2023년 9월 12일 화요일 12:45

CM03 230912T

Announcements

1. 지난 강의 수정 사항

   N/A

2. LN#1 and #2 are updated. Please reload them.

3. HW
   - HW02 will be assigned soon. Due will be next Tuesday. For details, check the PLMS class homepage.
     - Upper- and lower-case Greek letters

4. 강의 자료
   - Handouts and annotated pdfs are downloadable from the non-PLMS class homepage at http://cisl.postech.ac.kr/class/eece233/schedule.html .
   - Recorded CMs are available from cisl.postech YouTube channel. Please place clickable time stamps.

5. 출석
   - 수강변경기간(2023. 9. 4(월) ~ 9. 13(수)) 중의 수업, 중간 및 기말 시험일을 포함하여 전체 Class Meeting (CM) 약 30회중 1/4이하의 무단 결석(지각 2회 = 1회 무단 결석)은 성적에 영향을 주지 않습니다.
   - CM01, 02 출결상태에 대해 전자출결시스템(https://wpsc.postech.ac.kr/eams/login)에 수정입력해 놓았습니다. 정정사항이 있는 학생은 사유를 제출해 주세요. 첫날 강의에서 설명했듯, 앞으로는 따로 공지가 없어도 각 수강생이 직접 시스템 입력 상태를 확인하고 정정사항을 사유와 함께 알려 주셔야 합니다.

