Dr Carda's Material related to' Course Defense'
Not Complete
Started: January 9, 2004

Digital Signal Processing

Topics Provided by Course Handbook

CENG: An introduction to the design of digital signal processing systems. Topics include discrete-time signals and systems, the Z transform, infinite impulse-response digital filters, finite impulse-response digital filters, discrete Fourier transforms, fast Fourier transforms

CSC:

1. *Properties of digital signals and systems*
2. *Convolution, correlation and stability*
3. *The Z-transform, properties, and applications*
4. *Analog sampling and the Nyquist sampling theorem*
5. *The discrete Fourier transforms, properties and applications*
6. *Digital filter design techniques*
7. *Additional topics, as time allows, include adaptive filtering, sigma-delta converters,*
8. *Applications in audio and communications*

Filter Design

1. What is a **FIR filter**?

   A FIR filter is a finite response filter.
   Convolution operation:

   $$y(n) = \sum_{k=-\infty}^{\infty} h(k)x(k-n)$$

   Where x(k) is the input,
   H(k) is the unit sample response
   Y(n) is the output.

2. What is an IIR filter?

   - An infinite impulse response filter. That is, an impulse response that has an infinite number of `nonzero values, such as a decaying exponential. Often used to indicate that a filter is carried out by using recursion, rather than convolution.
   - **This implies that one can use difference equations to describe the system.**

3. Why would you use a FIR filter vs an IIR Filter?

4. What is the **Laplace transform**?

The Laplace transform is used in the analysis of continuous-time signals and LTI systems.

The S-Domain

What is the S-Domain?

5. What is the **Z Transform**?

Mathematical method used to analyze discrete systems that are controlled by difference equations, such as recursive (IIR) filters. Changes a signal in the time domain into a signal in the z-domain.

The z-transform of a discrete-time signal is defined as the power series:

$$X(z) \equiv \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

z is a complex variable.

The z-transform will be denoted by

$$X(z) = Z[x(n)]$$

which we will depict as:

$$x(n) \xrightarrow{z} X(z)$$

Since the z-transform is an infinite power series, it exists for only those values of for which the series converges. The region of convergence (ROC) of is the set of all values of for which attains a finite value.

6. What is the **Z-domain**?

The domain defined by the z-transform. Also called the **z-plane.**

7. What is an **impulse response**?

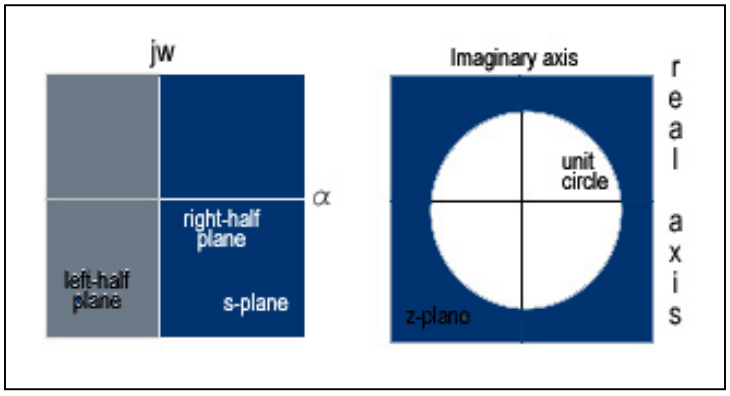
- The output of a system when the input of the system is an impulse train (the delta function, i.e. comb filter).

8. What does it mean to say a FIR filter has **linear phase**?

It means the filter coefficients are symmetric.

9. What are the properties of the bilinear transform?

- The left-half of the s-plane is mapped onto the interior of the unit circle in the z-plane.
- The entire jw-axis of the s-plane is mapped onto one complete revolution of the unit circle in the z-plane. α
- The right-half of the s-plane is mapped onto the exterior of the unit circle in the z-plane.



