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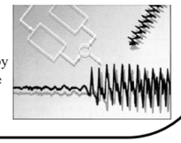
EECE233 Signals and Systems

Lecture Note #1

Prof. Joon Ho Cho

(Slides thanks to Qing Hu*, D. Boning, D. Freeman, T. Weiss, J. White, and A. Willsky)

1) Administrative details
2) Signals



* These lecture notes are based on the lecture notes used in 6.003 taught by Prof. Qing Hu at M.I.T. These notes are adopted for EECE233 under the permission of Prof. Qing Hu.

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Signals and Systems

EECE233 is about using mathematical techniques to help analyze and synthesize systems which process signals.

- Signals are variables that carry information.
- Systems process input signals to produce output signals.

Today: Signals, next lecture: Systems.

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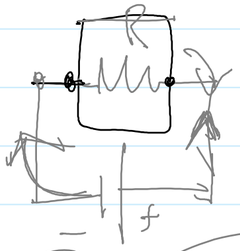

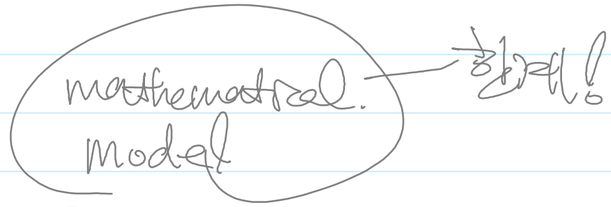

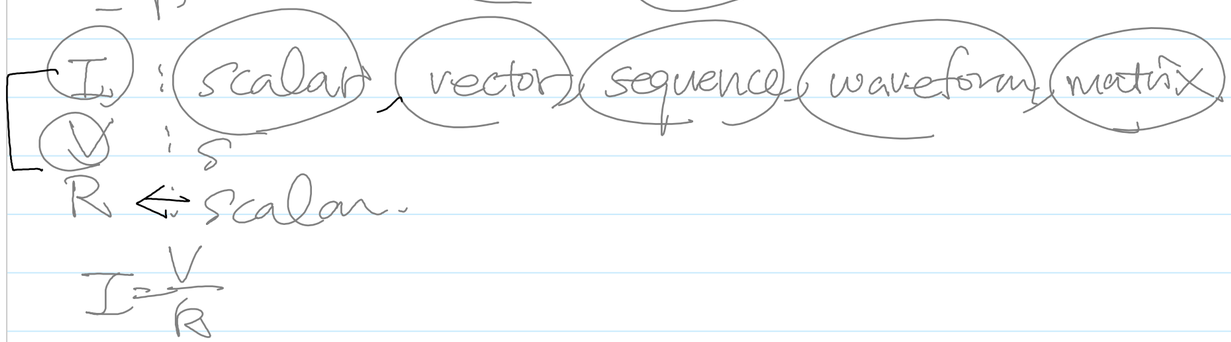

Examples of signals

- 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

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- In EECE233, we will treat noise as unwanted signals

