Introduction to Signals & Systems

Lecture 1

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Course Description:

This is a fundamental course not only in Biomedical Engineering but also for Electrical and Electronics Engineering and Computer Engineering.

70% attendance is obligatory.

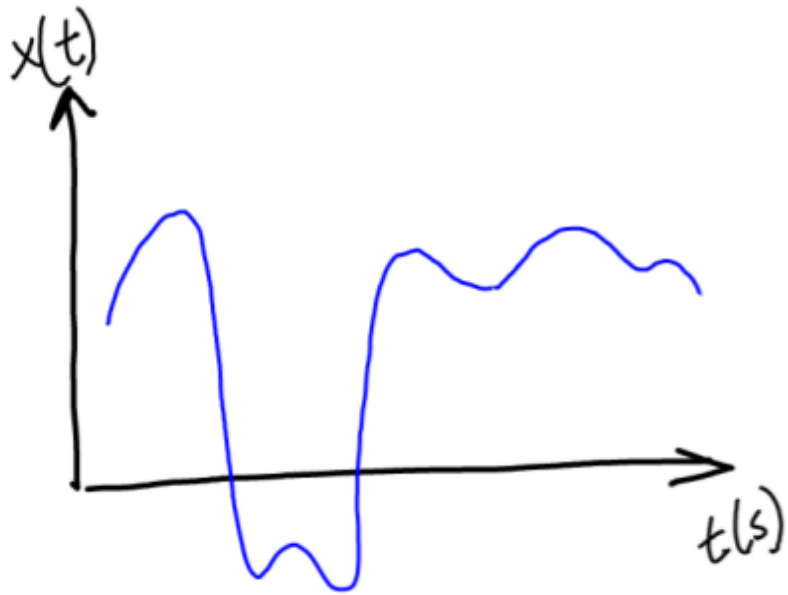
There will be homeworks.

There will be a single midterm and a final.

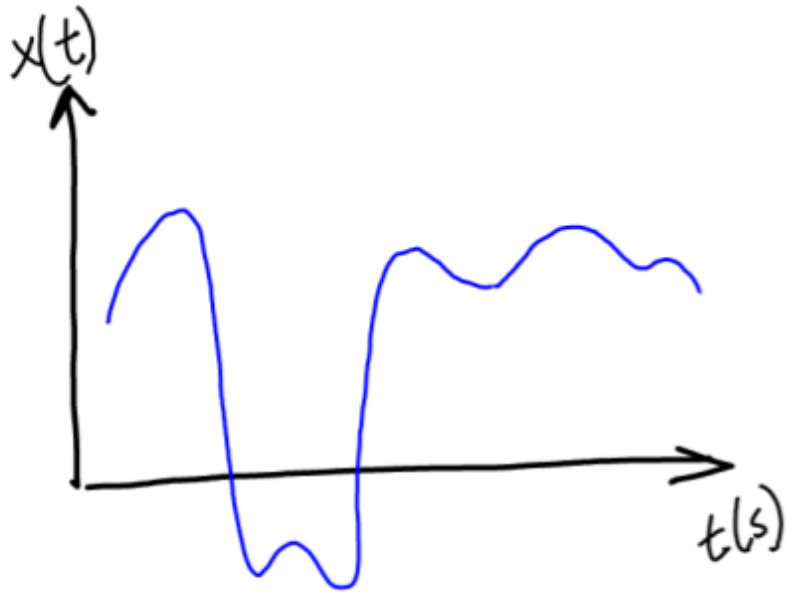
Text book: Allen V. Oppenheim, Allen S. Wilsky, "Signals and Systems", Prentice-Hall, 2. Ed.

Signal:

We can think of signals as functions of one or more independent variable(s).
They transmit information about a physical system.
Here is an example of a signal:



Independent Variable of a Signal:



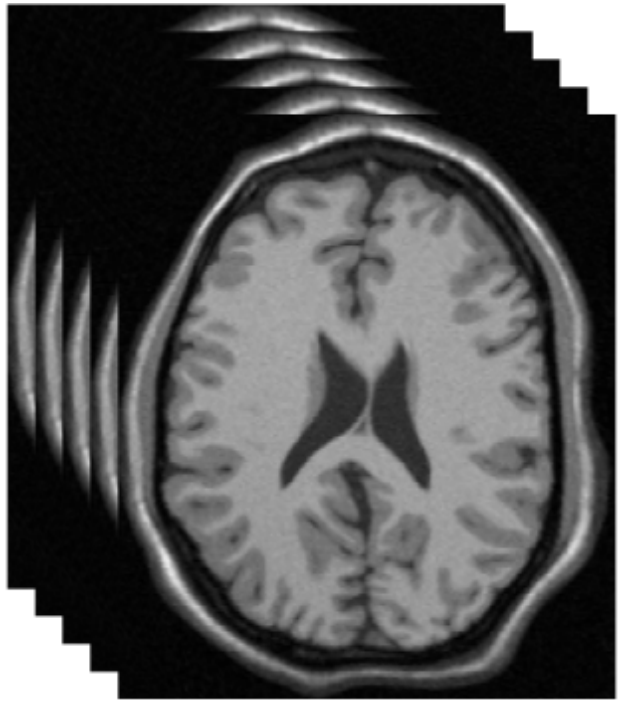
This signal has one independent variable: t
Since it has one independent variable, it is a 1D signal.
Are all signals 1D?
Can you come up with an example for 2D signal?

