Digital Signal Processing (DSP), Fall 2014

Lecture 1: Introduction,

Discrete-time signals and systems

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Part I: Introduction

- Introduction (Course overview)
- Discrete-time signals
- Discrete-time systems
- Linear time-invariant systems

General information

- **Prerequisites**:

  Background in advanced calculus including complex variables, Laplace- and Fourier transforms.

- **Required Textbook**
  - Discrete-Time Signal Processing,
  - Prentice Hall, 2nd Edition
  - Alan Oppenheim, Ronald Schafer, John Buck
- **Grading**
  - Attendance / participation 5%
  - Project 15%
  - Quizzes 10%
  - Assignments 0%
  - Midterm Exam 30%
  - Final Exam 40%

Useful References

- [1] Digital Signal Processing, Sanjit H. Mitra. Mc Graw Hill, 3rd Ed. 2006
- [2] Dimitris G. Manolakis and Vinay K. Ingle, Applied Digital Signal Processing, Cambridge University Press, 2011.
- [3] Real-Time Digital Signal Processing, Sen M. Kuo and Bob H. Lee, Wiley, 2001.
- [4] Digital Signal Processing, A. Oppenheim and R. Schafer, Prentice Hall, 1986 .
- [5] Optimum Signal Processing, S. Orfanidis, MacMillan,

Useful References

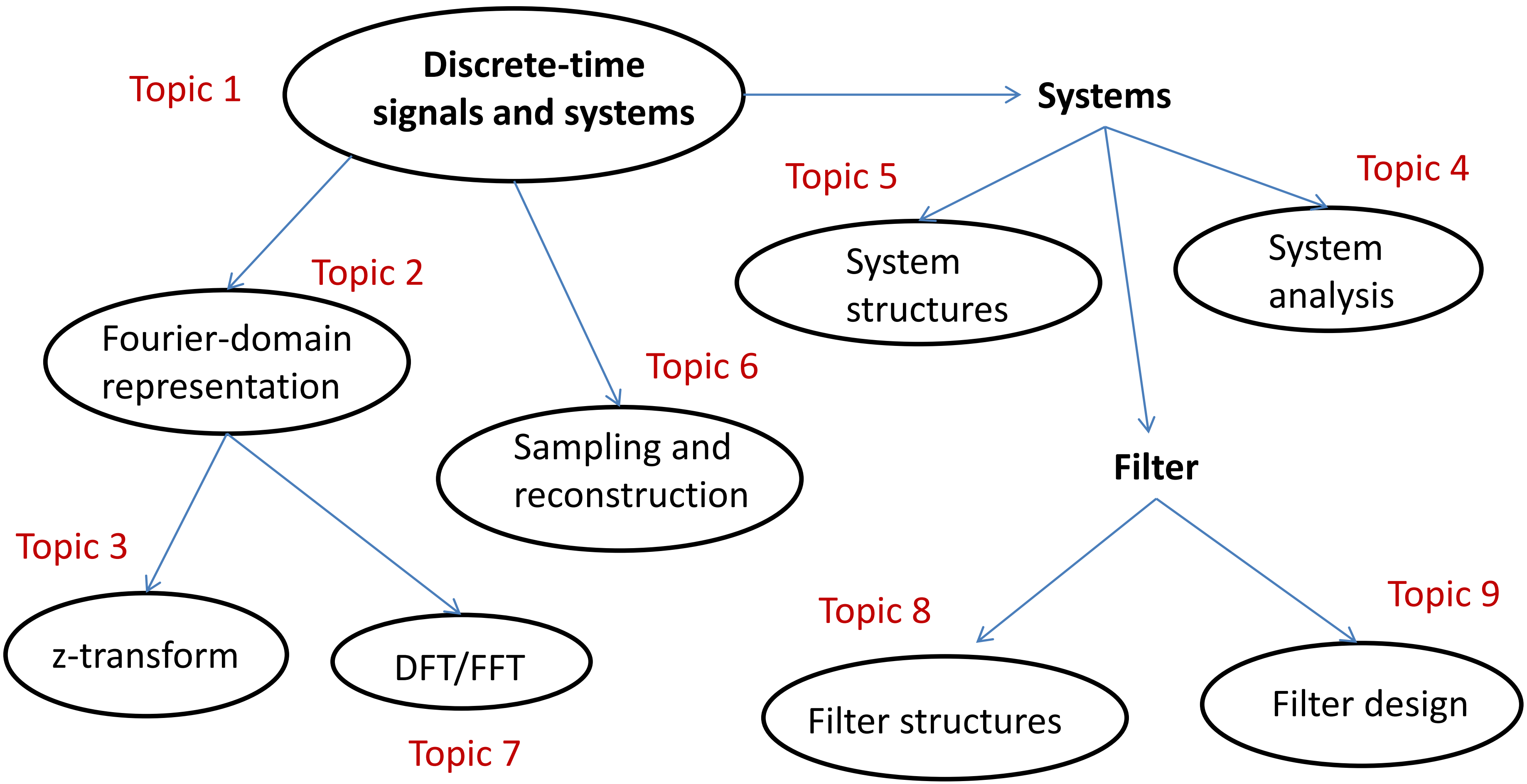
- [6] Digital Signal Processing: Principles, Algorithms, and Applications, J.G. Proakis and D.G Manolakis. Prentice Hall, 1996