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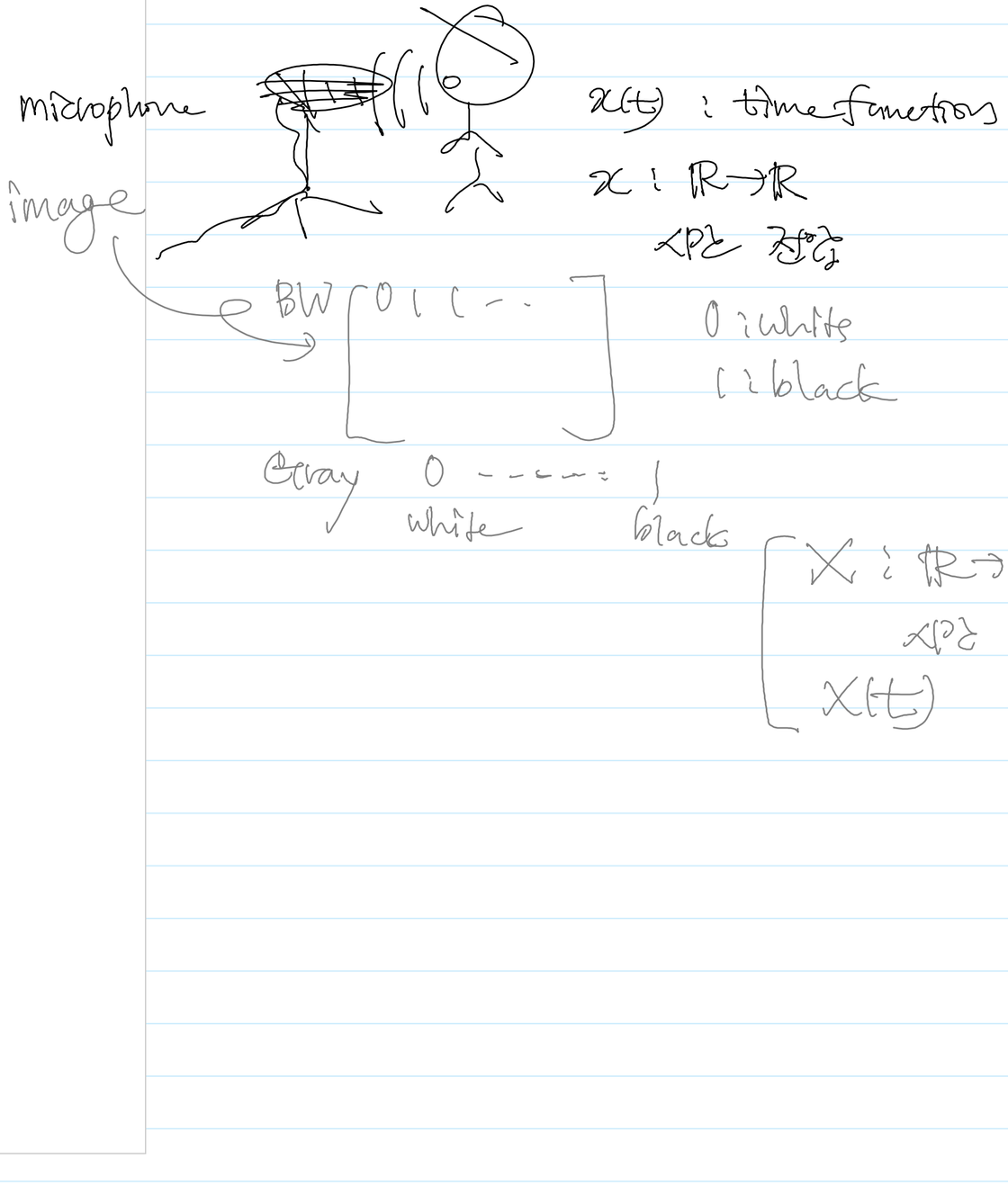
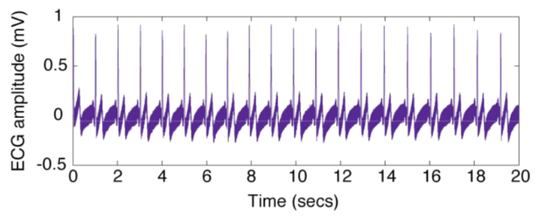


Signal Classification

Type of Independent Variable

Time is often the independent variable. Example: the electrical activity of the heart recorded with chest electrodes — the electrocardiogram (ECG or EKG).



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The variables can also be spatial

Eg. Cervical MRI

In this example, the signal is the intensity as a function of the spatial variables x and y.

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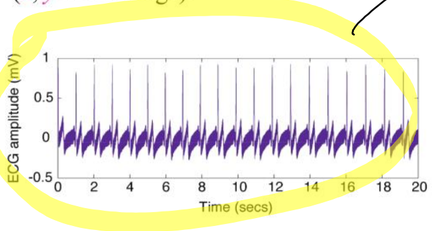
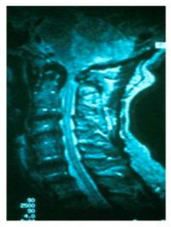
Independent Variable Dimensionality

An independent variable can be 1-D (t in the EKG) or 2-D (x, y in an image).





In EECE233, focus on 1-D for mathematical simplicity but the results can be extended to 2-D or even higher dimensions. Also, we will use a generic time t for the independent variable,whether it is time or space.

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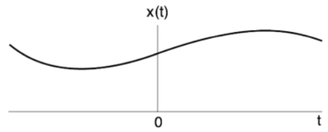
Continuous-time (CT) Signals



- Most of the signals in the physical world are CT signals, since the time scale is infinitesimally fine, so are the spatial scales. E.g. voltage & current, pressure, temperature, velocity, etc.

