وزارة التعليم العالي والبحث العلمي

جامعة ديالى

كلية العلوم

قسم علوم الحاسبات

Unit form for
Introduction to Digital Signal Processing (DSP)

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Introduction to DSP

Digital Signal Processing (DSP) is used to process the analysis of digital signals to retrieve essential information or improve specific features through algorithms and techniques that are essential for applications starting from telecommunications and audio processing to medical imaging and control systems. The general block diagram of DSP is shown below:

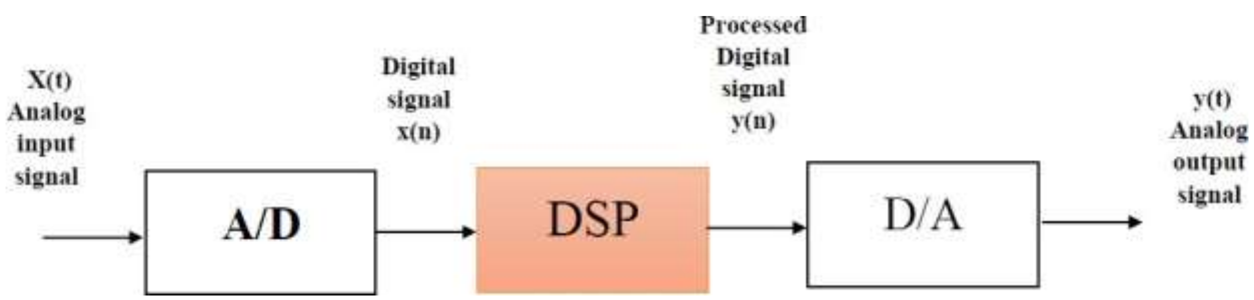


Fig.1 Block diagram of Digital Signal Processing

In real life most of the signals are analog in nature; to implement DSP on computer some fundamental steps are followed:

- An analog signal is sampled at a regularly spaced time interval to form a sequence of the signal amplitude.

- The sampled sequence of the analog magnitude is converted into a binary number.
- The sampling and conversion are done with an Analog to Digital Converter (ADC).
- Perform some operations (Processing) on the digitized analog signal to get an output value.
- Convert the processed output value into an analog signal using Digital to Analog Converter (DAC).

DSP has a number of advantages over analog signal processing:

Advantages: -

1- More flexible.

2- Often easier system upgrade.

3- Data easily stored in memory.

4- Better control over accuracy requirements.

5- DSP is less susceptible to noise and power supply disturbances than ASP.

