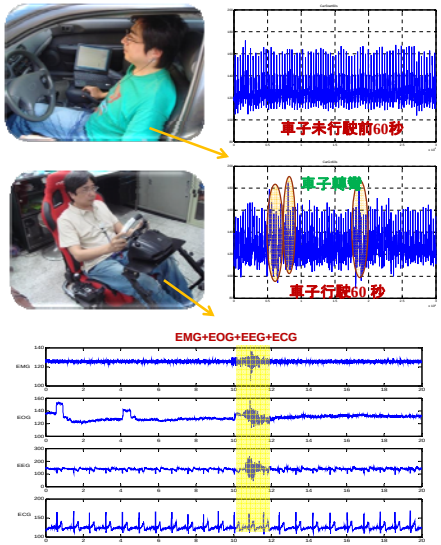
- 跟車控制模型
  - 相對距離運動方程
  - 驅動器動態方程
  - 行車阻力、摩擦力
- 驅動器控制
  - 方向盤
  - 油門開度
  - 煞車
- 目標
  - 跟車速度: 120Km/Hr
  - 速度誤差: ±5Km/Hr
  - 縱向跟車距離: 80m
  - 橫向跟車誤差: ±0.5m





Ongoing Project: Driver Assistance System

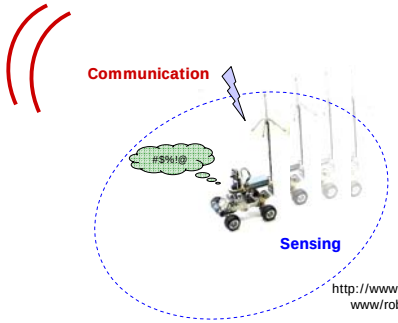
具有生理回饋駕駛模擬平台



Ongoing Project: Wireless Sensing and Control

http://imus.csie.ncku.edu.tw/imus/sensor/index.html

www.dei.unipd.it/~schenato/

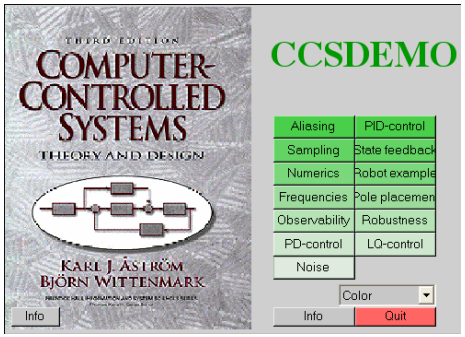


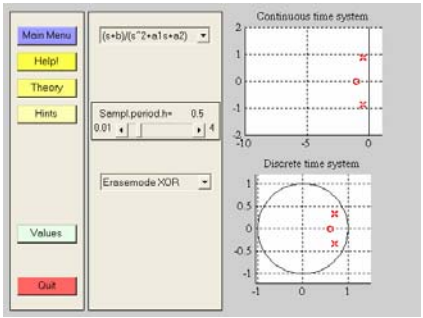
http://www.geology.smu.edu/~dpa-www/robo/camcar/index.html

Computer Aided Software Tools

Computer-Aided Software Tools

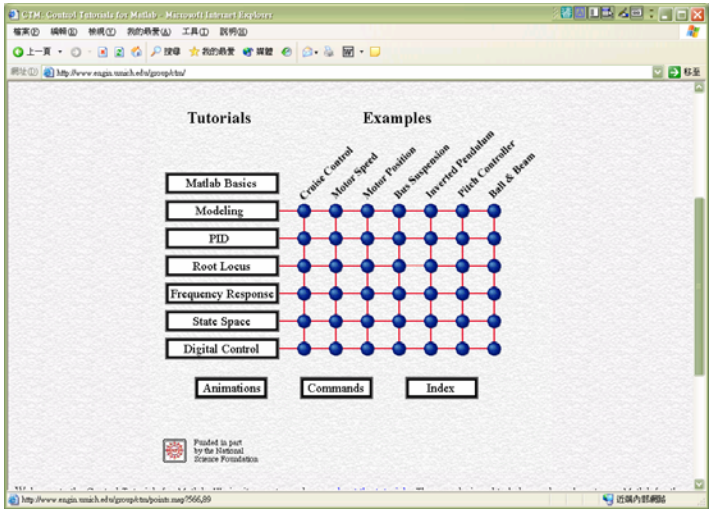
- CCSDEMO by Astrom & Wittnemark of Lund





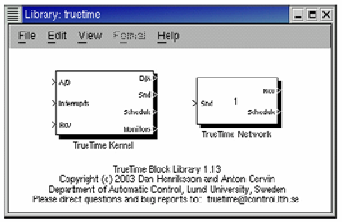
http://www.control.lth.se/~kursdr/ccs/when.html