2**D Signal**:

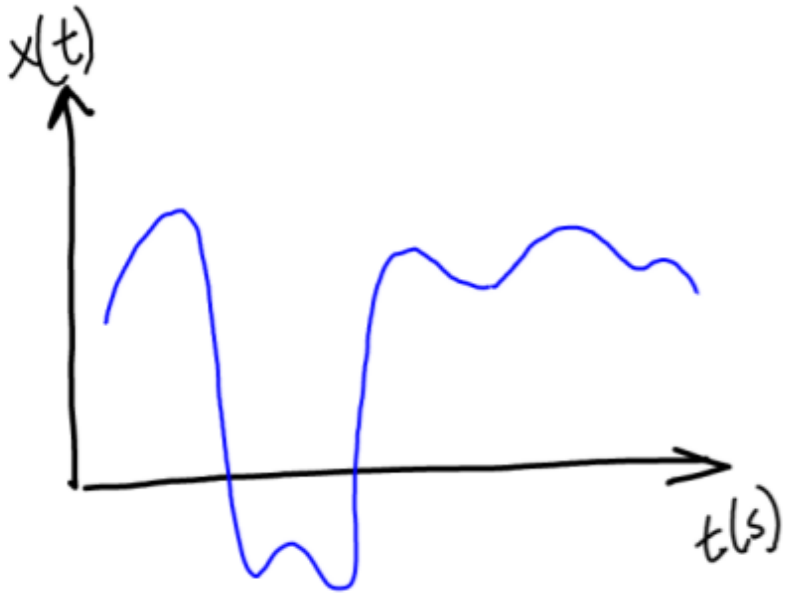
Images are examples of 2D signals.
We can think of images as signals that represent change of brightness through x and y coordinates.

3**D Signal**:

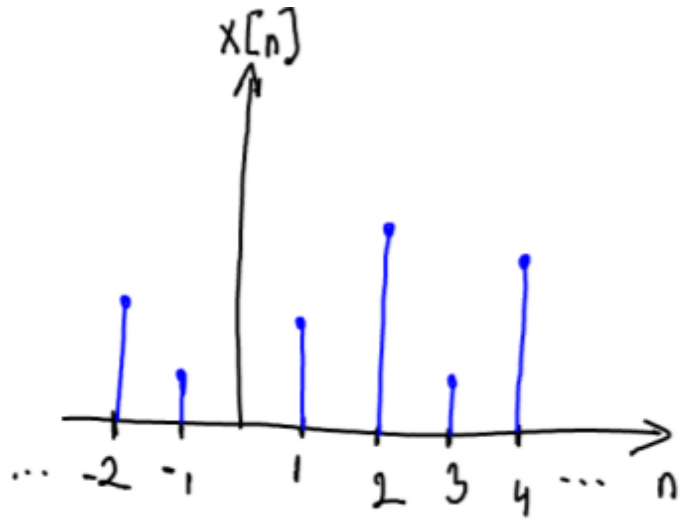
In medical imaging, we generally have 3D images.
In addition to x (horizontal) and y (vertical) coordinates, we have z coordinate representing slices.



Classes of Signals:



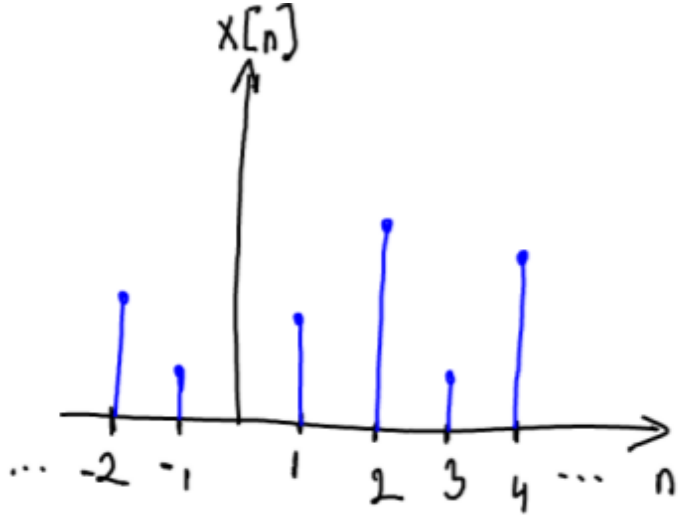
(a) Continuous Time Signal



(b) Discrete Time Signal

Figure : Classes of signals

Discrete Time Signals:



The signal is a function of an integer variable. Hence, it only takes values at integer values of the integer variable.
A real-world example to discrete time signals would be stock market exchange plots.

