Digital Signal Analysis and Processing

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Background of Signal Processing and DSP

What is Signal?

What is SP?

What is DSP?

Why DSP?

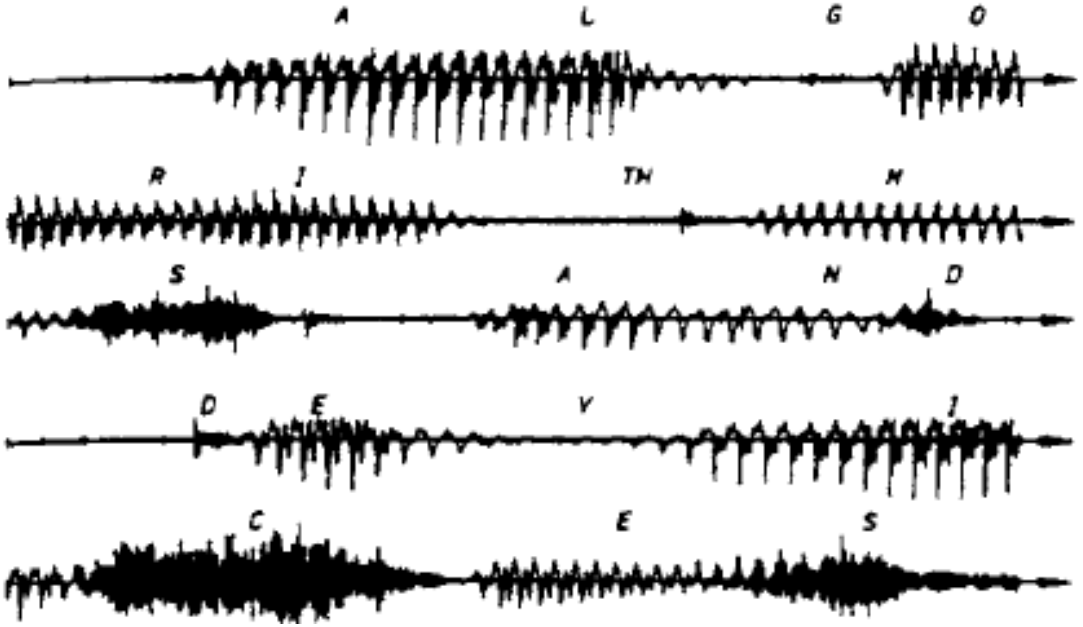
Where DSP?

Signals

- A ***signal*** is a function that conveys information about state or behavior of a physical system or variable.

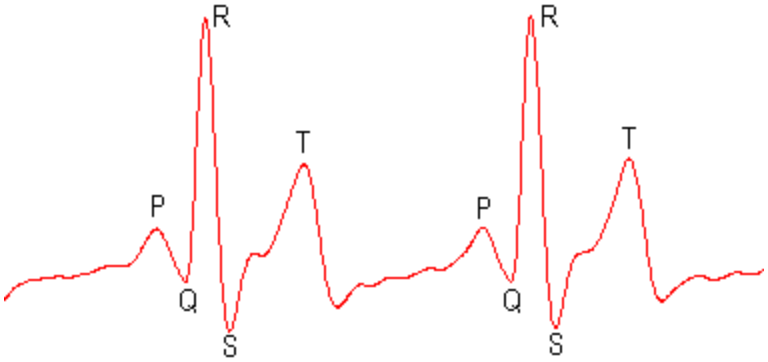
- In other words, signal is defined as any physical quantity that varies with time, space or any other independent variable or variables.

Example:
a speech signal



Signal Examples

- Other examples include:
  - An ECG



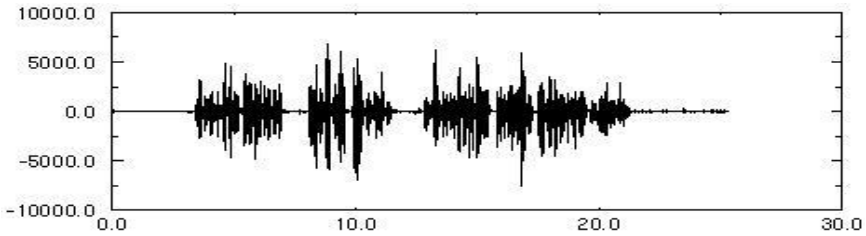
  - An Image

  - Stock Price

    and there can be so many others

Signal -Dimensions

- Based on number of independent variables
  - One dimensional e.g. speech signal (single independent variable: time)