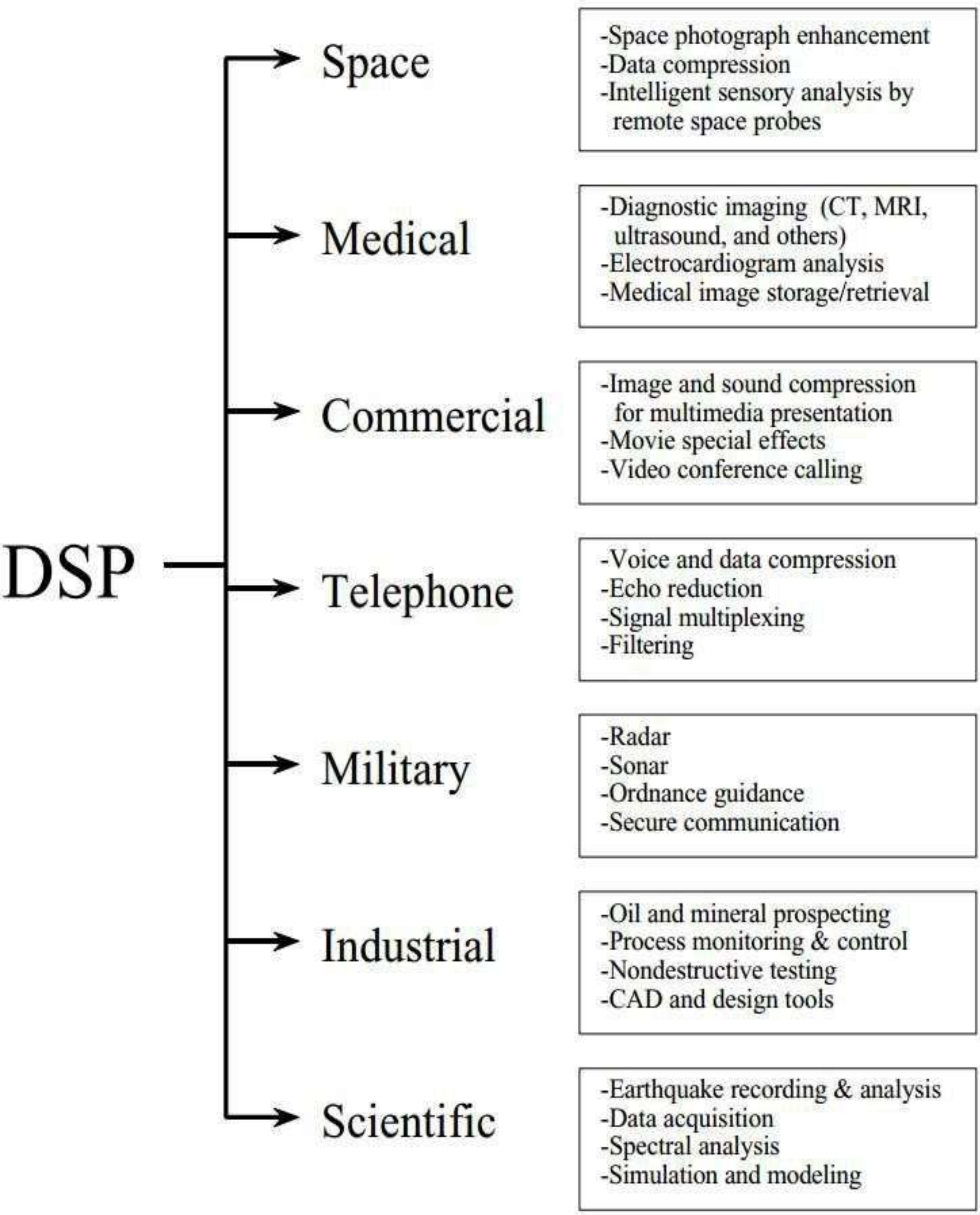
Limitations:

1. Analog to Digital Converter (A/D) and signal processors speed: wide-band signals still difficult to treat (real-time systems).

2. Cost/complexity added by Analog to Digital Converter (A/D) and Digital to Analog Converter (D/A) conversion.

DSP Applications:

The figure below shows the DSP applications. Many more areas are increasingly being explored by engineers and scientists. Applications of DSP techniques will continue to have profound impacts and improve our lives.


DSP
Space
-Space photograph enhancement
-Data compression
-Intelligent sensory analysis by remote space probes
Medical
-Diagnostic imaging (CT, MRI, ultrasound, and others)
-Electrocardiogram analysis
-Medical image storage/retrieval
Commercial
-Image and sound compression for multimedia presentation
-Movie special effects
-Video conference calling
Telephone
-Voice and data compression
-Echo reduction
-Signal multiplexing
-Filtering
Military
-Radar
-Sonar
-Ordnance guidance
-Secure communication
Industrial
-Oil and mineral prospecting
-Process monitoring & control
-Nondestructive testing
-CAD and design tools
Scientific
-Earthquake recording & analysis
-Data acquisition
-Spectral analysis
-Simulation and modeling

<u>Signal-Definition</u>

A Signal is the function of one or more independent variables that carries some information to represent a physical phenomenon.

Note - Any unwanted signal interfering with the main signal is termed as noise. So, noise is also a signal but *unwanted*.

According to their representation and processing, signals can be classified into various categories details of which are discussed below.

- **Continuous-Time Signals.**
- **Discrete-Time signals.**

<u>Continuous-Time Signals:</u>

Continuous-time signals are defined along a continuum of time and are thus, represented by a continuous independent variable. Continuous-time signals are often referred to as analog signals. This type of signal shows continuity both in amplitude and time. These will have values at each instant of time. *Sine* and *cosine* functions are the best examples of Continuous-time signals.

