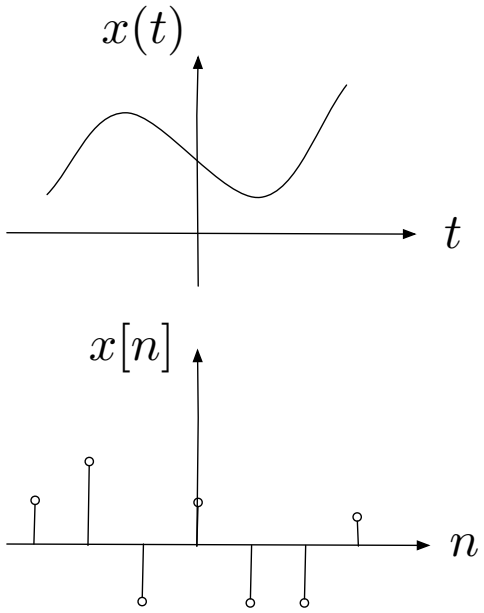
ECEN 314: Signals and Systems

Lecture Notes 1: Introduction

Reading:

- Current: SSOW 1.1
- Next: SSOW 1.2

1 Signals

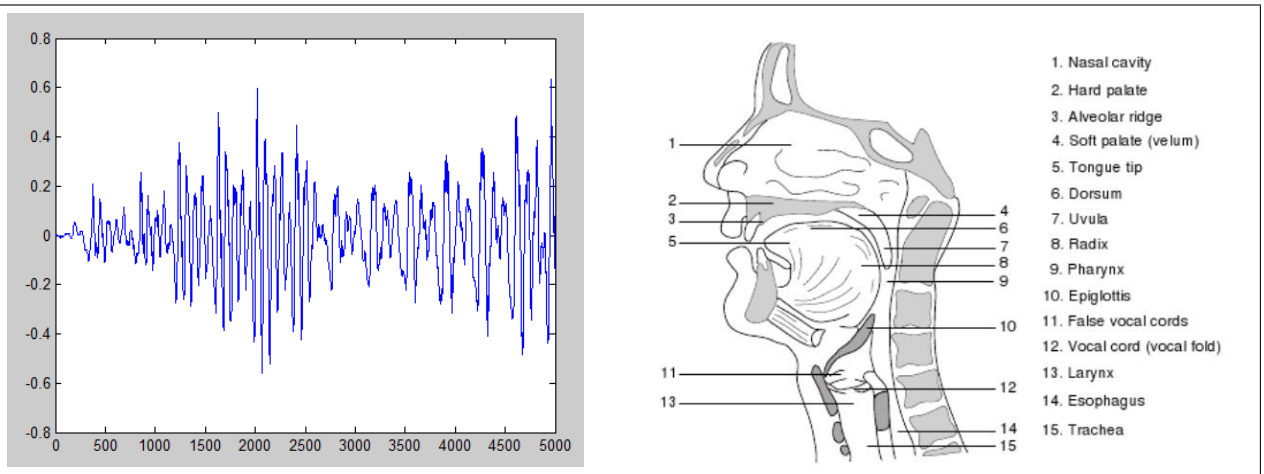


A *signal* is a function of an independent variable (e.g., time) that carries some information or describes some physical phenomenon.

- Notation
  - Continuous-time (CT) signal $x(t)$: independent variable t takes continuous values
  - Discrete-time (DT) signal $x[n]$: independent variable n takes only integer values
  - Note: $x(t)$ is used to denote both "the signal" and "the signal value at time t"
- Examples
  - Electrical signals: Voltages and currents in a circuit.

  - Acoustic signals: Audio and speech signals.
  - Biological signals: ECG, EEG, medical images.
  - Financial signals: Dow Jones indices.
- Independent variables
  - Can be continuous: Time and location.
  - Can be discrete: Digital image pixels, DNA sequence.
  - Can be 1-D, 2-D, ..., N-D.

This course focuses on a single independent variable (1-D) which we call "time". Most of the signals in the physical world are CT signals. DT signals are often formed by sampling a CT signal because DT signals can be directly processed by the powerful digital computers and digital signal processors (DSPs). This is the last topic of this course: sampling and digital processing of CT signals.