- [7] Digital Signal Processing, R.A. Roberts and C.T. Mullis. Addison-Wesley, 1996

- [8] Matrix Computations, G. Golub, C. Van Loan, Johns Hopkins University Press, 1983.

- [9] MATLAB Reference Guide: High-Performance Numeric Computation and Visualization Software, The MathWorks, Inc., South Natick, MA.

Course at a glance



Course objectives (Part I)

- To give the students a comprehension of the concepts of discrete-time signals and systems.
- To give the students a comprehension of the Z- and the Fourier transform and their inverse.
- To give the students a comprehension of the relation between digital filters, difference equations and system functions.
- To give the students knowledge about the most important issues in sampling and reconstruction.

Course objectives (Part II)

- To make the students able to apply digital filters according to known filter specifications.
- To provide the knowledge about the principles behind the discrete Fourier transform (DFT) and its fast computation.
- To make the students able to apply Fourier analysis of stochastic signals using the DFT.
- To be able to apply the MATLAB program to digital processing problems and Presentations.

Where is DSP


Nikon


JVC
25x


Now Playing
9 of 13
Just Feel Better
Santana
All That I Am
3:30
-0:49
MENU


DSP


28 mi
12:42 PM
Lawrence street
Brighton Blvd.
MAX-HEIM-Street
Brighton Blvd.
Harrison street
Options
SONY

DSP is Everywhere

- Sound applications
  - Compression, enhancement, special effects, synthesis, recognition, echo cancellation,…
  - Cell Phones, MP3 Players, Movies, Dictation, Text-to-speech,…
- Communication
  - Modulation, coding, detection, equalization, echo cancellation,…
  - Cell Phones, dial-up modem, DSL modem, Satellite Receiver,…
- Automotive
  - ABS, GPS, Active Noise Cancellation, Cruise Control, Parking,…

DSP Application

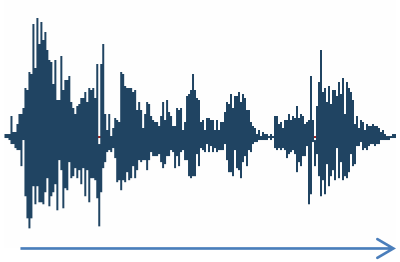
- Medical
  - Magnetic Resonance, Tomography, Electrocardiogram,…
- Military
  - Radar, Sonar, Space photographs, remote sensing,…
- Image and Video Applications
  - DVD, JPEG, Movie special effects, video conferencing,…
- Mechanical
  - Motor control, process control, oil and mineral prospecting,…

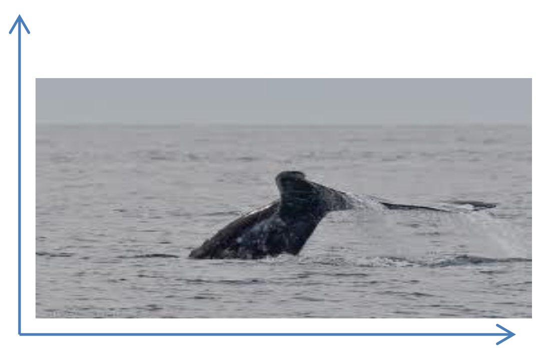
What is a signal ?

