EN1060 Signals and Systems: Introduction

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Section 1

Introduction to Signals and Systems

- Signals and systems find many application in communications, automatic control, and form the basis for signal processing, machine vision, and pattern recognition.
- Electrical signals (voltages and currents in circuits, electromagnetic communication signals), acoustic signals, image and video signals, and biological signals are all example of signals that we encounter.
- They are functions of independent variables and carry information.

Introduction to Course Contd.

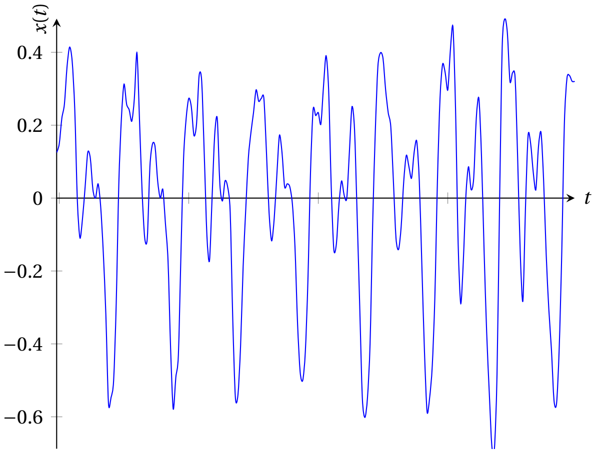
- We define a system as a mathematical relationship between an input signal and an output signal.
- We can use systems to analyze and modify signals.
- Signals and systems have brought about revolutionary changes.
- In this course we will study the fundamentals of signals and systems.
- Types of signals in continuous time and discrete time, linear time-invariant (LTI) systems, Fourier analysis, sampling, Laplace transform, z-transform, and stability of systems are the core components of the course.

After completing this course you will be able to do the following:

- Differentiate between continuous-time, discrete-time, and digital signals, and techniques applicable to the analysis of each type.
- Apply appropriate theoretical principles to characterize the behavior of linear time-invariant (LTI) Systems.
- Use Fourier techniques to understand frequency-domain characteristics of signals.
- Use appropriate theoretical principles for sampling and reconstruction of analog signals.
- Use the Laplace transform and the z-transform to treat a class of signals and systems broader than what Fourier techniques can handle.

- In this course we study signals and systems that process these signals.
- Categories of signals:
  - Continuous-time signals: independent variable is continuous, $x(t)$
  - Discrete-time signals:independent variable is an integer, $x[n]$
- There are some very strong similarities and also some very important differences between discrete-time signals and systems and continuous-time signals and systems.

- The independent variable is continuous.
- E.g., sound pressure at a microphone as a function of time (one-dimensional signal).
- E.g., image brightness as a function of two spatial variables (two-dimensional signal).
- Con convenience, we refer to the independent variable as time.



A function of a continuous variable
A speech signal: a continuous-time, one-dimensional signal

An image on a film: a continuous-time, two-dimensional signal

- Function of an integer variable.
- Takes on values at integer values of the argument of $x[n]$.

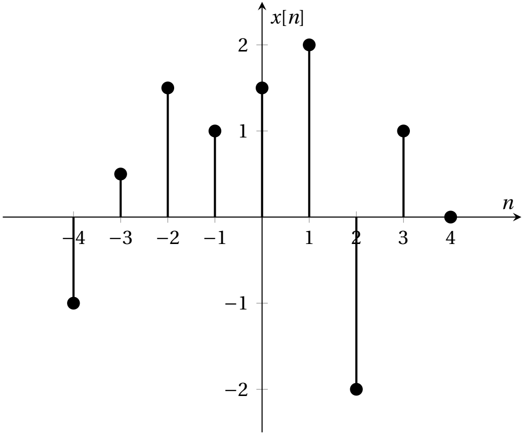


Figure: DT Signal

Digital Signals

- What is a digital signal?
  - A quantized discrete-time signal. I.e., $x[n, m]$ can take only a value from a finite set of values.
- What is a digital image?
  - A two-dimensional, quantized, discrete-time signal.
  - A 600×800 image: $n \in [0, 599]$, $m \in [0, 799]$, $x[n, m] \in [0, 255]$. 8-bit image.

Systems

- A system processes signals.
- Examples of systems:
    - Dynamics of an aircraft.
    - An algorithm for analyzing financial and economic factors to predict bond prices.
    - An algorithm for post-flight analysis of a space launch.
    - An edge detection algorithm for medical images.

