Introduction to Biomedical Signal Processing

The Nature of Biomedical Signals

- The living organism made up of many component system and each system is made up of several subsystems that carry on many physiological processes.
- Most physiological processes are accompanied by or manifest themselves as signals that reflect their nature and activities.
  - Signals: biochemical, electrical, physical

The Nature of Biomedical Signals

- Diseases or defects in a biological system cause alteration its normal physiological processes, leading to pathological processes.
- A pathological process is typicaaly associated with signals that are different in some respects from the corresponding normal signals.

Sensing of Biological Signals

- The signals can be sensed by qualitative or quantitative manner.
- Measurement
  - Scalar
  - Function of time
    - discrete x[n]
    - continuous x(f)
    - digital
  - Multivariant vector

Objectives of Biomedical Signal Analysis

- Information gathering
  - measurement of phenomena to interpret a system
- Diagnosis
  - detection of malfunction, pathology, or abnormality
- Monitoring
  - obtaining continuous or periodic information about a system

Objectives of Biomedical Signal Analysis

- Therapy and control
  - Modification of the behaviour of system based upon the outcome of the activities listed above to ensure a specific result
- Evaluation
  - Objective analysis to determinate the ability to meet functional requirements, obtain a proof of performance, perform quality control, or qualify the effect of treatment

Signal Acqusition Procedures

- Invasive
  - placement of transducers or other devices inside the body
- Noninvasive
  - minimize risk
  - surface electrodes
- Active
  - require external stimuli
- Passive
  - not require external stimuli

The Components of Human-Instrument System

- The subject or patient
- Stimulus or procedure of activity
- Transducers
  - electrodes, sensors
- Signal-conditioning equipment
  - amplifier, filter
- Display equipment
  - oscilloscopes, strip charts, computer monitors etc.

The Components of Human-Instrument System

- Recording, data processing, and transmission equipment
  - Analog instrumentation tape recorders, analog-to-digital converters (ADCs), digital-to-analog converters (DACs), digital tapes, CDs, computers, telemetry systems etc.
- Control devices
  - Power supply, isolation equipment, patient intervention systems

Properties of Biomedical Instruments

- Isolation of the subject or patient
- Range of operation
  - The minimum to maximum values of the signal being measured.
- Sensitivity
  - the smallest signal variation measurable (resolution)
- Linearity
- Hysteresis
  - a lag in measurement due to the direction of variation of the entity being measured.

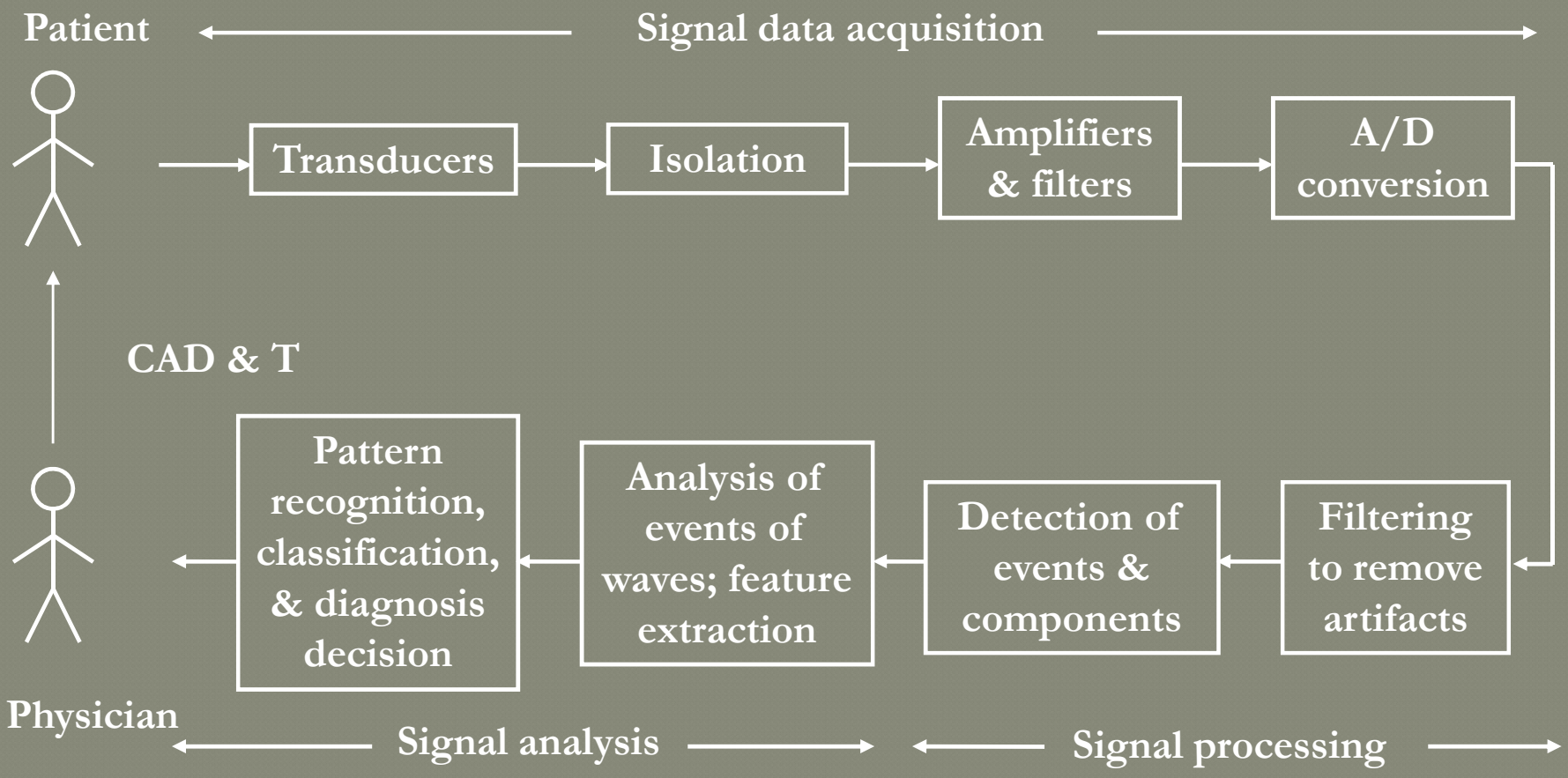
Properties of Biomedical Instruments

- Frequency response
  - represents of the variation of the sensitivity with frequency
- Stability
  - an unstable system could preclude repeatability and consistency of measurements
- Signal to noise Ratio (SNR)
  - noises could compromise the quality of the signal being acquired.
- Accuracy

Difficulties of Biomedical Signal Processing

- Accessibility of the variables to measurement
- Variability of the signal source
- Inter-relationship and interactions among physiological systems
- Effect of the instrumentation or procedure on the system
- Physiological artifacts and interference
- Energy limitation
- Patient safety

Computer Aided Diagnosis and Therapy



Why the CAD Systems are Used?

- Humans are highy skilled and fast in analysis of visual patterns and waveforms, but are slow in arithmetic operations with large numbers of values.
- Humans could be affected by fatigue, boredom and enviromental factors. Computers are inanimate but mathematically accurate and consistent machines can be designed to perform repetitive tasks.

Why the CAD Systems are Used?

- Analysis by humans is usually subjective and qualitative.
- Analysis by humans is subject inter-observers and intra-observers variation with time.
- The biomedical signals are fairly slow therefore these can be analised on-line by low-end computers.
- Off-line analysis by the stored data.

Reference

- Rangaraj M. Rangayyan: Biomedical Signal Analysis, IEEE Press/Wiley, New York, NY, 2002.