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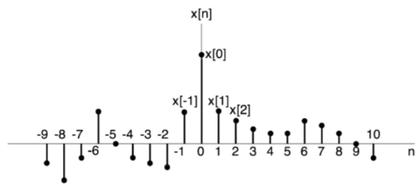
Discrete-time (DT) Signals

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



- Examples of DT signals in nature:
  - DNA base sequence
  - Population of the nth generation of certain species
  - ⋮
- Notation in EECE233: $x(t)$ — CT, $x[n]$ — DT

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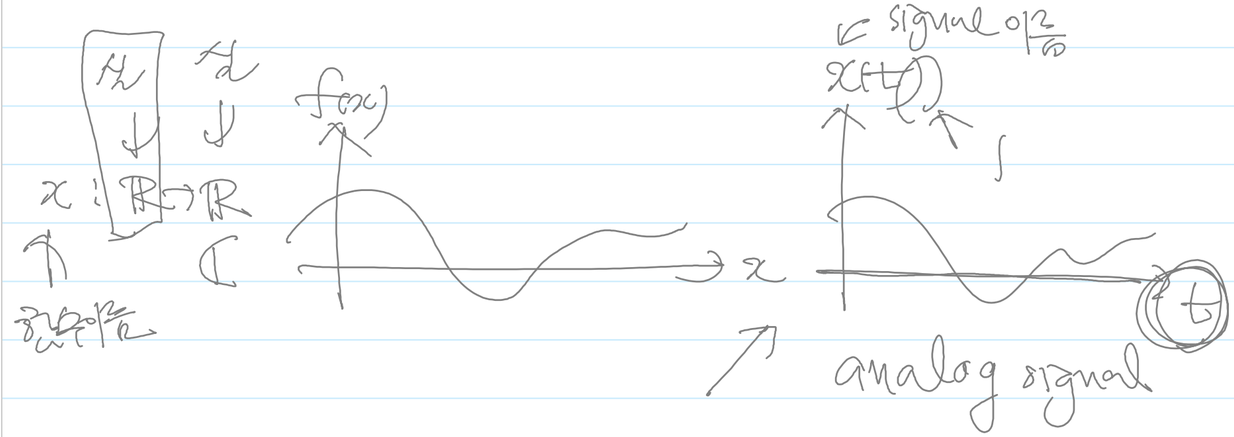

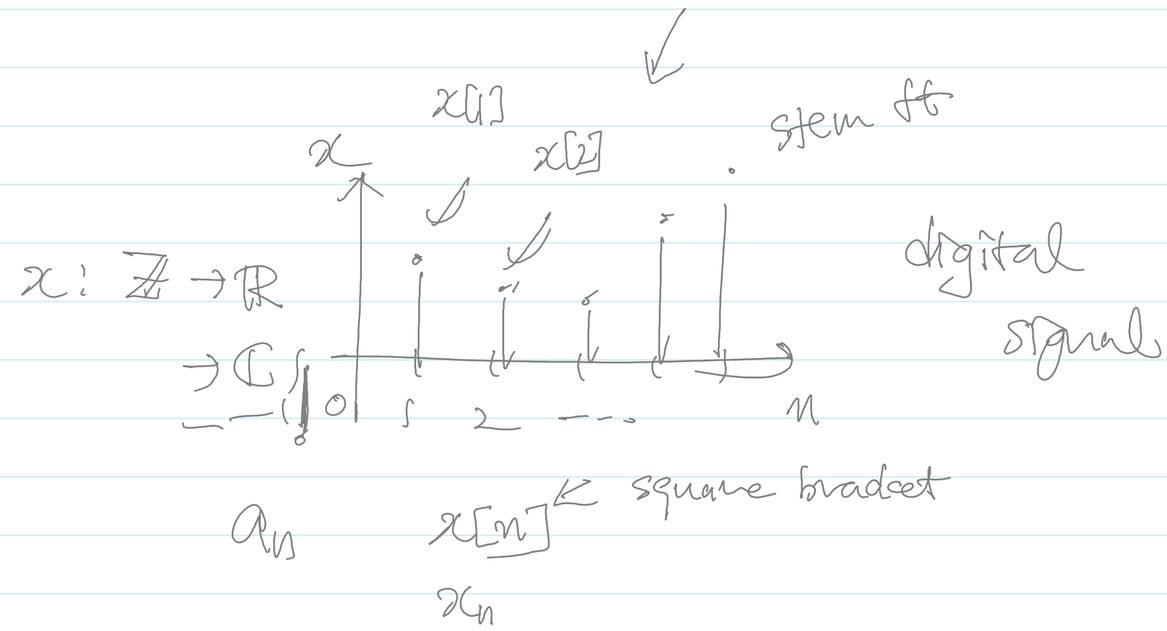

5페이지

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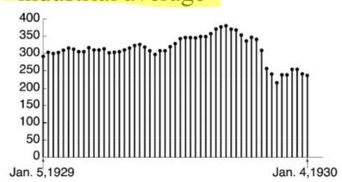
Many human-made Signals are DT