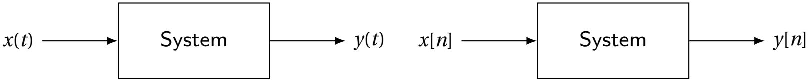


Figure: CT and DT Systems.

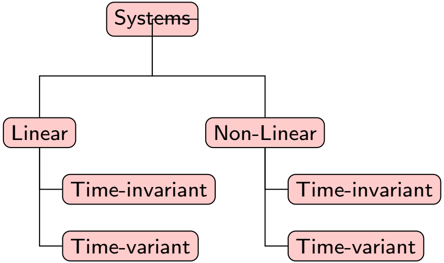


Figure: System types.

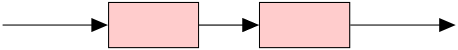
This course is focused on the class of linear, time-invariant (LTI) systems.

Examples of Systems

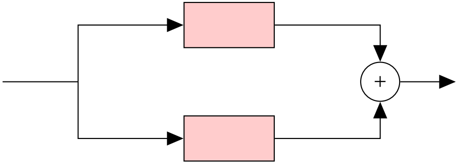
- Dynamics of an aircraft.
- An algorithm for analyzing financial and economic factors to predict bond prices.
- An algorithm for post-flight analysis of a space launch.
- An edge detection algorithm for medical images.

- To build more complex systems by interconnecting simpler subsystems.
- To modify the response of a system.
- E.g.: amplifier design, stabilizing unstable systems.

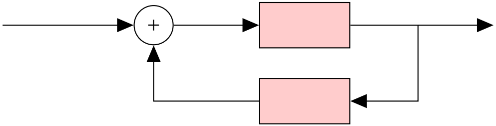
Signal-Flow (Block) Diagrams



Series (Cascade)



Parallel



Feedback

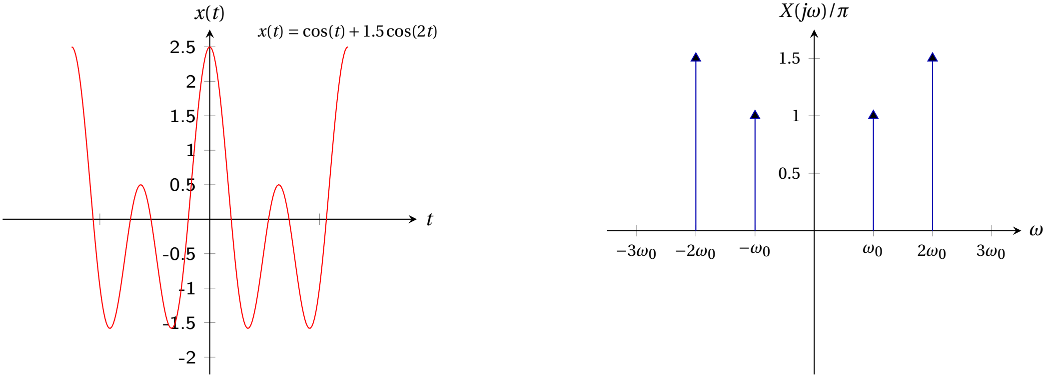


Figure: Domains.

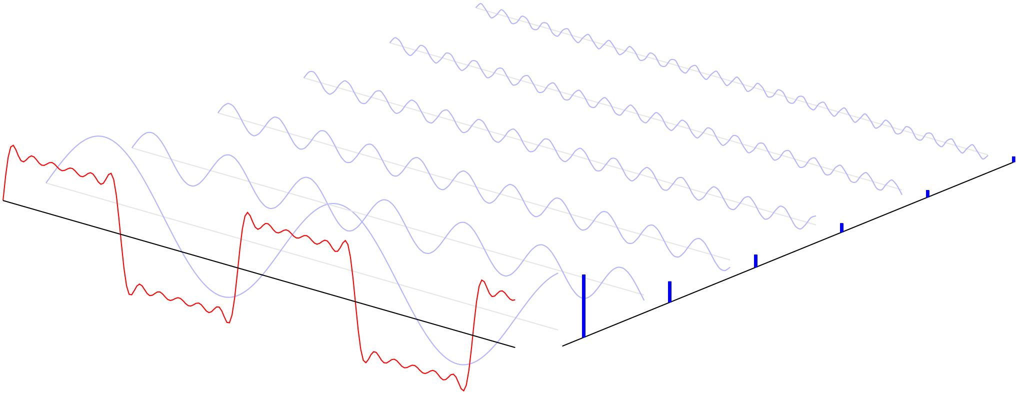


Figure: Square wave: time and frequency domains.