Fundamentals of DSP
Chap. 1: Introduction

Chia-Wen Lin

Dept. CSIE, National Chung Cheng Univ.

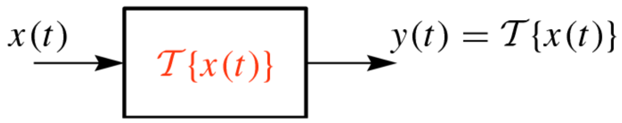
Chiayi, Taiwan

Office: 511

Phone: #33120

Digital Signal Processing

- Signal Processing is to study how to represent, convert, interpret, and process a signal and the information contained in the signal
- DSP: signal processing in the digital domain



McClellan, Schafer and Yoder, *Signal Processing First,* ISBN 0-13-065562-7.
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Who Should Take this Course?

- Applications of DSP
  - Multimedia (audio, speech, image, and video) signal processing
  - Communication and networking
  - Biomedical applications
  - Radar
  - Seismic wave analysis
  - SOC for signal processing and communication
  - Time series analysis (e.g., power load forecasting, Stock market trend analysis, etc.)

Math Background for this Course

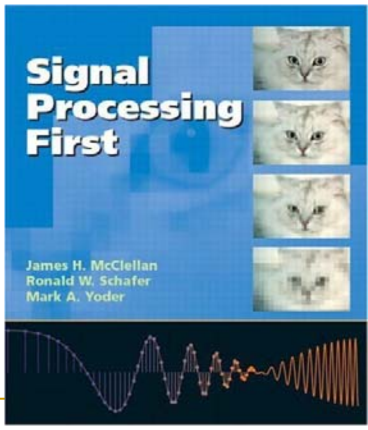
- Calculus
- Engineering Math
  - Laplace Transform
  - Fourier analysis
  - Complex variables
- Linear Algebra
  - Inner product
  - Basis functions
  - Linear transformations

Courses Related to Multimedia Signal Processing

- Undergraduate-level
  - Signals and Systems (EE)
  - Fundamentals of DSP
  - Introductions to Multimedia Systems (CS)
- Graduate-level
  - Digital Signal Processing
  - Digital Speech/Audio Processing
  - Digital Image Processing
  - Digital Video Processing
  - Multimedia Systems
  - Pattern Recognition
  - Computer Vision
  - Computer Graphics
  - Visual Communication
  - …

Textbook

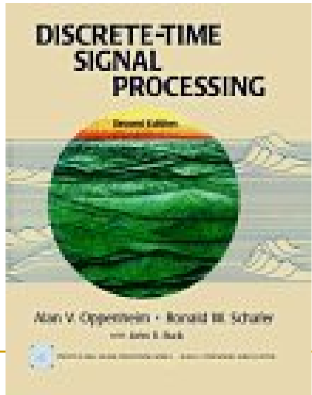
Signal Processing First, **J. H. McClellan, R. W. Schafer, and M. A. Yodar*, Pearson Prentice Hall, US,* 2003. (imported by 開發)**



Reference

Discrete-Time Signal processing, **A. V. Oppenheim, R. W. Schafer, and J. R. Buck*, Pearson Prentice Hall, US,* 1999. (imported by 全華)**

One of the bibles in DSP textbooks



Course Outline

- Introduction
- Sinusoids
- Spectrum Representation
- Sampling and Aliasing
- FIR Filters
- Frequency Response of FIR Filters
- z-Transform
- IIR Filters
- Continuous-Time Signals and LTI Systems
- Frequency Response
- Continuous-Time Fourier Transform
- Filtering, Modulation, and Sampling
- Computing the Spectrum

Grading Policy

- Homework (20~25%)
  - In-class assignments
  - Computer assignments (using Matlab)
- Exams (75~80%)
  - Midterm * 3 (every 3 chapters)
  - Final

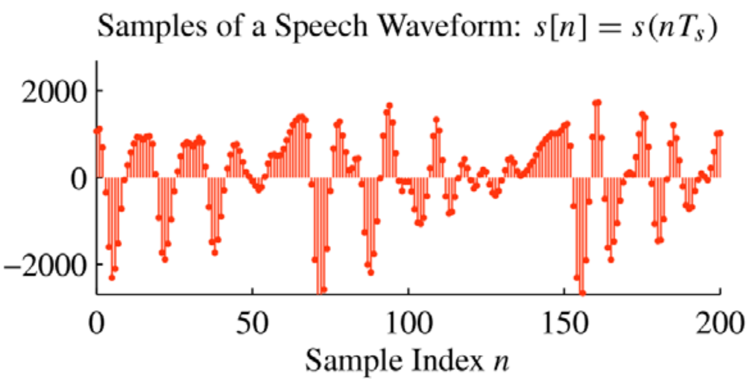
Signals and Systems

- Signals
  - "Something" that carries information
  - Speech, audio, image, video, biomedical signals, radar signals, seismic signals, etc.
- Systems
  - "Something" that can manipulate, change, record, or transmit signals
  - CD, VCD/DVD

