ELEC 310
Digital Signal Processing

Alexandra Branzan Albu

Course information

Instructor:

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Schedule:

Tuesday, Wednesday, Friday 10:30-11:20 ECS 125

Office Hours:

Wednesdays and Fridays 2:00 pm-3:30 pm EOW 315 or by appointment

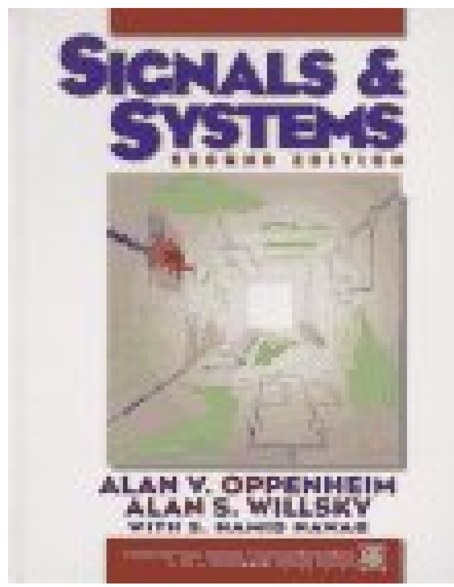
Course website:

www.ece.uvic.ca/~elec310

Textbook

A. V. Oppenheim, A. S. Willsky, and S. H. Nawab

Signals and Systems, 2^{nd} edition



Marking scheme

- Regular homework assignments: 15%
  - Due dates must be respected; late hand-ins will be penalized.
- One quiz: 10%
  - Tentative date: February 3rd
- In-class midterm: 30%
  - Similar to homework assignment
  - Tentative date: March 3rd
- Final exam: 45%

Who am I?

- since 2005: Assistant professor at UVic (ECE)
- 2003-2005: Assistant professor at Laval (ECE)

- office: EOW 315
- email: aalbu@ece.uvic.ca

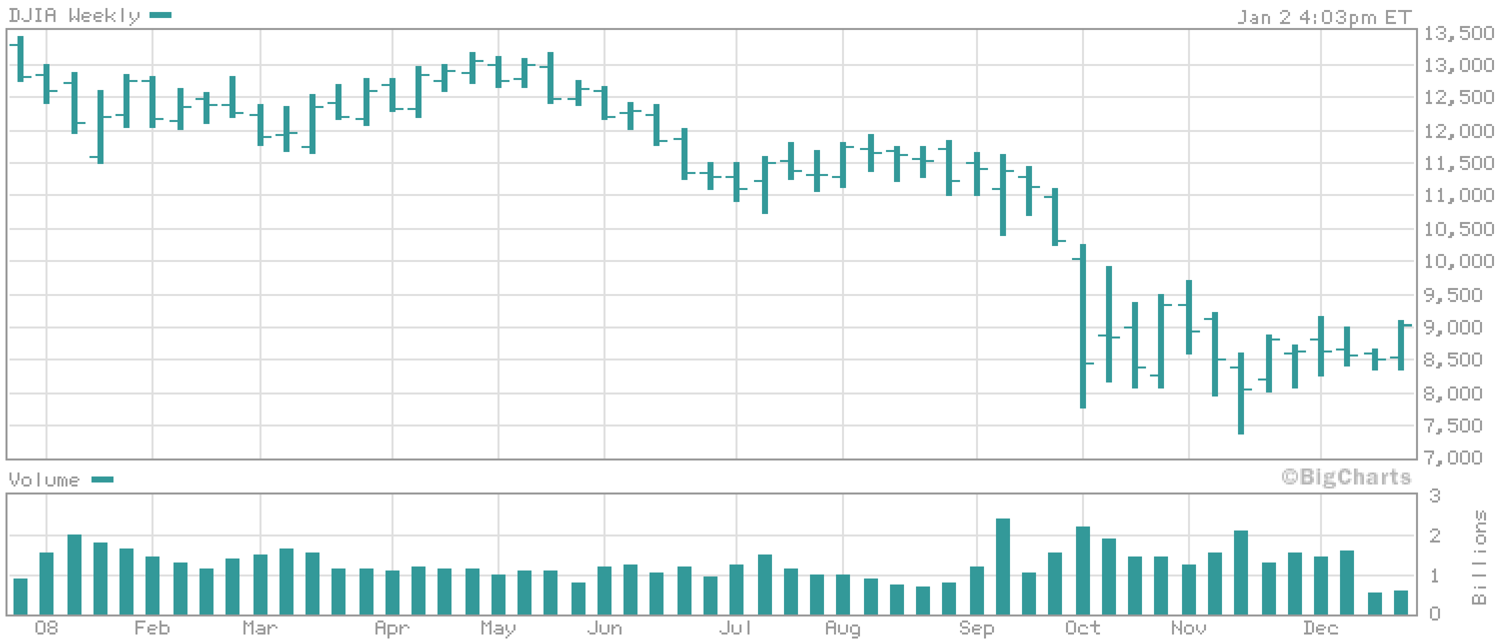
- my research: Computer Vision
  - medical image analysis
  - human motion analysis
  - www.ece.uvic.ca/~aalbu

What is DSP?