- Control Tutorial for Matlab & Simulink
  by Tilbury of UMich & Messner of CMU



http://www.engin.umich.edu/group/ctm/

- TrueTime: Simulation of Networked and Embedded Control System



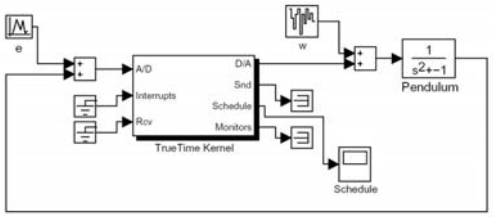
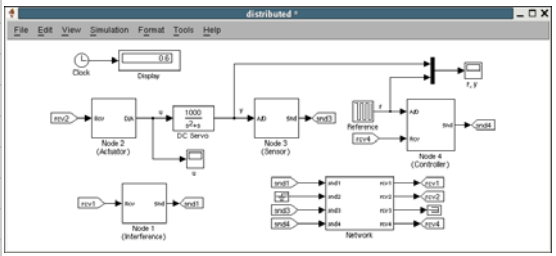
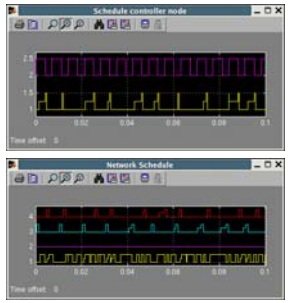


Figure 1 The TRUETIME block library.



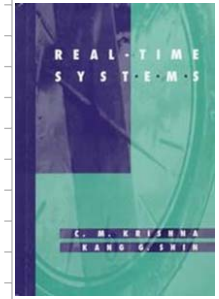


http://www.control.lth.se/truetime/

Books on Real-Time Control Systems

Real-Time Systems

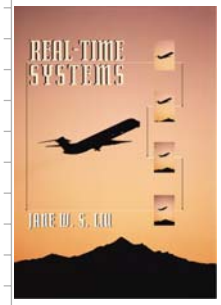
- Real-Time Systems, 1997
- Krishna and Shin, McGraw-Hill



1. Introduction
2. Characterizing Real-Time Systems and Tasks
3. Task Assignment and Scheduling
4. Programming Languages and Tools
5. Real-Time Databases
6. Real-Time Communication
7. Fault-Tolerance Techniques
8. Reliability Evaluation Techniques
9. Clock Synchronization

Real-Time Systems

- Real-Time Systems, 2000
- Jane W. S. Liu, Prentice Hall



1. Typical Real-Time Applications.
2. Hard Versus Soft Real-Time Systems.
3. A Reference Model of Real-Time Systems.
4. Commonly Used Approaches to Hard Real-Time Scheduling.
5. Clock-Driven Scheduling.
6. Priority-Driven Scheduling of Periodic Tasks.
7. Scheduling Aperiodic and Sporadic Jobs in Priority-Driven Systems.
8. Resources and Resource Access Control.
9. Multiprocessor Scheduling and Resource Access Control.
10. Scheduling Flexible Computations and Tasks with Temporal Distance Constraints.
11. Real-Time Communications.
12. Operating Systems.

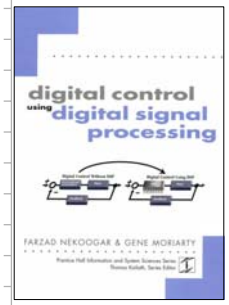
Real-Time Computer Control: An Introduction

- Real-Time Computer Control: An Introduction, 2nd, 1994
- S. Bennett, Prentice Hall

1. Introduction to Real-time Systems
2. Concepts of Computer Control
3. Computer Hardware Requirements for Real-time Applications
4. DDC Algorithms and Their Implementation
5. Languages for Real-time Applications
6. Operating Systems
7. Design of Real-time Systems - General Introduction
8. Real-time System Development Methodologies - 1
9. Real-time System Development Methodologies - 2
10. Design Analysis
11. Dependability, Fault Detection and Fault Tolerance

Digital Control Using Digital Signal Processing

- Digital Control Using Digital Signal Processing, 1998
- Nekoogar & Moriarty, Prentice Hall



1. Introduction to Digital Control Using digital signal processing
2. Mathematical models of discrete systems
3. Analysis of discrete systems
4. Design of digital control systems
5. DSPs in control systems
6. Modern design techniques and their applications

A. The MATRIX[subscript x] and MATLAB Design and Analysis Software
B. dSPACE
C. C Tables of Transforms
D. D Partial-Fraction Expansion Method
E. Matrix Analysis
F. Motion Controller Boards
G. Sample DSP Programs
H. Computer Architecture