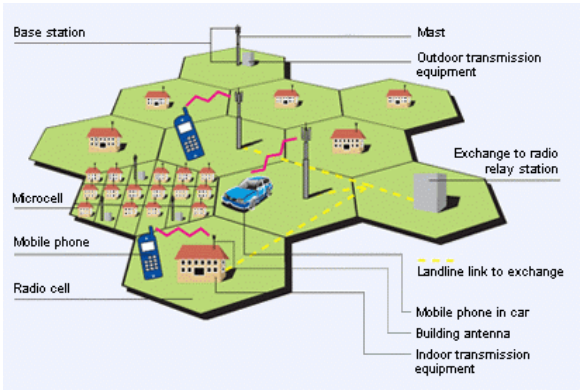
Speech waveform and production

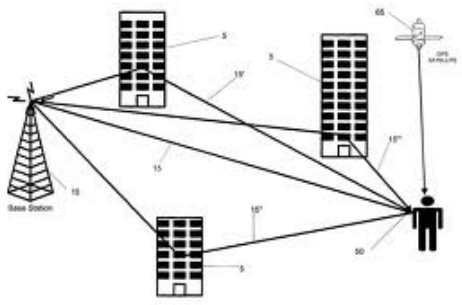
Daily Dow Jones 2012

2 Applications

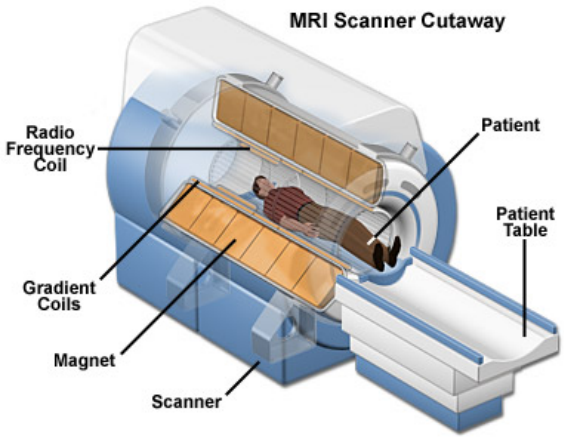
The analysis of signals and systems now plays a fundamental role in a wide range of engineering disciplines:

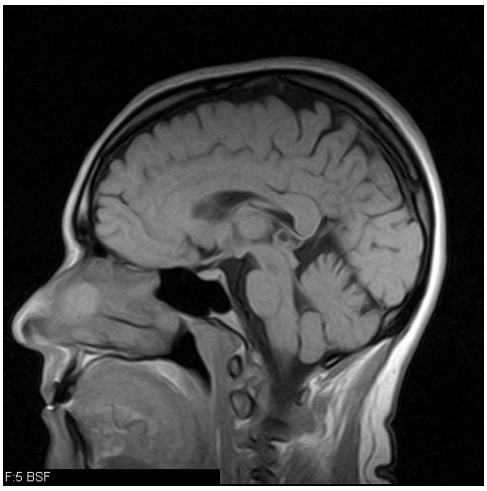
- Telecommunications: AM/FM Radio, speech, mobile phone, and internet
- Medical scanning and imaging: MRI and ultrasound
- Music: recording, processing, and synthesis
- Petroleum: Seismic surveying and Geological exploration