Ex.#1 Weekly Dow-Jones industrial average



Ex.#2 digital image

Ex#3. ticking clock

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

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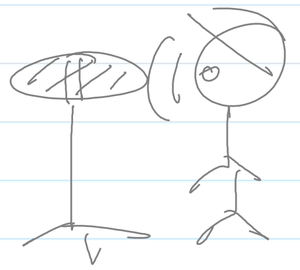


Acoustic Speech signal

→ electrical signal

CT signal

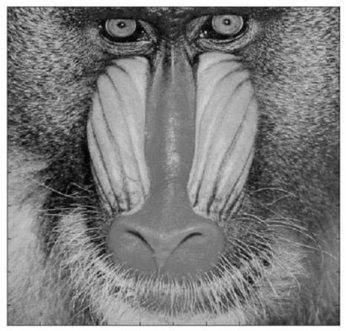
series. DT signal

0.2 0.8 - 400

300

Mandrill Example

Unblurred Image & No Noise



← original

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Mandrill Example

Blurred Image (bad focus)

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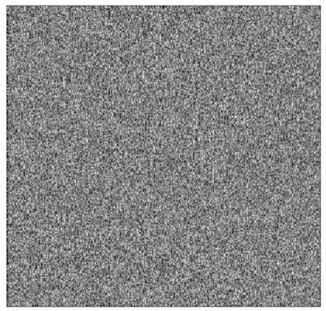
Mandrill Example

Unblurred Image – 0.1% Noise (too dark)



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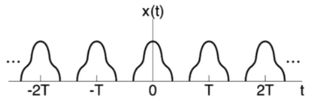
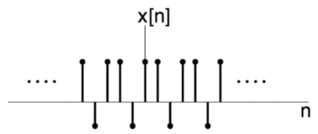
Signals with symmetry

- Periodic signals
  CT $x(t) = x(t + T)$



- **Ex.** 60-Hz power line, computer clock, etc.

DT $x[n] = x[n + N]$



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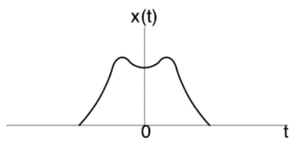
Signals with symmetry (continued)

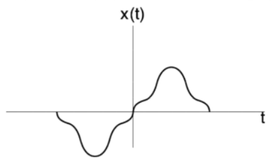
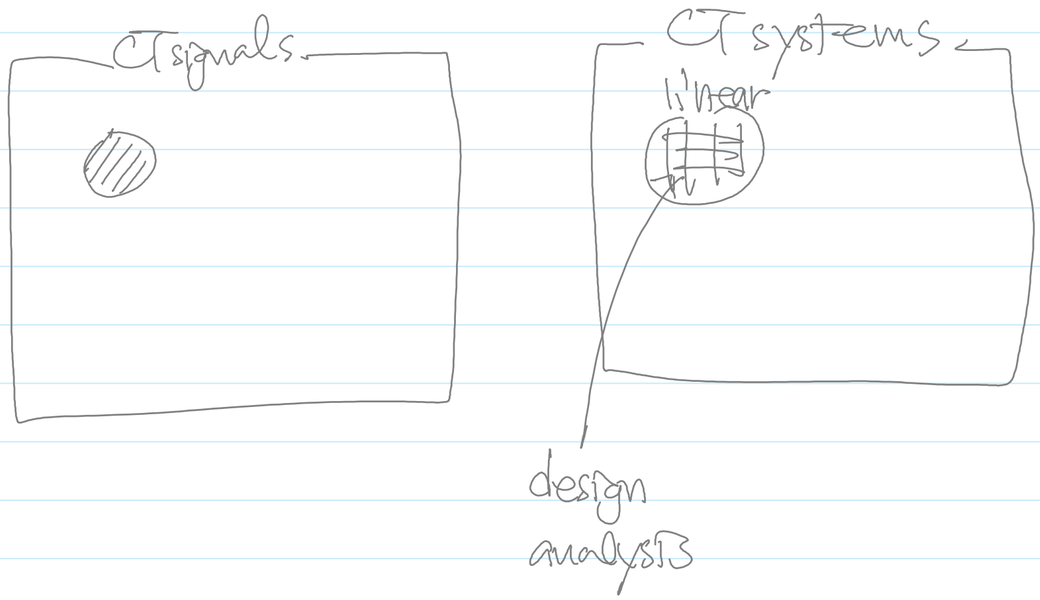
- Even and odd signals
  Even $x(t) = x(-t)$ or $x[n] = x[-n]$



Odd $x(t) = -x(-t)$ or $x[n] = -x[-n]$

$x(0) = 0$

or $x[0] = 0$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