6. 관련 개설과목 23-2학기

   EECE233 신호 및 시스템

   EECE341 정보통신공학 개론

   EECE443/NGCN302 통신 및 네트워크 실험

   CSED 221 컴퓨터 SW 시스템 개론

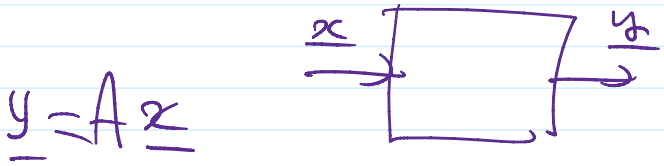
   CSED 331 알고리즘

CSED 332 소프트웨어 설계방법

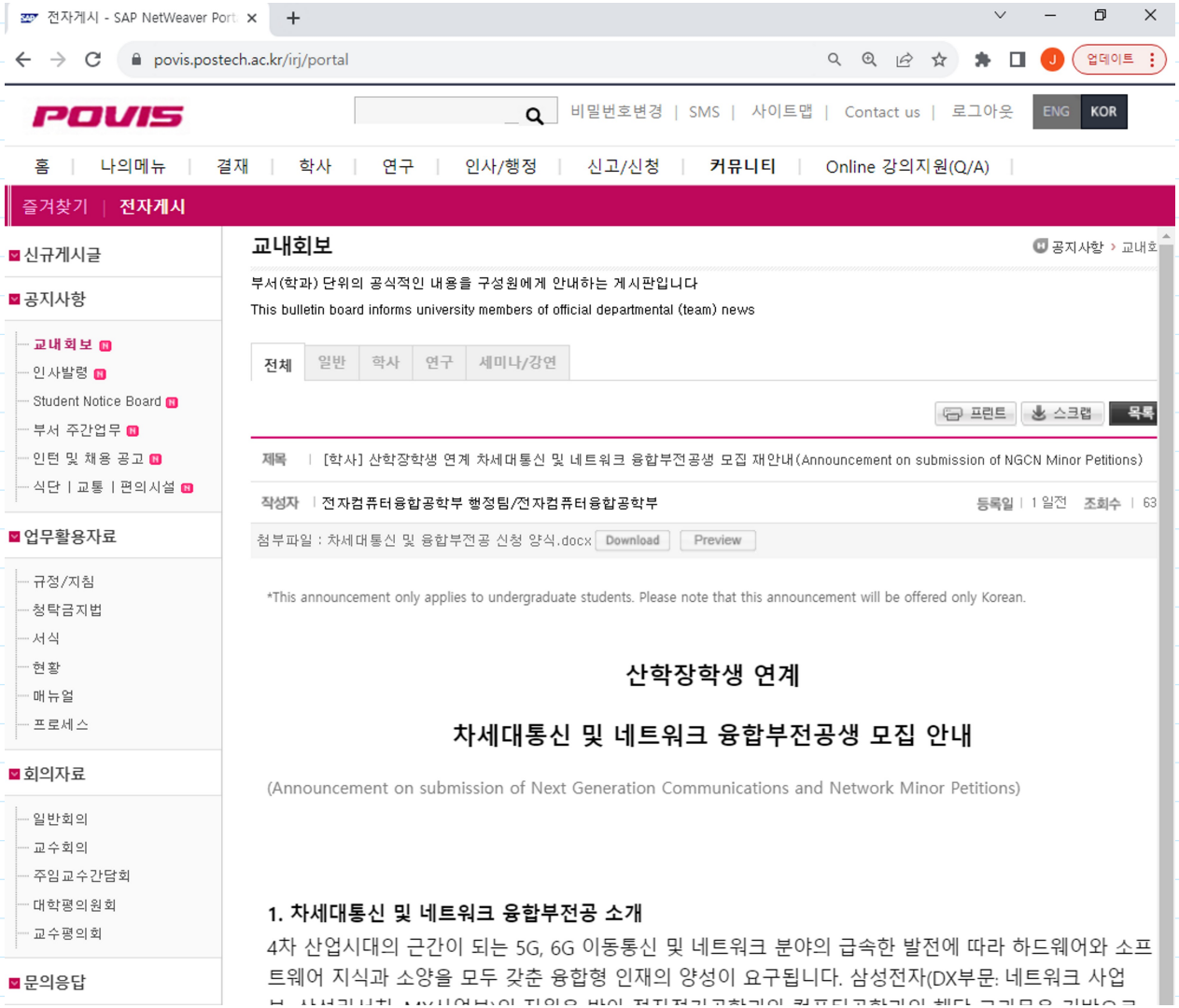
CSED 342 인공지능

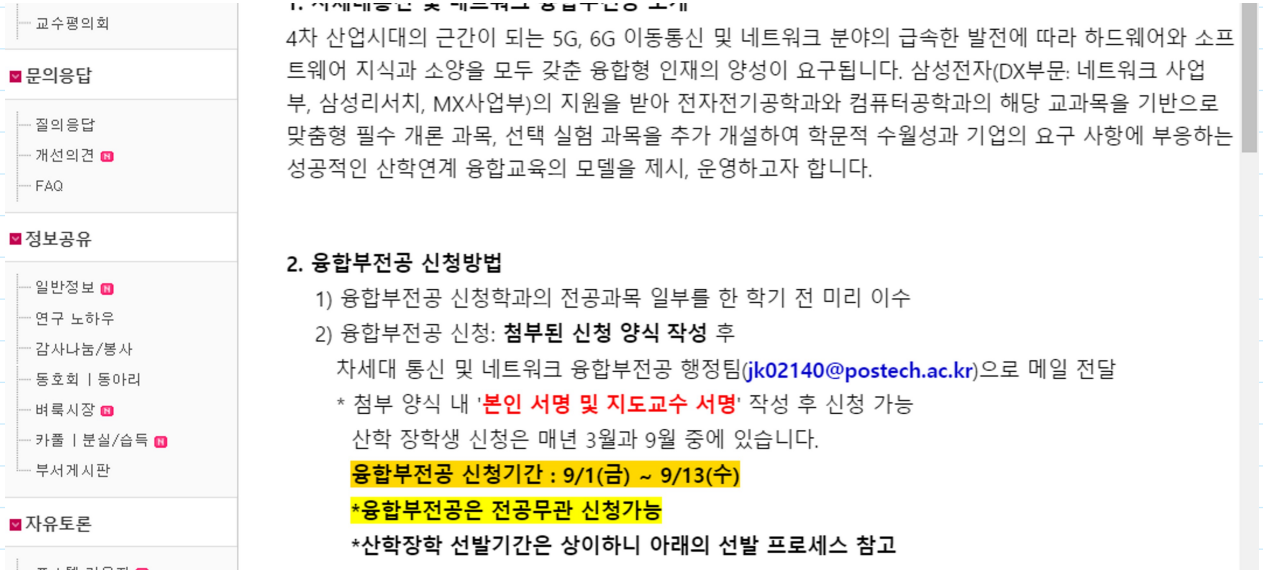
CSED 530 컴퓨터공학을 위한 고급 확률이론

MATH 203 응용선형대수



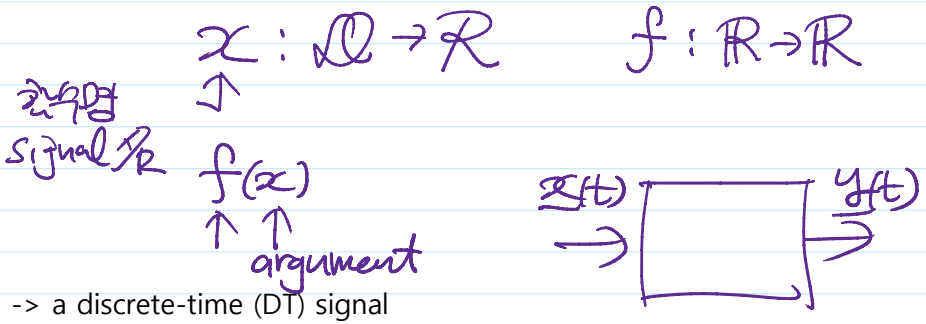
7. 통신 및 네트워크 융합부전공 신청 (교내회보에서 '융합부전공'으로 검색, www.ngcn.postech.ac.kr)





7. Overview (The numbers are the chapter numbers of the textbook)
   1. Signals and Systems
   2. Linear Time-Invariant Systems
   3. Fourier Series Representation of Periodic Signals
   4. Continuous-time Fourier Transform
   5. Discrete-time Fourier Transform
   6. Time and Frequency Characterization of Signals and Systems
   9. Laplace Transform
   10. Z-transform
   7. Sampling
   8. Communication Systems

8. Review
   - A system is a mapping rule from a domain to a range.
     - The domain is a set of every admissible input signal.
       - 0-D: a scalar
       - 1-D: a vector
       - 2-D: a matrix
       - 3-D: a tensor
       - 1-D: a sequence of scalars-> a discrete-parameter signal -> a discrete-time (DT) signal



        - 1-D: a waveform or a function -> a continuous-parameter signal -> a continuous-time (CT) signals
        - 1-D or 2-D: a sequence of Mx1 vectors
        - 1-D or 3-D: a sequence of MxN matrices
        - n-D: field
        - polynomial
        - graph, etc.
    - The range is the set that includes the set of possible output signals.
    - Any set can be a domain.
- Among every possible pari of a domain and a range, we mainly consider in this course 4 combinations:
    - a CT system: a CT signal goes in and a CT signal comes out
    - a DT system: a DT signal goes in and a DT signal comes out
    - a CT/DT converter: a CT signal goes in and a DT signal comes out
    - a DT/CT converter: a DT signal goes in and a CT signal comes out

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G(E,V)

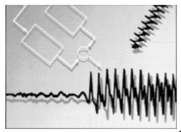
EECE233 Signals and Systems

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.

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.