- A flow of information
- (mathematically represented as) a function of independent variables such as time (e.g. speech signal), position (e.g. image), etc.
- A common convention is to refer to the independent variable as time, although may in fact not.

Example signals

- Speech: 1-Dimension signal as a function of time $s(t)$;.
- Grey-scale image: 2-Dimension signal as a function of space $i(x,y)$
- Video: 3 x 3-Dimension signal as a function of space and time $\{r(x,y,t), g(x,y,t), b(x,y,t)\}$.

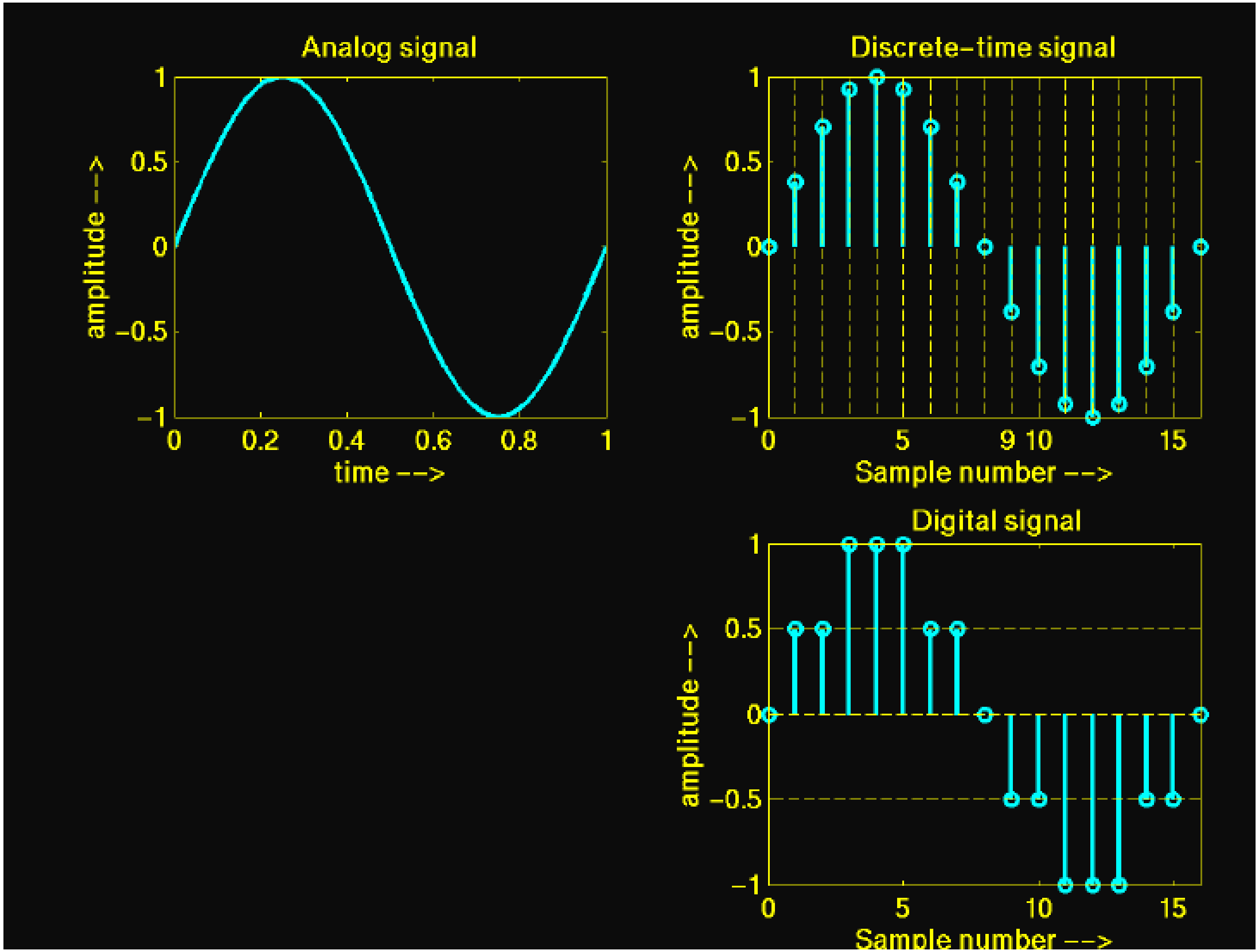




Types of signals

- The independent variable may be either continuous or discrete
  - Continuous-time signals
  - Discrete-time signals are defined at discrete times and represented as sequences of numbers
- The signal amplitude may be either continuous or discrete
  - Analog signals: both time and amplitude are continuous
  - Digital signals: both are discrete
- Computers and other digital devices are restricted to discrete time
- Signal processing systems classification follows the same lines