10. *What are difference equations?*

11. *What is the Fourier Transform?*

12. ***BIBO** stability?*

General knowledge

1. What is **causality**?

A system is said to be **causal** if the present value of the output signal depends only on the present and/or past values of the input signal. A **non-causal** system depends on future values of the input signal

2. What is the **bilinear transform** and why is it relevant?

3. What is the **sample-and-hold** method?

Using a frame buffer or something similar (in hardware), we use the sample and hold theorem to translate a discrete signal into continuous form. The current value from the buffer is held for the duration of some time. In image processing, this is equivalent to holding for one pixel.

4. What is the **Nyquist Theorem** and what does it tell us?

Nyquist Theorem: If a continuous time signal is band-limited to frequencies below BW, then it can be perfectly represented by – and reproduced from - a discrete time signal consisting of a set of equally spaced samples, if and only if the sampling frequency F_S is at least twice as high as BW.

1. *Properties of digital signals and systems*
    a. *Types of signals*
        i. Continuous-periodic
        ii. Discrete-periodic
        iii. Continuous-aperiodic
        iv. Discrete-aperiodic

2. *Convolution, correlation and stability*
    a. *Convolution is the operation of multiplying one signal with another.*
    b. *Correlation:*
    c. *Stability: Filters remain stable if the value of a pole/*
3. *The Z-transform, properties, and applications*
    a. *Z-Domain*
    b. *Z-Transform*
4. *Analog sampling and the Nyquist sampling theorem*
    a. *Analog Sampling*
    b. *Nyquist Sampling Theorem*
5. *The discrete Fourier transforms, properties and applications*
    a.
6. *Digital filter design techniques*
    a.
7. *Additional topics, as time allows, include adaptive filtering, sigma-delta converters,*
8. *Applications in audio and communications*
    a.

Computer Science Expectations

1. *Properties of digital signals and systems*
    a. *Static Vs. Dynamic Systems*
        i. *Static System: One that depends only on current inputs (not past)*
            1. *These types of systems have finite memory.*
        ii. *Dynamic Systems: One that depends on past and present inputs.*
            1. *Has infinite memory.*
    b. *Time Invariant vs. Time Variant systems*
        i. *A time invariant system is one where the input-output characteristics for the system do not change with time.*
    c. *Linear vs. Non-linear systems*
        i. *Linear System: One that statisfies the superposition principle.*
    d. *Causal Vs. Noncausal systems*
        i. *A **causal** system is one where the outputs depend only on present and past inputs, but does not depend on future inputs.*
        ii. *A **noncausal** system is where the output depends on past, present and future input values – which is not realistic and cannot be implemented.*
    e. *Stable vs. Unstable systems*
        i. ***BIBO**: Bounded Input-Bounded Output. This implies that a bounded input will result in a bounded output.*
        ii. *If, for some system, the input is bounded by the output is not, the system is classified as **unstable**.*
        iii.
2. *Convolution, correlation and stability*
    a. *Cross-Correlation equation*

$$r_{xy}(l) = \sum_{n=-\infty}^{\infty} x(n)y(n-l)$$ *for l=0, +-1, +-2…*

where l is the time shift or lag parameter.
For l=0, we simply multiply each element:
X=[1, 2, 3, 4], y=[2, -4,-1,0]
Then, R=[2,-8, -3, 0]

3. *The Z-transform, properties, and applications*
4. *Analog sampling and the Nyquist sampling theorem*
    a. **Nyquist Sampling Theorem**: States that we must sample at 2 x the highest frequency contained in the signal in order to fully be able to rebuild the signal.
    b. **Analog Sampling**
        i. Folding Frequency: The frequency at which
5. *The discrete Fourier transforms, properties and applications*
    a. *The DFT.*
6. *Digital filter design techniques*
7. *Additional topics, as time allows, include adaptive filtering, sigma-delta converters, Applications in audio and communications*

Advanced Digital Systems

1.

Real Time Processing

1. What are the types of busses on the TI TMS 32050?
   2 types
   (1) Program Bus
   (2) Data Bus

Links
http://www.mhhe.com/engcs/compsci/forouzan/

http://dsp7.ee.uct.ac.za/~nicolls/lectures/eee401f/03_ztrans_2up.pdf
http://spsc.inw.tugraz.at/courses/dspue/ss02/
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