ECE 308
Introduction

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Introduction

- There is a significant interest in digital signal processing area with the rapid development in integrated-circuit technology.
- Inexpensive and relatively fast digital circuit have made it possible to construct highly sophisticated digital systems capable of performing complex digital signal processing functions and task.
- Some signals with extremely wide bandwidths or real-time processing requiring. Analog or optical signal processing is the only possible solution for such signals.

Advantages:

•Digital circuits are cheaper and more reliable

•Digital processing hardware allows programmable operations, so be can easily modify and flexibility in system design.

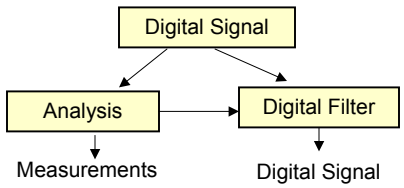
Why Study Digital Signal Processing?

- There is a lot of competition for top jobs after college graduation, and hands-on DSP experience will differentiate you from other graduates.
- DSP technology is used in cellular phones, hard disk drives, motors, global positioning systems, modems, wireless base-stations, GPS-capable personal digital assistants, network routers, hearing aids, anti-lock brakes, and much more! DVD and digital cameras are becoming increasingly popular.
- DSP is the fastest-growing segment of the semiconductor market.

Advantages of Digital over Analog Signal Processing

- A digital programmable system allows flexibility in reconfiguring the digital signal processing operations simply by changing the program
- *Reconfiguration of an analog system requires redesign of hardware.*
- Digital signal processor provides much better control of accuracy requirements. Accuracy requirement in the A/D Converting.
- *Tolerance in analog circuit components make it extremely difficult for the system designer to control the accuracy of an analog processing system*
- Digital signals are easily stored on magnetic media without distortion or loss of signal fidelity.
- *Analog signal may lose signal quality.*
- Digital signal processing can allow more sophisticated signal processing algorithms.
- *It is difficult to perform precise mathematical operations on signals in analog operations*
- In some cases a digital implementation of the signal processing system is cheaper than analog implementation.

To important Categories of DSP



- *Signal Analysis:* Deals with the measurement of signal properties. It is generally a frequency-domain operations. Some of its applications:
  - Spectrum analysis
  - Speech recognition
  - Speaker verification
  - Target detection
- *Signal Filtering:* This task is characterized by the "signal in-signal out" situation. It is usually time domain operation. Some of its applications:
  - Remove of unwanted background noise
  - Remove of interference
  - Separation of frequency band
  - Shaping of the signal spectrum

Signals, Systems, and Signal Processing

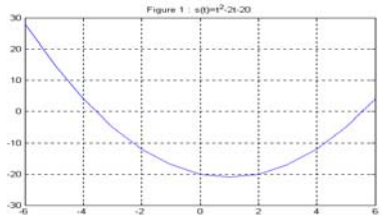
A signal

A signal is defined as any physical quantity that varies with time, space, or any other independent variable(s).

A signal as a function of one or more independent variables.

Example: $s(t) = t^2 - 2t - 20$

where t is called independent variable (time) and s(t) is dependent variable.



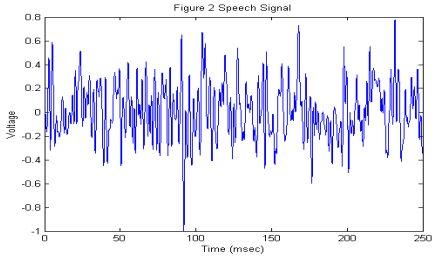

```
>> t=-6:6;
>> s=t.^2-2*t-20;
>> plot(t,s)
>> grid on
>> title('Figure 1 : s(t)=t^2-2t-20')
```


Signals, Systems, and Signal Processing

- There are some signals that functional relationships are unknown or too complicated. Such a *speech signal*. It may be represented to a high degree of accuracy as a sum of several sinusoidal of different amplitudes and frequencies.

$$\sum_{i=1}^{N} A_i(t)\sin\left[2\pi f_i(t)t + \theta_i(t)\right]$$

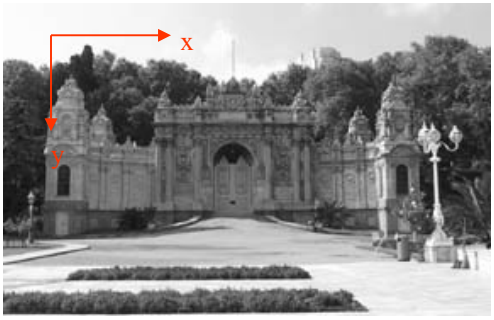
where $A_i(t)$, $f_i(t)$, $\theta_i(t)$ and are the set of amplitude, frequencies, and phases.



Signals, Systems, and Signal Processing

An example of a signal with two independent variables is an image signal.

$$I(x, y)$$



Signal Types

- The different types of signals:
- Simple Signals - Single Channel – One Dimensional
  - Analog Signal
  - Discrete Signal
  - Digital Signal
- Higher Order Signals
  - Single Channel and Multidimensional Signals
  - Multi Channel and Single Dimensional Signals
  - Multi Channel and Multidimensional Signals

- The value of the signal can be a real-valued scalar quantity,

$$s_1(t) = A\sin 4\pi t$$

- A complex-valued quantity

$$s_2(t) = Ae^{j4\pi t} = A\cos 4\pi t + jA\sin 4\pi t$$

Signal Types

- Or vector form

$$\mathrm{S}_3(t) = \begin{bmatrix} s_1(t) \\ s_2(t) \\ s_3(t) \end{bmatrix}$$

- A vector form signal is referred as a multi-channel signal.
- An example of 3-leads electrocardiogram (ECG).

- If the signal is a function of a single independent variable, the signal is called a one-dimensional signal
- On the other hand, a signal is called M-dimensional if its value is a function of M independent variables.

- An example of a two-dimensional signal is a picture. The intensity of brightness at each point is

$$I(x, y)$$

Signal Types

- For a black-and-white TV picture may be treated as a three-dimensional signal.

$$I_b(x, y, t)$$

- A color TV picture may be described by three intensity function of the form by the vector .

$$\mathrm{I}(x, y, t) = \begin{bmatrix} I_r(x, y, t) \\ I_g(x, y, t) \\ I_b(x, y, t) \end{bmatrix}$$

Signals, Systems, and Signal Processing

A system

A system can be defined as a physical device that performs an operation on a signal.

Example:

- A filter is used to perform some operation(s) on the signal to reduce the noise and interface corruption from the desired information-bearing signal.

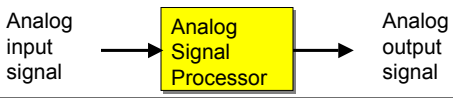
Such operations are usually referred to as signal processing.

- If the operation on the signal is linear, the system is called linear.
- If the operation on the signal is nonlinear, the system is called nonlinear

The digital signal processing on the signal may be preformed by a digital hardware, a software program, or a combination of digital hardware and software with each of performs its own set of specified operations

Basic Elements of a Digital Signal Processing

- Most of the cases signals are analog in nature. It may be processed directly by appropriate analog system



- An analog signal may be processed by digital signal processor using interface between the analog signal and the digital processor. This interface is called an *analog-to-digital (A/D) converter*. An other interface may be required after the processing to convert from digital signal to the analog signal, which is called a *digital-to-analog (D/A) converter*.