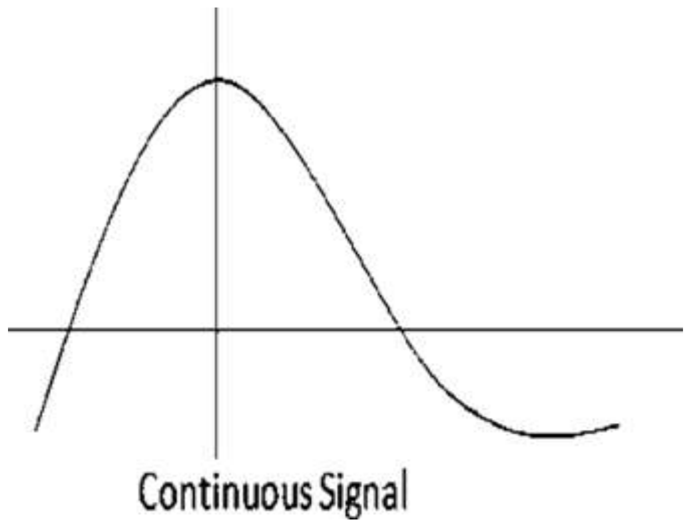


Fig.2 Continuous-time signals

<u>Discrete-Time Signals</u> (DTS)

A discrete-time signal (DTS) is a function of an integer-valued variable, n , that is denoted by (n). Every independent variable has a distinct value. Thus, they are represented as a sequence of numbers.

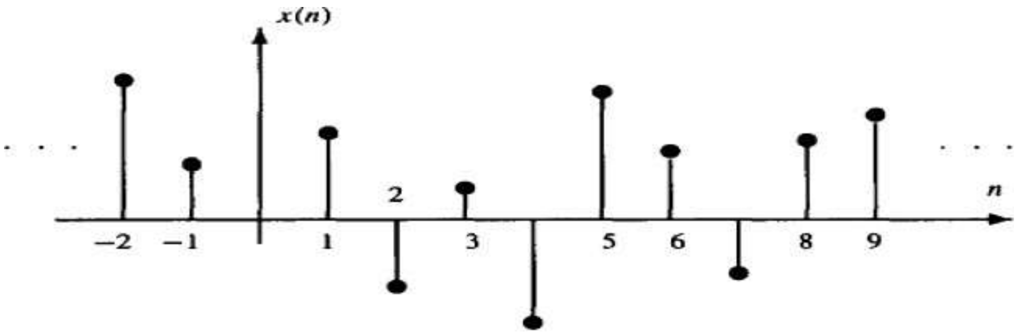


Fig.3 Discrete –time signals

The figure above depicts a discrete signal's discrete amplitude characteristic over a period of time. Mathematically, these types of signals can be formularized as:

$$x = \{x[n]\}, -\infty < n < \infty$$

Where, *n* is an integer.

It is a sequence of numbers *x*, where n^{th} number in the sequence is represented as *x[n]*.

<u>Classification of DT Signals</u>

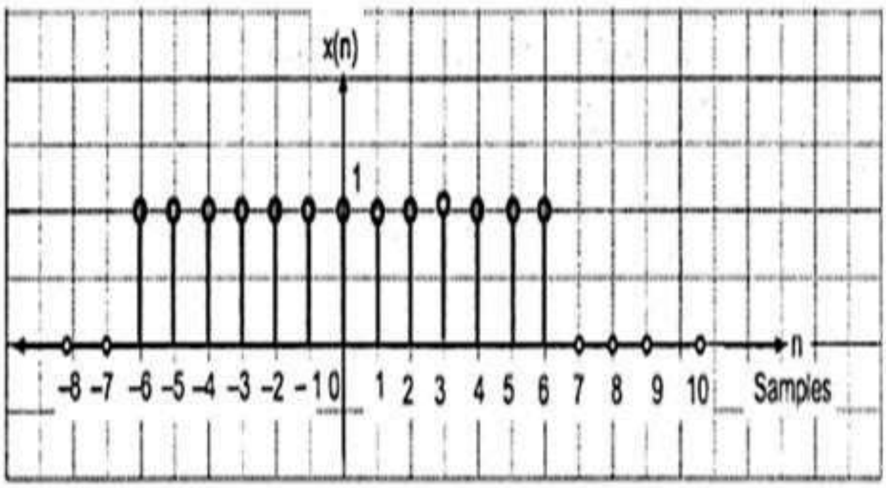
Discrete time signals can be classified according to the conditions or operations on the signals.