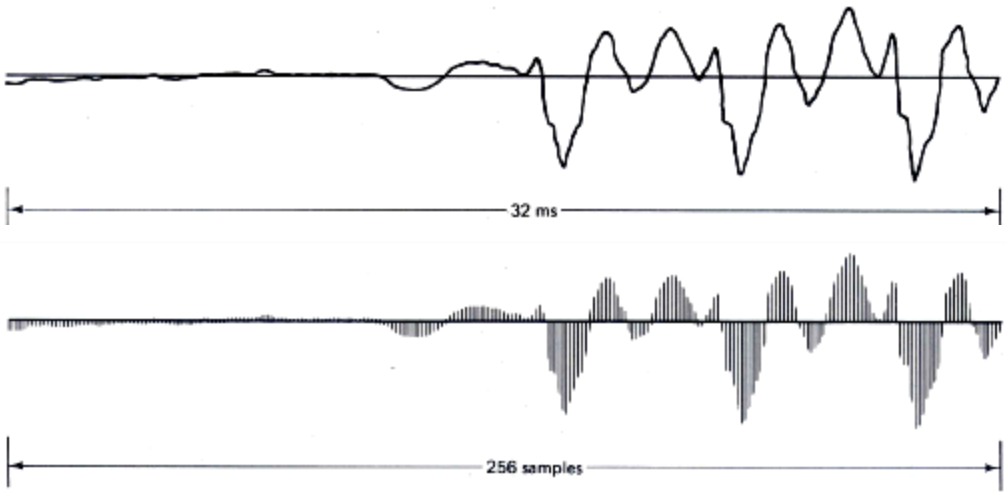
  - Two dimensional e.g. image (two independent variable: two spatial coordinates)

  - Three dimensional e.g. video (two independent variable: two spatial coordinates and additional independent variable: time)

CT/DT Signals

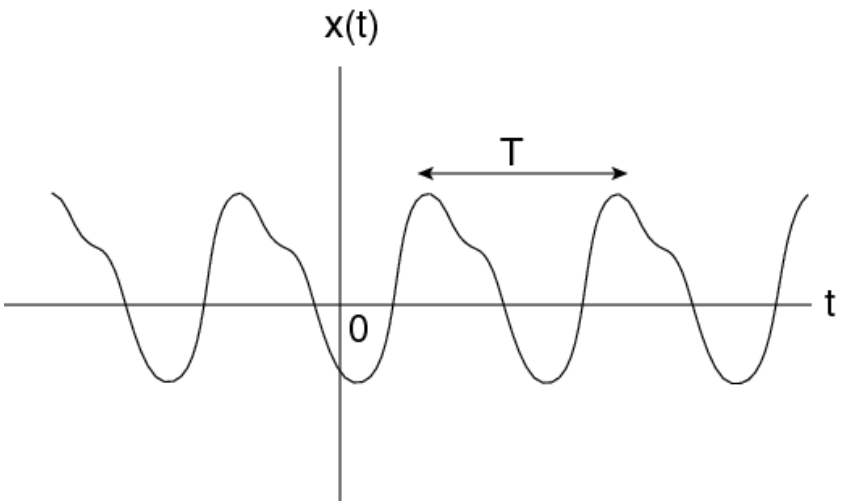
Based on nature of independent variables, signals can be classified as :

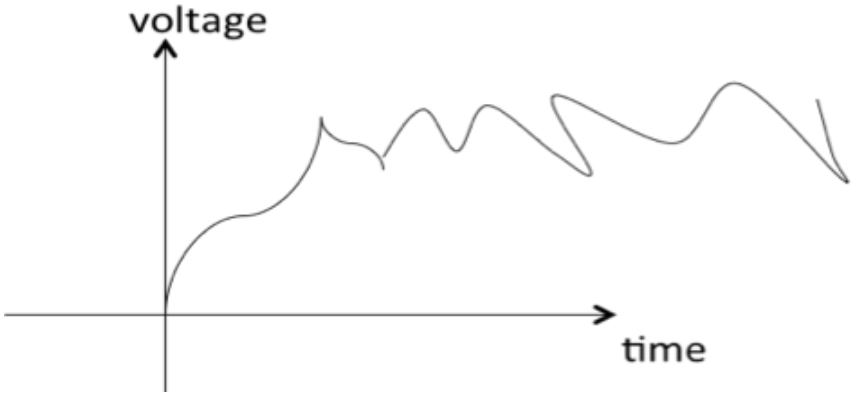
- Continuous Time (CT) Signals:
  - -Independent variable (usually time) is continuous.
  - - Signal is defined for all time within an interval.
- Discrete Time (DT) Signals:
  - - Independent variable is discrete
  - - Signal is defined only for discrete values of time



Periodic/Non-periodic

- Based on repetitiveness:
  - Periodic Signal:
    -Repeats its history
    -
  - Aperiodic Signals
    - Doesnot repeat its history

