Signals and Systems

Fall 2003
Lecture #1
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1) Administrative details
2) Signals
3) Systems
4) For examples ...

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Signals are functions of independent variables that carry information. For example:

- Electrical signals --- voltages and currents in a circuit
- Acoustic signals --- audio or speech signals (analog or digital)
- Video signals --- intensity variations in an image (e.g. a CAT scan)
- Biological signals --- sequence of bases in a gene
THE INDEPENDENT VARIABLES

- Can be continuous
  - Trajectory of a space shuttle
  - Mass density in a cross-section of a brain

- Can be discrete
  - DNA base sequence
  - Digital image pixels

- Can be 1-D, 2-D, ..., N-D

- For this course: Focus on a single (1-D) independent variable which we call “time”.

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

- Most of the signals in the physical world are CT signals—E.g. voltage & current, pressure, temperature, velocity, etc.
DT Signals

• $x[n]$, $n$ — integer, time varies discretely

• Examples of DT signals in nature:
  — DNA base sequence
  — Population of the $n$th generation of certain species

\begin{figure}
\centering
\includegraphics[width=\textwidth]{dt_signals}
\end{figure}
Many human-made DT Signals

Ex.#1 Weekly Dow-Jones industrial average

Ex.#2 digital image

Why DT? — Can be processed by modern digital computers and digital signal processors (DSPs).

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For the most part, our view of systems will be from an input-output perspective:

A system responds to applied input signals, and its response is described in terms of one or more output signals

\[ x(t) \rightarrow \text{CT System} \rightarrow y(t) \]

\[ x[n] \rightarrow \text{DT System} \rightarrow y[n] \]
EXAMPLES OF SYSTEMS

• An RLC circuit

\[ x(t) \quad + \quad y(t) \quad - \]

• Dynamics of an aircraft or space vehicle
• An algorithm for analyzing financial and economic factors to predict bond prices
• An algorithm for post-flight analysis of a space launch
• An edge detection algorithm for medical images
SYSTEM INTERCONNECTIONS

• An important concept is that of interconnecting systems
  — To build more complex systems by interconnecting simpler subsystems
  — To modify response of a system

• Signal flow (Block) diagram

  Cascade

  Parallel

  Feedback