Types of signals



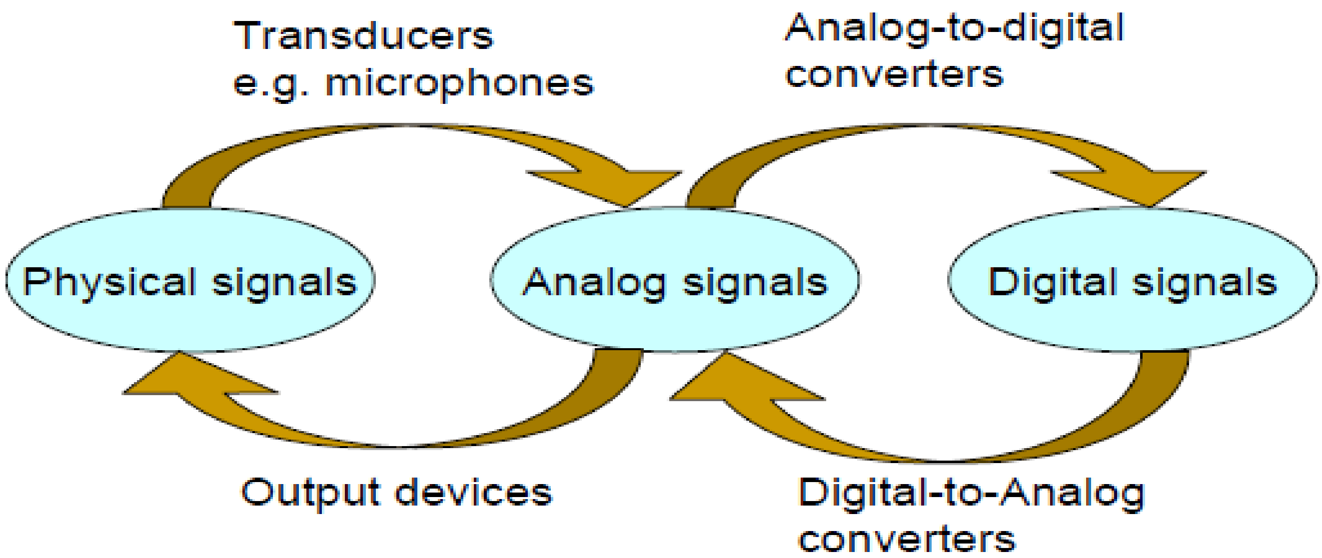
Digital signal processing

- Modifying and analyzing information with computers – so being measured as sequences of numbers.

- Representation, transformation and manipulation of signals and information they contain

Typical DSP system components

- ❑ Input lowpass filter to avoid aliasing
- ❑ Analog to digital converter (ADC)
- ❑ Computer or DSP processor
- ❑ Digital to analog converter (DAC)



Limitations of Analog Signal Processing

- Accuracy limitations due to
  - Component tolerances
  - Undesired nonlinearities
- Limited repeatability due to
  - Tolerances
  - Changes in environmental conditions
    - Temperature
    - Vibration

Limitations of Analog Signal Processing

- Sensitivity to electrical noise
- Inflexibility to changes
- Limited dynamic range for voltage and currents
- Difficulty of implementing certain operations
  - Nonlinear operations
  - Time-varying operations
- Difficulty of storing information

Pros and cons of DSP

Pros:

- Easy to duplicate
- Stable and robust: not varying with temperature, storage without deterioration
- Flexibility and upgrade: use a general computer or microprocessor

Cons:

- Limitations of ADC and DAC
- High power consumption and complexity of a DSP implementation: Unsuitable for simple, low power applications
- Limited to signals with relatively low bandwidth

History of DSP

- ❑ Prior to 1950's: analog signal processing using electronic circuits or mechanical devices
- ❑ 1950's: computer simulation before analog implementation, thus cheap to try out
- ❑ 1965: Fast Fourier Transforms (FFTs) by Cooley and Tukey – make real time DSP possible
- ❑ 1980's: IC technology boosting DSP