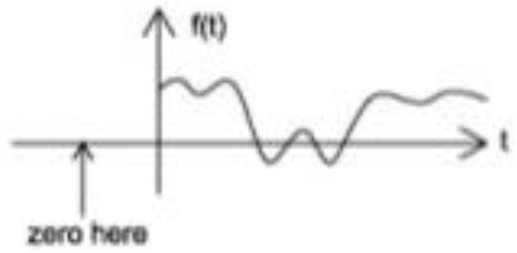




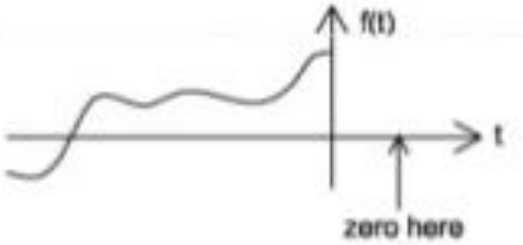
Causal/Non-causal

- Based on existence:
  - Causal Signals
  - Anticausal Signals
  - Twosided Signals

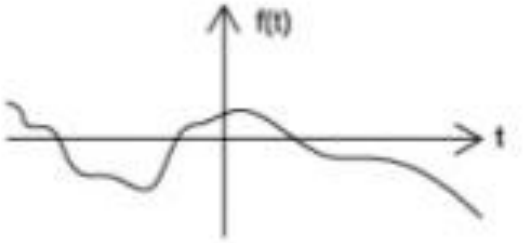
Causal



Anticausal



Noncausal

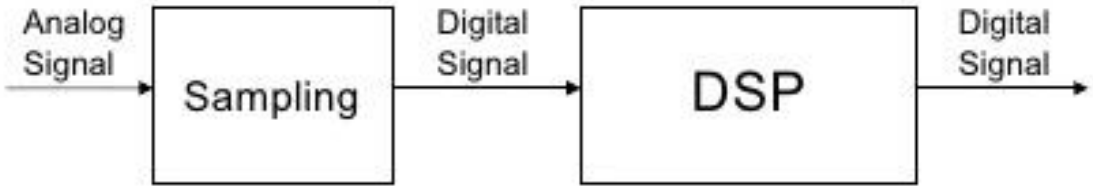


Systems And Processing

- A ***system*** may be defined as a physical device that performs an operation on a signal.
- The operations performed on the signal are ***signal processing.***
- An example is the filter used to reduce the noise and interference corrupting the information bearing signal.
- Filter is the system and filtering is the signal processing task.
- In many cases, the softwares and algorithms may also act as system

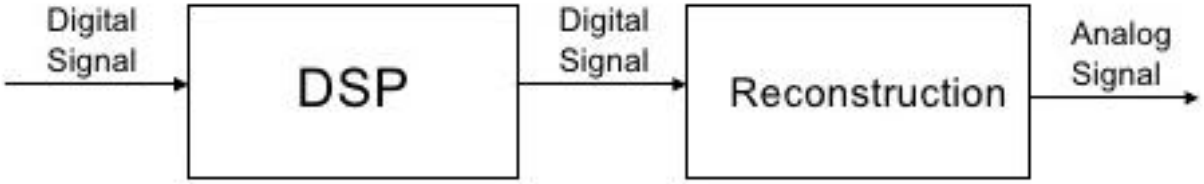
DSP

To implement DSP we must be able to:



convert analog signals into the digital information

- sampling & involves analog-to-digital conversion



convert the digital information, after being processed back to an analog signal

- involves digital-to-analog conversion & reconstruction

DSP of Analog Signals

To implement DSP we must be able to:

perform both A/D and D/A conversions

e.g. digital recording and playback of music (signal is sensed by microphones, amplified, converted to digital, processed, and converted back to analog to be played

Applications Areas of DSP

- Space photograph enhancement
- Data compression
- Intelligent sensory analysis by remote space probes

- Diagnostic Imaging (CT, MRI, Ultrasound and others
- Electrocardiogram analysis
- Medical image storage and retrival

- Image and sound compression for multimedia purpose
- Special effects in movies
- Video conferencing calling

- Voice and data compression
- Echo reduction
- Signal multiplexing and filtering Filtering