"Discrete-Time" Signal vs "Digital" Signal

- Discrete-Time signal
  - A "sampled" version of a continuous signal
  - What should be the sampling frequency which is enough for perfectly reconstructing the original continuous signal?
    - Nyquist rate (Shannon sampling theorem)
- Digital Signal
  - Sampling + Quantization
  - Quantization: use a number of finite bits (e.g., 8 bits) to represent a sampled value

Example of 1-D Signals



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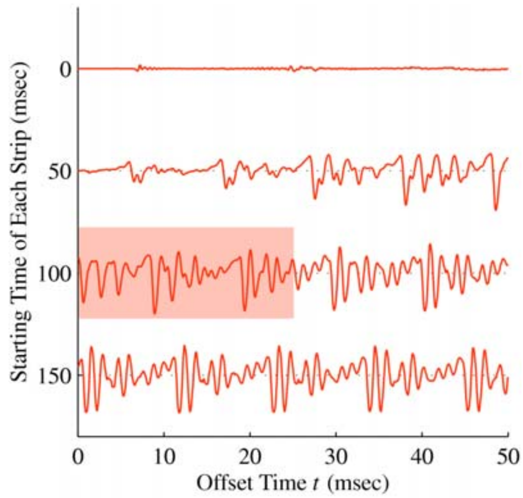
Examples of Signals: Speech Waveform



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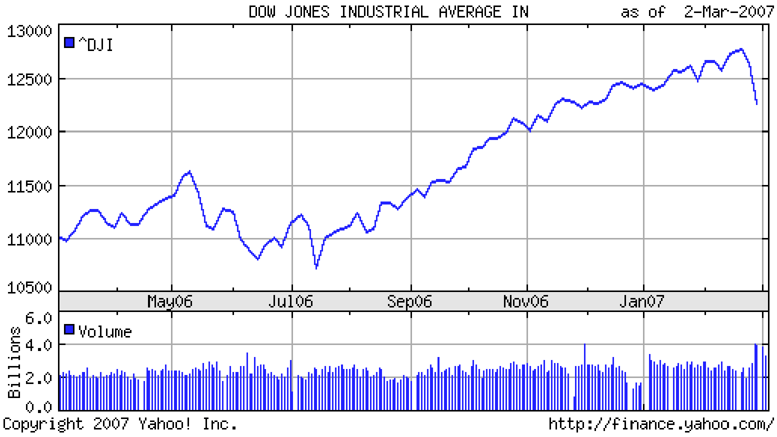
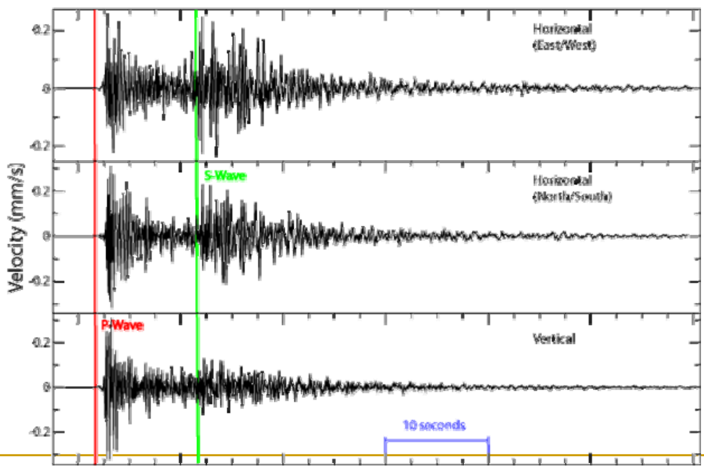
Digital Speech Signal

- Voice frequency range: 20Hz ~ 3.4 KHz
- Sampling rate: 8 KHz (8000 samples/sec)
- Quantization: 8 bits/sample
- Bit-rate: 8K samples/sec * 8 bits/sample = 64 Kbps (for uncompressed digital phone)
- In current Voice over IP (VOIP) technology, digital speech signals are usually compressed (compression ratio: 8~10)
- What is the compression ratio of MP3?

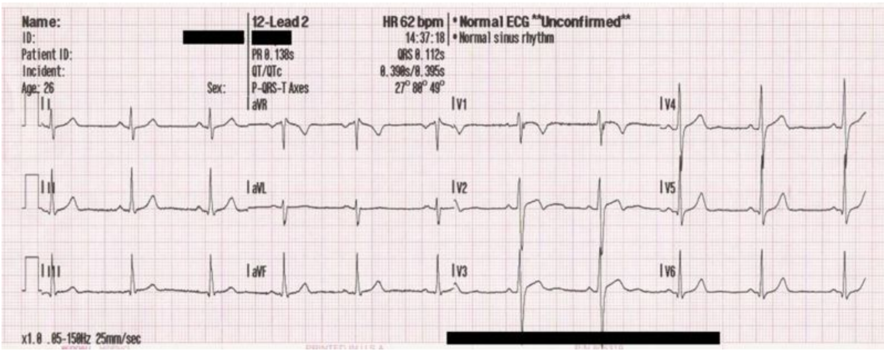
Example of 1-D Signals
Dow Jones Industrial Average