- **a- Even and Odd Signals**
- **b- Periodic and Non-Periodic Signals**

a. <u>Even Signals</u>

A signal is said to be ***even*** or symmetric if it satisfies the following condition;

$$(-n) = (n)$$



Here, we can see that

$x(-1)= x(1)$, $x(-2)= x(2)$ and $X(-n)=x(n)$. Thus, it is an ***even*** signal.

Example: Find whether the signal $x(n) = n^2 + n^4$ is even or odd.

Solution:-

$$(-n) = (n)$$

$$X(-n) = (-n)^2 + (-n)^4$$

$$=n^2+n^4$$

The signal is ***even*** because $(-n) = (n)$

b.Odd Signal

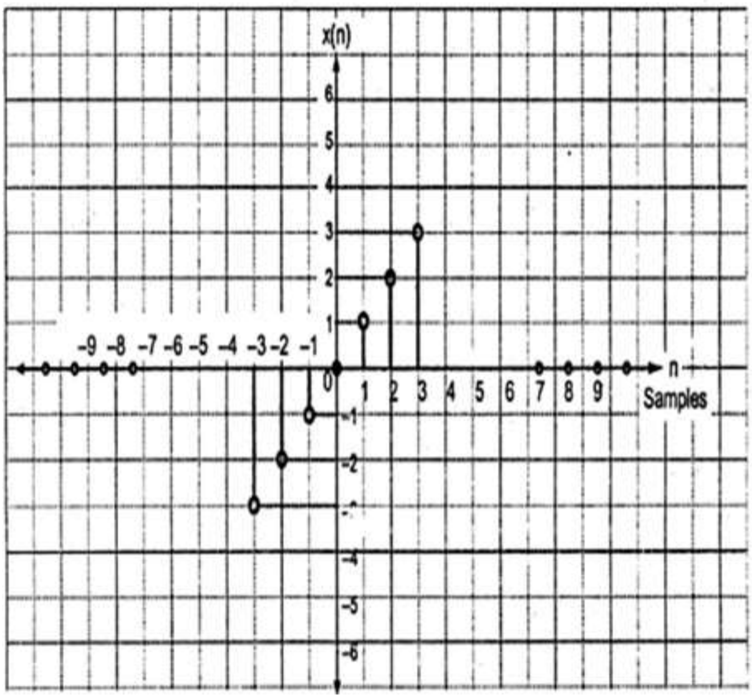
A signal is said to be odd if it satisfies the following condition;

$$(-n) = -(n)$$

From the figure below, we can see that

$x(1)= -x(-1)$, $x(2)= -x(2)$ and $x(n)= -x(-n)$.

Hence, it is an ***odd*** as well as anti-symmetric signal.



Example: Find whether the signal $\boldsymbol{x(n) = n^3}$ are ***even*** or ***odd***.
Solution:-