- DSP (Digital Signal Processing) is processing of signals by digital means.
- Digital=numerical
- A digital signal consists of a stream of numbers
- Applications: audio, image, video, radar, sonar, communications, biomedical engineering, etc.

Why DSP?

- Discrete-time (DT) signals can be processed by modern <u>digital</u> computers and <u>digital</u> signal processors



Why DSP? (cont'd)

- Large variety of techniques
  - Linear and nonlinear math operations work over a wide dynamic range of signal, 2^31 to 2^-31 for standard floating point
  - Lossless data compression algorithms available
  - Adaptive filters
- Software-based implementations require no custom hardware - just use standard signal I/O boards and write custom software
- No tuning of analog components (R,L,C) during production or during maintenance.

Signals

- Signals is a description of how one parameter changes with another parameter.
  - Voltage changes over time in an electronic circuit
  - Brightness changes with distance in an image
- The pattern of change conveys information

Signals represent information

More examples:

- Electrical signals: voltages and currents in a circuit
- Acoustical signals: variation in air pressure
- Video signals: variations of intensity on a frame-by-frame basis

Signals (cont'd)

- Signals may not convey information directly and may not be free from disturbances (signal to noise ratio)
- We need signal processing techniques for:
  - Enhancing the signal-to-noise ratio (noise removal)
  - Signal storage (compression)
  - Signal transmission (compression, modulation etc)
  - Signal analysis (feature extraction, pattern recognition etc)

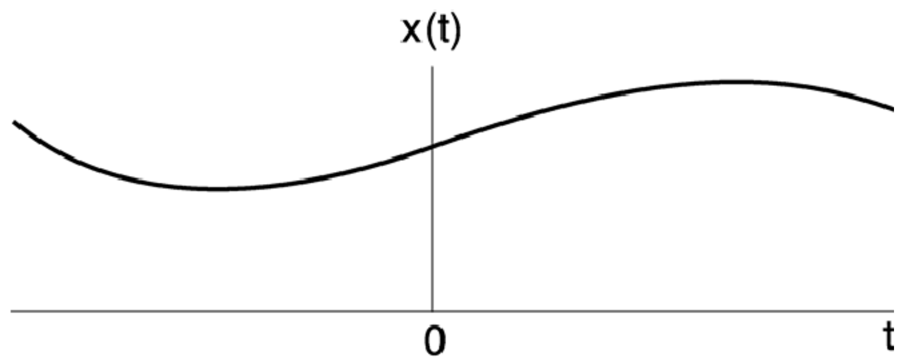
Independent variables

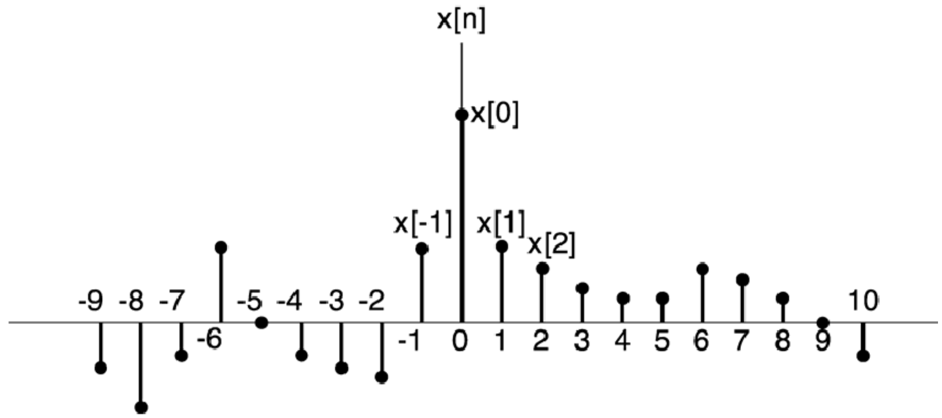
- To carry information, a signal must have a pattern of variation of some sort (i.e. spatial or temporal).
- Mathematical representation of signals : functions of one or more independent variables
  - Speech signal=acoustic pressure as a function of time
  - Image signal= {R(x,y), G(x,y), B(x,y)}

For this course, we will focus on one independent variable: time

- Continuous time (CT) signals : $x(t)$, t takes continuous values
- Discrete time (DT) signals: $x[n]$, n takes integer values only