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

⋮

- In EECE233, we will treat noise as unwanted signals

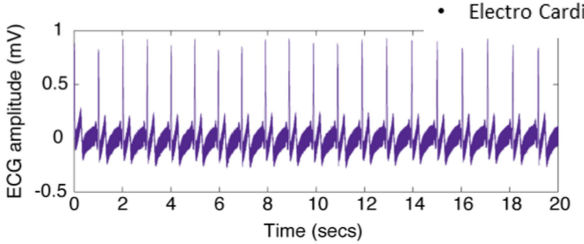
signal
- scalar
- vector
- matrix
- sequence
- waveform
- field
- polynomial
- tensor
- graph

Signal Classification

Type of Independent Variable

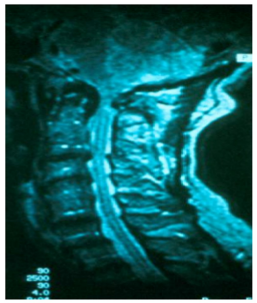
Time is often the independent variable. Example: the electrical activity of the heart recorded with chest electrodes — the electrocardiogram (ECG or EKG).

- Electro Cardio Gram 심전도



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.

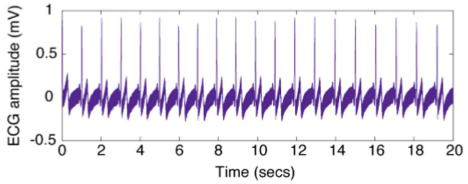
- cervical: 목의
- The left signal can be modeled as, e.g.,

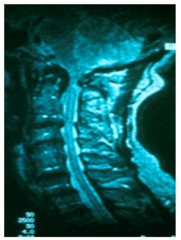
x: {1,2,...,800}x{1,2,...,600} -> [0,1]

Since the domain is 2-D, this signal is a 2-D signal.

Independent Variable Dimensionality

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





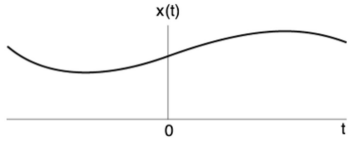
In EECE233, focus on 1-D for mathematical simplicity but the results can be extended to 2-D or even higher dimensions. Also, we will use a generic time t for the independent variable,whether it is time or space.

$\mathbb{R}$

$\mathbb{R}^2 \Rightarrow (0,0)$

$\mathbb{R} \times \mathbb{R}$

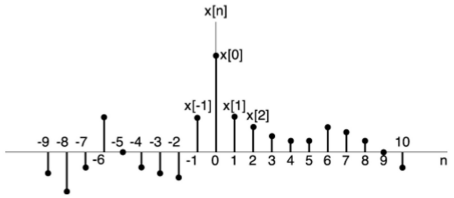
Continuous-time (CT) Signals



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

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

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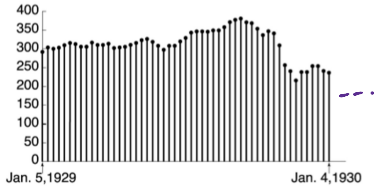
- Notation in EECE233: $x(t)$ — CT, $x[n]$ — DT

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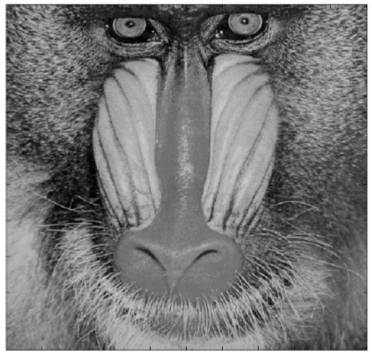
Why DT? — Can be processed by modern digital computers and digital signal processors (DSPs).

Mandrill Example

Unblurred Image & No Noise

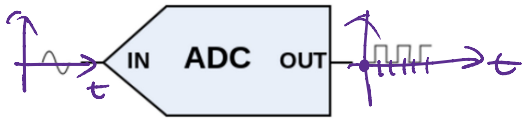


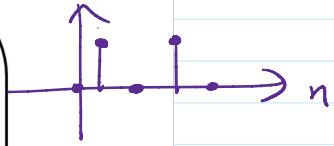
- a scalar: a 0–D signal because x: {1}->R
- a vector: a 1-D signal because x: {1,...,300} ->R
- a matrix: a 2-D signal because x: {1,...,M}x{1,...,N} ->R
- a 60 FPS BW video of 600x300 pixels
  - a (2-D matrix-valued) 1-D signal X[n] because x: Z-> a set of 1-bit 600x300 BW images
  - a (scalar-valued) 3-D signal X_n[k,l] because x: Zx {1,...,300} x{1,...,600}-> {0,1}