$$(-n) = -(n)$$

$$x(-n) = (-n)^3$$

$$= -n^3$$

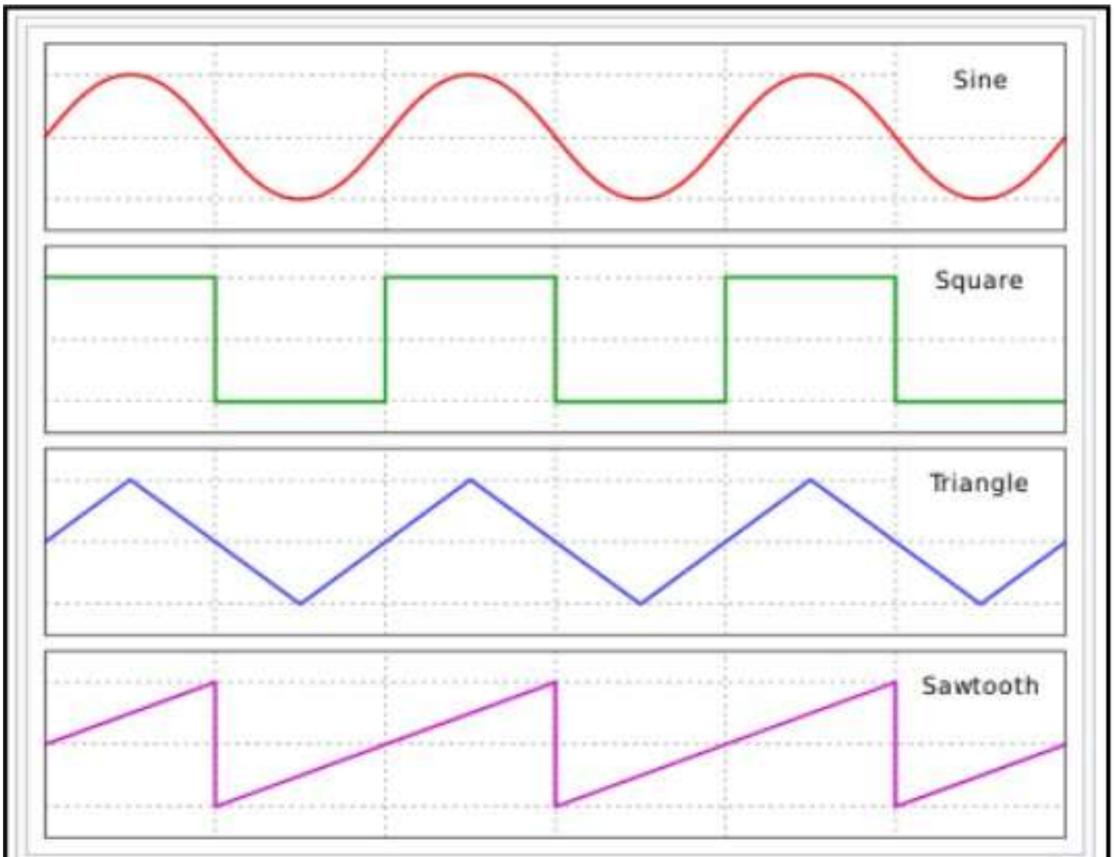
The signal is ***odd*** because (-*n)* = - *(n)*

Periodic and Non-Periodic Signals

A signal ***(t)*** is considered to be periodic signal when it is repeated over cycle of time or regular interval of time. This means periodic signal repeats its pattern over a period. The function ***(n)*** can be periodic if it satisfies following equation.

$$\boldsymbol{(n) = (n+N)}$$

There are four types (waveform) of periodic signal such as:



Sine, square, triangle, and sawtooth waveforms

Example:

a) Find whether the signal $x(n) = cos0.01\pi n$ are Periodic or Non-Periodic.

<u>Solution:</u>

$$x(n) = \cos 0.01\ \pi n$$

We have the condition:

$$x(n) = x(n+N)$$

So

$$x(n) = \cos 0.01\ \pi\ (n+N)$$

Where $w_o = 2\pi f$

$$f= w_o /2\pi$$

$$= 0.01\pi /2\pi \ = \ 1/200 = \ K/N$$

$$N=200$$

So, the signal is **periodic**.

b) $X(n) = \cos\frac{n}{8}\cos\frac{\pi n}{8}$

Sol:- $w_1 = 1/8$, $w_2 = \pi /8$

$w_1 = 2\pi f_1 = 1/16\pi$, w_1 is **Non Periodic**

$w_2 = 2\pi f_1 = 1/16$, w_2 is **Periodic**

So, the signal is **Non Periodic.**

Homework:-

1- Find whether the signal are even or odd:

a- $x(n)$=sin4t

b- $x(n)$=cos3t

2- Find whether the signal are periodic or not:

a- $x(n) = \sin 3n$

b- $x(n)=(-1)^n$ π

c. $x(n) = \cos(0.3\pi n)$