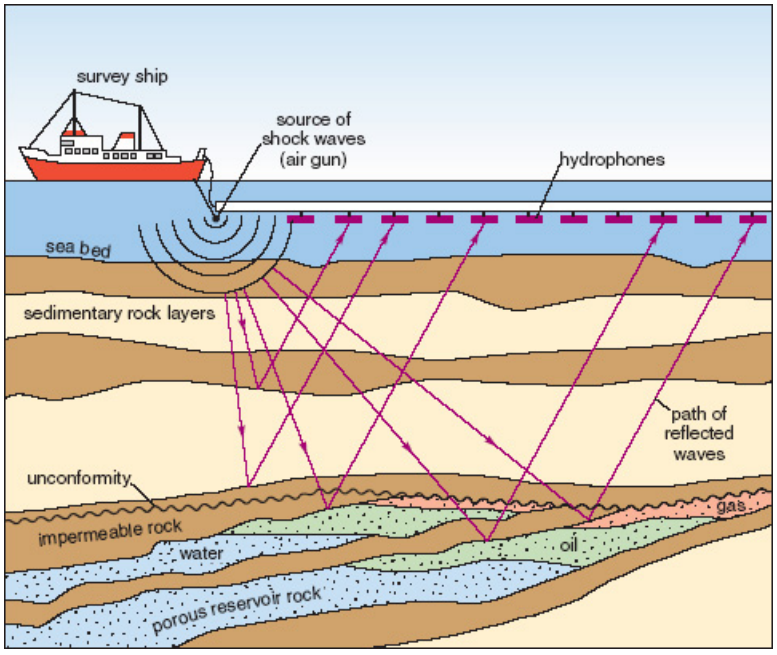


Wireless and Cellular Communication





Magnetic Resonance Imaging (MRI)



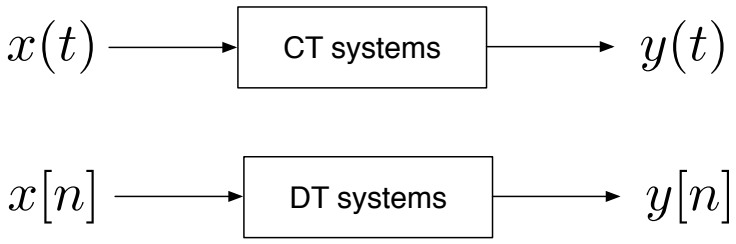
Marine Reflection Seismology for Oil Exploration

3 Systems

A *system* responds to one or several input signals, and its response is described in terms of one or several output signals.

This course focuses on single-input single-output (SISO) systems:

- Examples



- An RLC circuit.
- The dynamic of an aircraft.
- An edge detection algorithm for medical images.
- An algorithm for analyzing financial data to predict stock/bond prices.

Systems can be extremely diverse. However, from the input-output perspective, many systems share the same feature of being "linear" and "time-invariant". This course offers the theory of linear time-invariant (LTI) systems.

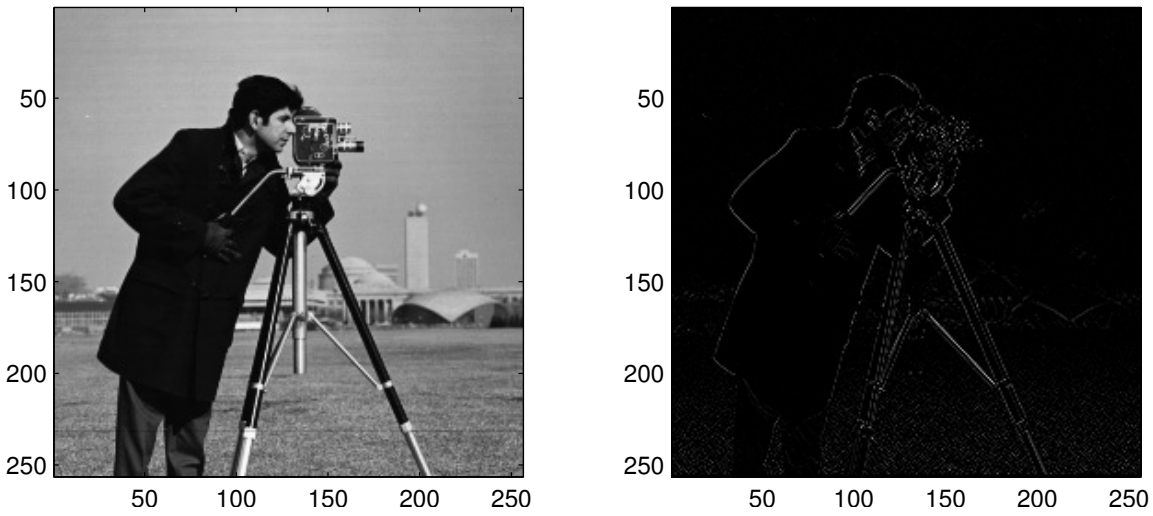


Image processing example

4 System Interconnection

Systems can be interconnected to:

- build more complex systems; and
- modify the response of an existing system.