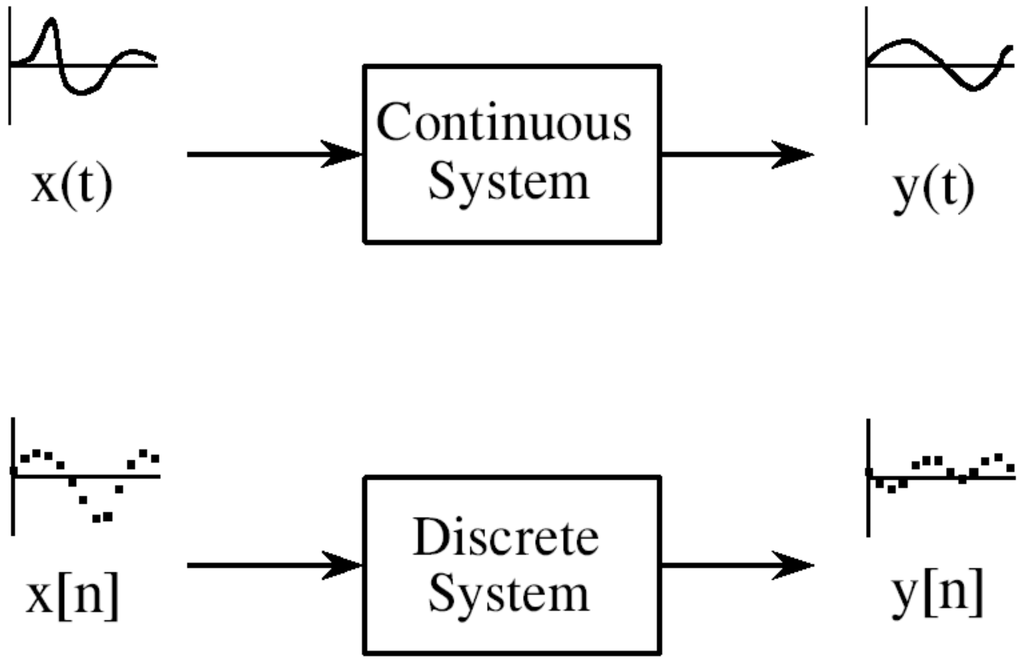
Examples of CT and DT signals





Systems

- A system is any process that produces an output signal as a result of an input signal

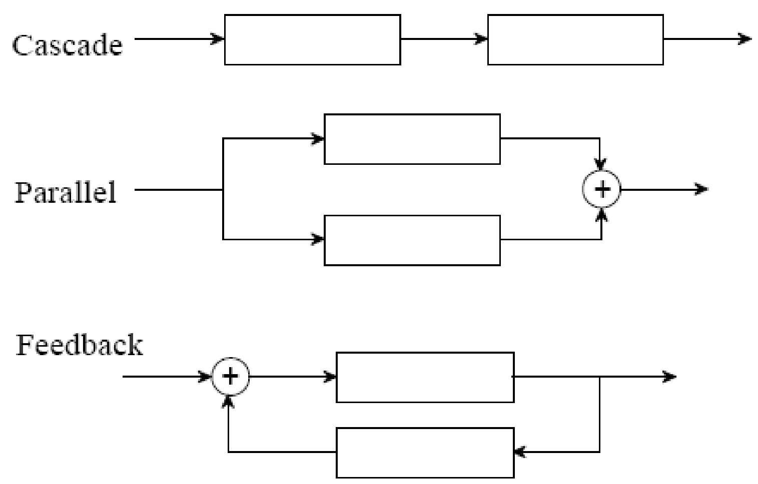


Systems (cont'd)

- Systems are usually **designed** for very specific tasks:
  - Remove noise in an electrocardiogram
  - Sharpen an out-of-focus image
  - Remove echoes in an audio recording
- In other applications, we need to understand how an existing system works (system **analysis**)
  - When speaking into a telephone, we expect the other person to hear something that resembles our voice
  - However, the transmission line introduces distorsions, thus its output signal may be very different from the input signal
  - If we understand how the transmission line is changing the signal, then we can try to compensate its effect.

System Interconnections

- An important concept for
  - building more complex systems by interconnecting simpler subsystems
  - modifying the response of a system
- Signal flow (Block) diagram



Course Overview

- Brief review of continuous-time signals and systems
- Discrete signals and systems
  - Discrete signals
    - Definitions, properties, operations
  - Discrete systems (time-domain analysis)
    - Linear, time-invariant systems (LTI)
    - Digital filters: difference equations, impulse response
    - convolution
- Analysis in the frequency domain
  - The Discrete-Time Fourier Transform (DTFT)
  - The Discrete Fourier Transform (DFT)
  - Frequency response of LTI systems
- Sampling, aliasing, and reconstruction
- Z-transform analysis
  - The direct and inverse Z-transform:
    - definition and properties
  - Transfer function of an LTI system
    - Region of convergence (ROC), zeros, poles

Prerequisites

ELEC 240/260

- CT signals
- Fourier series for analysis of continuous signals
- Fourier transform
- Laplace transform
- Sampling theorem
- Complex numbers

How to get a good mark in ELEC 310

- Before class
  - read required sections in textbook (see course site)
- During class
  - Take notes, ask questions, participate in class discussions
- After class
  - Read slides
  - Re-read corresponding textbook sections
  - Work drill problems and examples in textbook
  - Work homework problems