# EN1060 Signals and Systems: Introduction

Ranga Rodrigo
ranga@uom.lk

The University of Moratuwa, Sri Lanka

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Section 1

# Introduction to Signals and Systems

# Outline

- Signals and systems find many application in communications, automatic control, and form the basis for signal processing, machine vision, and pattern recognition.

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- 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.

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- 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.

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- 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.

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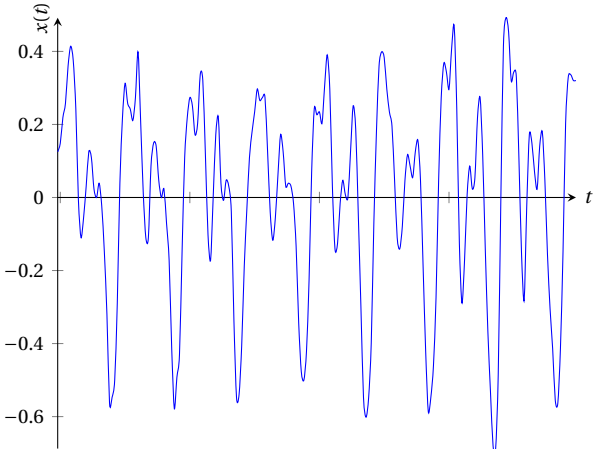
  - Discrete-time signals:independent variable is an integer, $x[n]$
- There are some very strong similarities and also some very important differences between discrete-time signals and systems and continuous-time signals and systems.

# Continuous-Time Signals $x(t)$

- 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 $x[n]$.

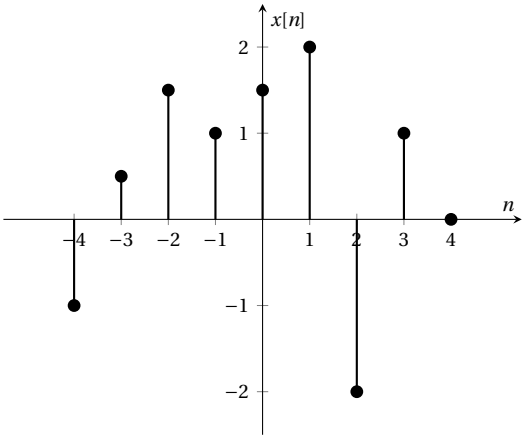



Figure: DT Signal

# 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 $600 \times 800$ image: $n \in [0,599]$, $m \in [0,799]$, $x[n,m] \in [0,255]$. 8-bit image.

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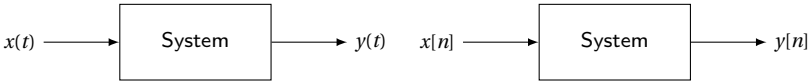


Figure: CT and DT Systems.

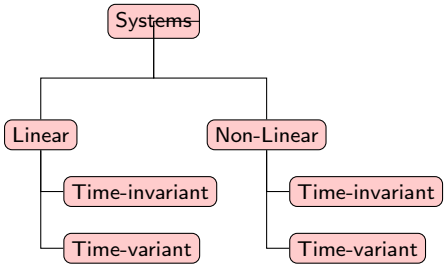


Figure: System types.

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.
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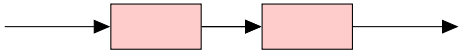
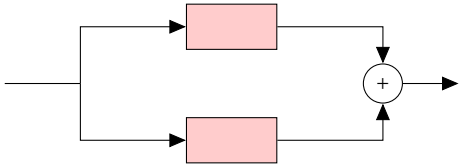
# Systems Interconnections

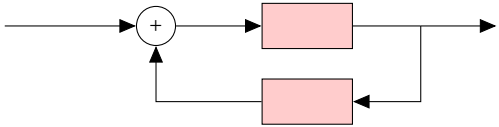
- To build more complex systems by interconnecting simpler subsystems.
- To modify the response of a system.
- E.g.: amplifier design, stabilizing unstable systems.



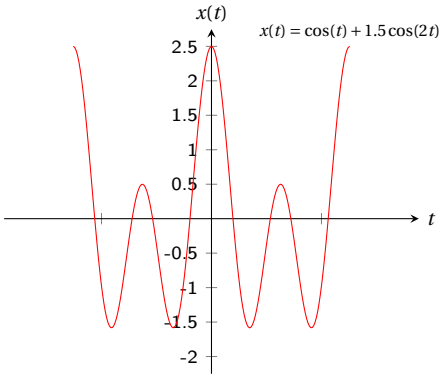
Series (Cascade)




Parallel




Feedback



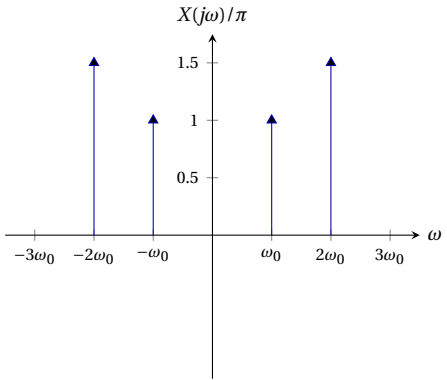




Figure: Domains.

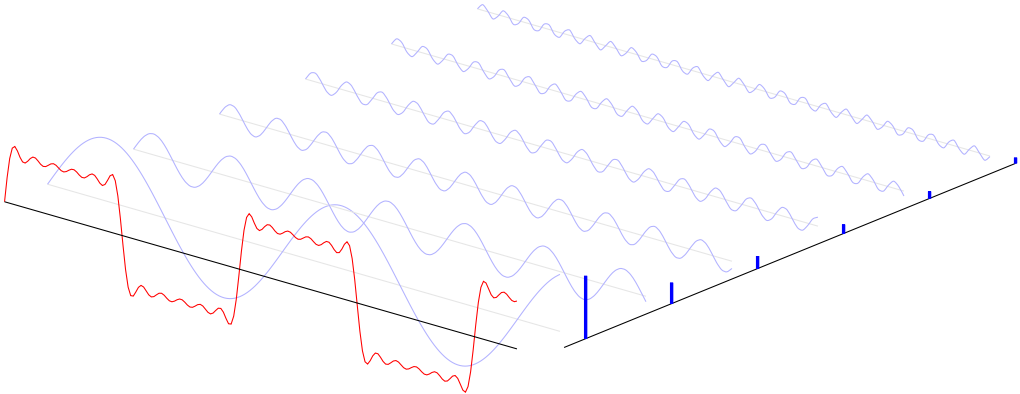


Figure: Square wave: time and frequency domains.