Example of 1-D Signals
Seismic Wave



Example of 1-D Signals Electrocardiogram



Example of 2-D Signals: Image

Digital Image Signal

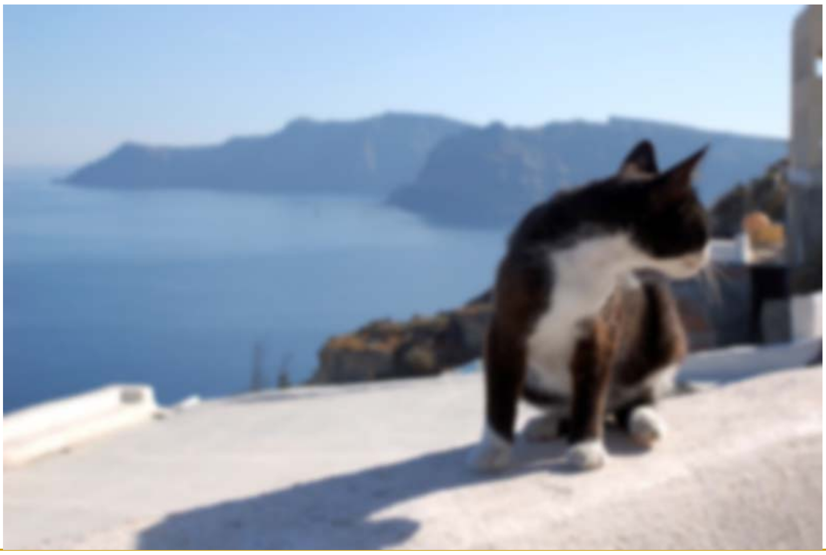
- An one mega-pixel image (1024x1024)
- Quantization: 24 bits/pixel for the RGB full-color space, and 12 bits/pixel for a reduced color space (YCbCr)
- Bit-rate: 1024x1024 samples/sec * 12 bits/pixel = 12 Mbits = 1.5 Mbytes (for uncompressed digital phone)
- How many uncompressed images can be stored in a 2G SD flash-memory card?
- What is the compression ratio of JPEG used in your digital camera?

Digital Image Signal (Con.)

- In your image processing course, you were taught how to do
  - Edge detection (high-pass filtering)
  - Image blurring or noise reduction (low-pass filtering)
  - Object segmentation (spatial coherence classification)
  - Image compression (retaining most significant info)
- The above are all about mathematical manipulations.
  - Could you give mathematical formulations for the above manipulations?
  - Could you characterize the frequency behaviors of the above operations?
  - Could you design an image processing tool to meet a given spec?

Digital Image Processing: Edge Detection

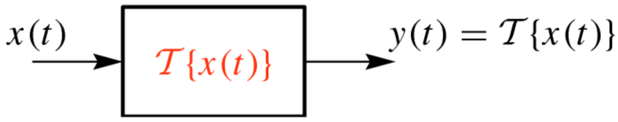
Digital Image Processing: Blurring



Example of 2-D Signals
Surface Search Radar Signal

Example of 3-D Signals: Video

Mathematical Representation of Systems



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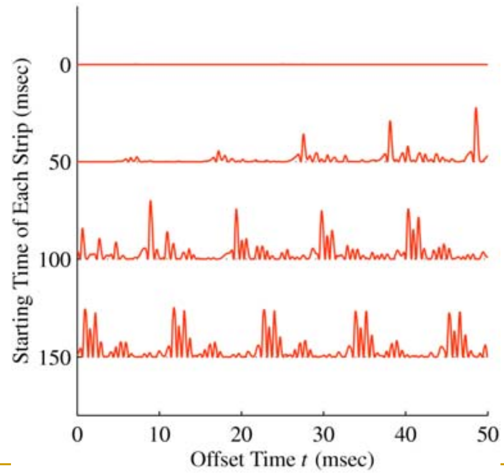
Example of a Continuous-Time System

$$y(t) = [x(t)]^2$$



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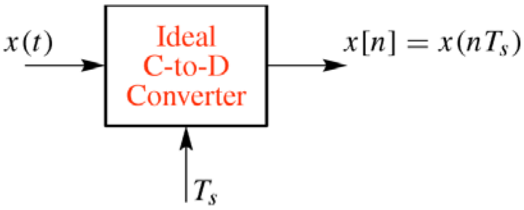
Discrete-Time System: Sampling



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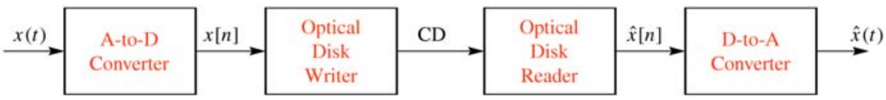
Example of Discrete-Time Systems: Audio CD



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