Discrete or Continous? Which One is Important?:

Both are important.

Yet, as the digital technology (computers) advances rapidly, we are more dealing discrete time signals.

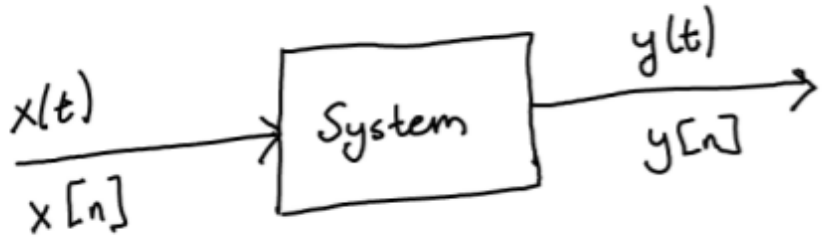
What if we need to process a continous time signal with our computers?

We can convert the continous time signal to discrete first and then we can process it

We will learn sampling theorem in the upcoming lectures.

System:

A system basically processes a signal.



There are many different types of systems. While we are analyzing systems, we exploit some of their properties for characterization.

Types of Systems:

- Linear Systems
- Non-linear Systems
- Time-invariant
- Time-varting

LTI: Linear Time Invariant

Examples of Systems:

Filters are examples of systems. Filters that we apply to our pictures and filters that are used to supress the background noise in recording are all examples of systems that are used to process signals.

(a) Noisy Image

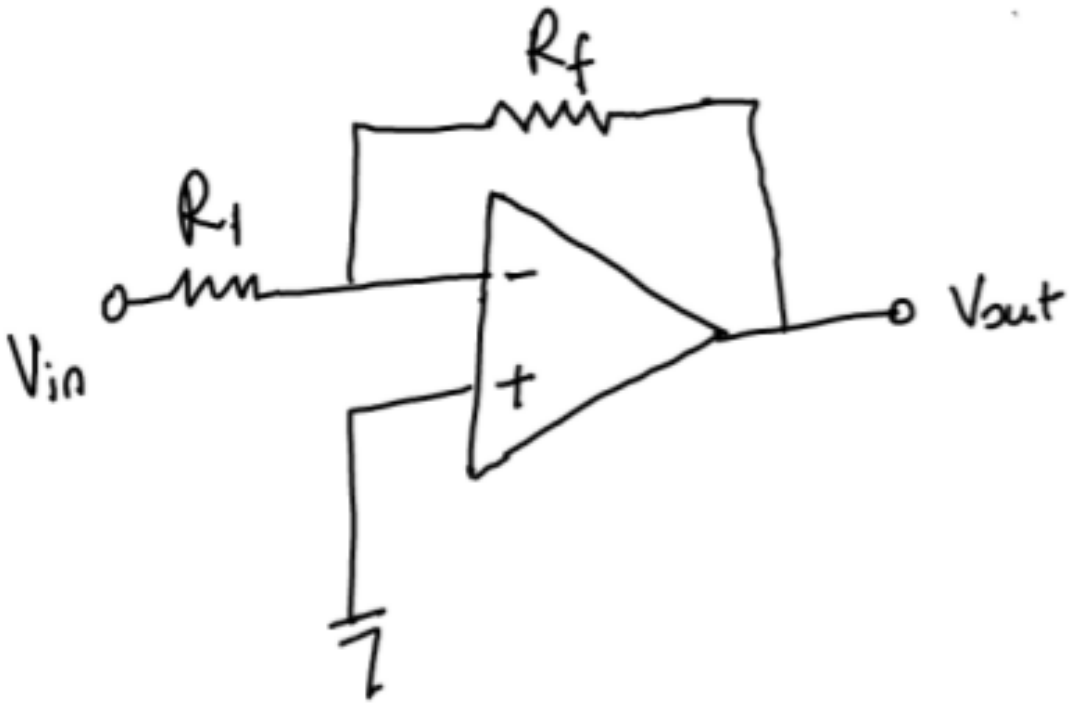
(b) Filtered Image

Connected Filters:

Systems can be also used connected to each other. There are several ways of connecting systems:

- series (cascade)
- parallel
- feedback

Feedback:



Inverting Amplifier

Analysis and Representation of Signals:

There are several domains that analysis and representations of signals can be done:

- Time Domain: x(t), x[n]
- Frequency Domain

Frequency Domain:

- Fourier Transform
- Laplace Transform
- z Transform

Laplace Transform and z Transform are extensions of Fourier Transform.