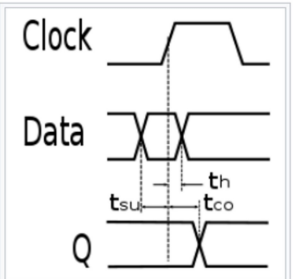
$X[n]$

$\uparrow$

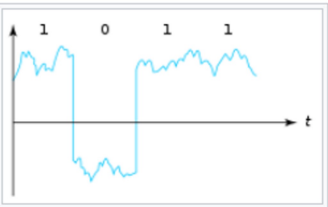
$\in \mathbb{R}^{600\times300}$







Clocking digital signals through a clocked flip-flop

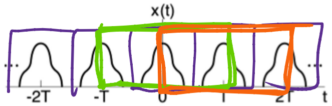


A received digital signal may be impaired by noise and distortions without necessarily affecting the digits

Signals with symmetry

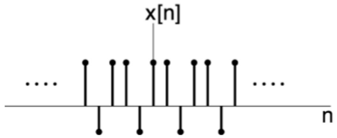
- Periodic signals

  CT $x(t) = x(t + T)$ for all t.

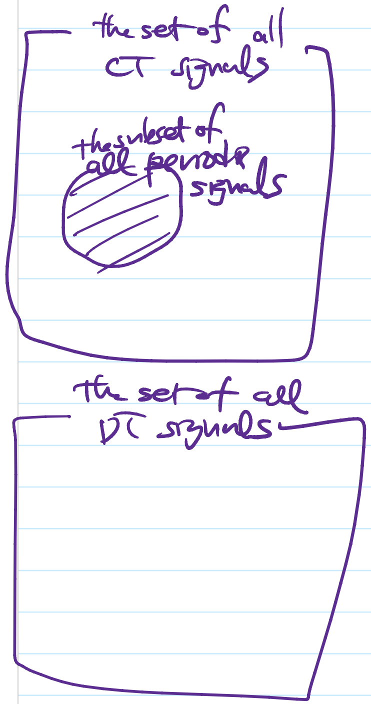


- **Ex.** 60-Hz power line, computer clock, etc.

  DT $x[n] = x[n + N]$ for all n.

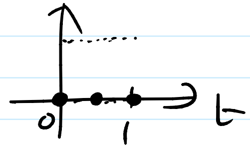


definition, existence, uniqueness; a, an, the
정의, 존재성, 유일성



/ex/

$x(t) = \begin{cases} 0, & \text{for } x \in \mathbb{Q} \\ 1, & \text{for } x \in \mathbb{Q}^c \end{cases}$



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Def. A CT signal x(t) is periodic, if there exists T>0 s. t. x(t) = x(t+T), for all t.
Lemma. If periodic, then there exists T>0 s.t x(t) = x(t+nT), for all t and all integer n.

Def. For a periodic signal, the smallest period is called the fundamental period, if exists.
Lemma. For a periodic signal with fundamental period T_0, any period is an integer multiple of T_0.

Signals with symmetry (continued)

- Even and odd signals

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

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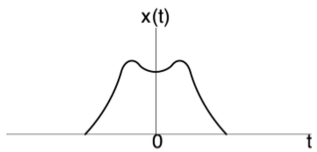
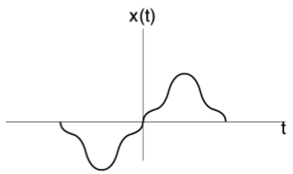
  우함수



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

$x(0) = 0$

or $x[0] = 0$



The zero function is even and odd at the same time.