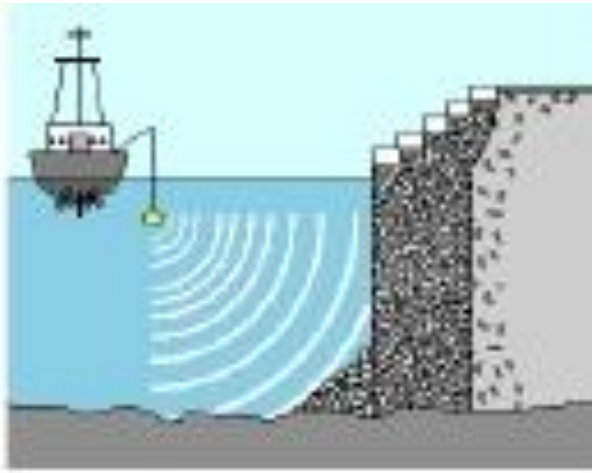
- RADAR/SONAR
- Weapon guidance
- Secure Communication

- Oil and mineral prospecting
- Process monitoring and control
- Nondestructive testing
- CAD and design tools

- Earthquake recording and analysis
- Data acquisition / Spectral analysis
- Simulation and Modeling

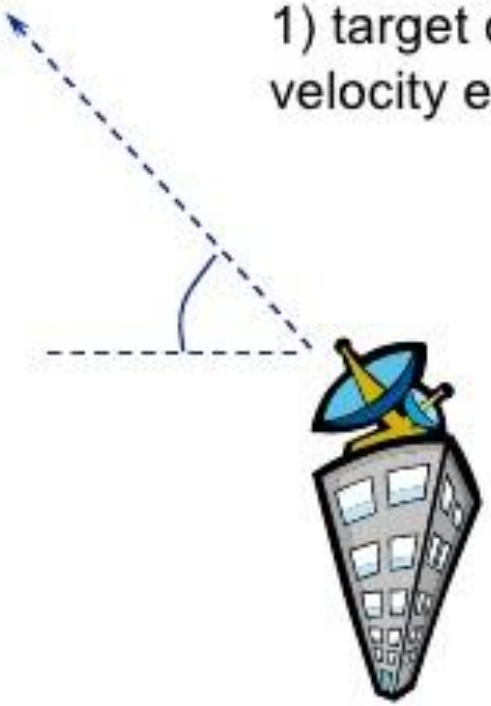
Applications of DSP

Radar and Sonar:



Examples

1) target detection – position and velocity estimation



2) tracking

Applications of DSP

Biomedical: analysis of biomedical signals, diagnosis, patient monitoring, preventive health care, artificial organs

Examples:

1) electrocardiogram (ECG) signal – provides doctor with information about the condition of the patient's heart

2) electroencephalogram (EEG) signal – provides Information about the activity of the brain

Applications of DSP

Speech applications:

-Speech generation
-Speech recgnition

Examples

1) noise reduction – reducing background noise in the sequence produced by a sensing device (microphone)

2) speech recognition – differentiating between various speech sounds

3) synthesis of artificial speech – text to speech systems for blind

Applications of DSP

Communications: Telecomunications

-Multiplexing
-Compression
-Echo control

Examples

1) telephony – transmission of information in digital form via telephone lines, modem technology, mobile phones

2) encoding and decoding of the information sent over a physical channel (to optimise transmission or to detect or correct errors in transmission)

Applications of DSP

Image Processing:

- Medical
- Space
- Commercial product

Examples

1) content based image retrieval – browsing, searching and retrieving images from database

2) image enhancement

2) compression - reducing the redundancy in the image data to optimise transmission / storage

Applications of DSP

Music Applications:

Examples:

1) Recording

2) Playback

3) Manipulation (mixing, special effects

Applications of DSP

Multimedia:

generation storage and transmission of sound, still images, motion pictures

Examples:

1) digital TV

2) video conferencing

Advantages of DSP

Many signals is nature are analog.
We need additional A/D and D/A components for DSP.

Why still do it?

- Digital system can be simply reprogrammed for other applications / ported to different hardware / duplicated

  (Reconfiguring analog system means hadware redesign, testing, verification)
- DSP provides better control of accuracy requirements

  (Analog system depends on strict components tolerance, response may drift with temperature)
- Digital signals can be easily stored without deterioration

  (Analog signals are not easily transportable and often can't be processed off-line)
- More sophisticated signal processing algorithms can be implemented

  (Difficult to perform precise mathematical operations in analog form)

Advantages of DSP

- DSP systems are more robust
  (Precision not effected by external factors, hence reproducible results)
  (Less effected by noise)

- DSP structure are flexible
  (Easy interconnection of DSP blocks)
  (Possibility of sharing a processor between several tasks)

Limitations of DSP

- Cost/Complexity added by A/D and D/A conversion.
- Increased bandwidth requirement for transmission after conversion to digital.
  - Sampling theorem says double the bandwidth
- Input bandwidth is technology limited:
  - Higher the bandwidth faster the A/D converter needed.
- Digitization (includes quantization) adds error:
  - Quantization error
- Aliasing and limited frequency resolution.