SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF BIOMEDICAL ENGINEERING

19BMB302 - BIOMEDICAL SIGNAL PROCESSING

III YEAR/ V SEMESTER

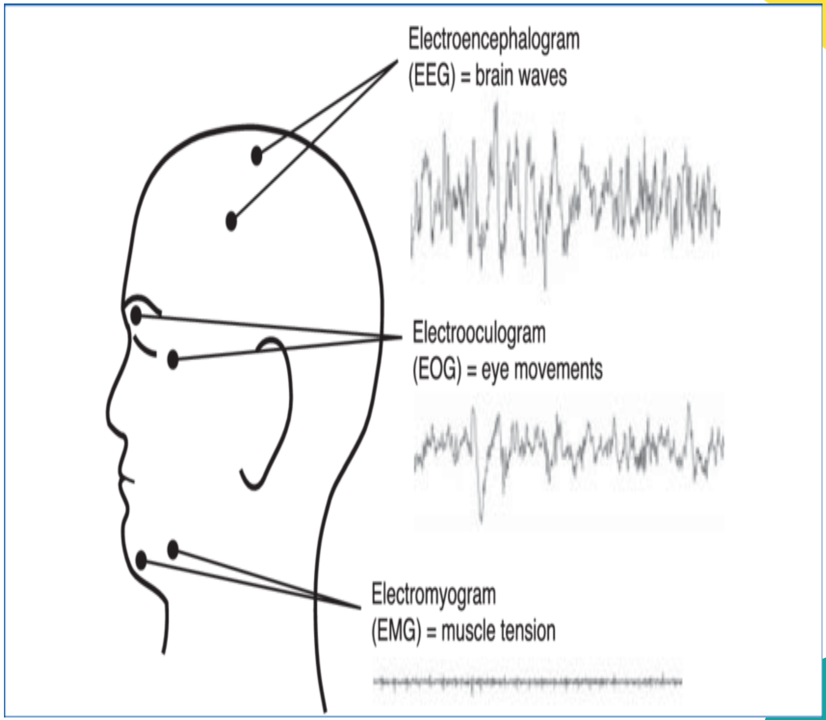
Unit IV : BIOSIGNALS AND THEIR CHARACTERISTICS

- Source of Bioelectric potential
- Resting and action potential
- Propagation of action potentials nerves
- Characteristics of biomedical signals
- The ECG-Cardiac electrophysiology
- Relation of ECG components to cardiac events
- Clinical applications

Characteristics of Biomedical Signals

Introduction

- Biomedical signals are recordings of physiological activities generated by the human body. They play a critical role in diagnosing, monitoring, and researching health conditions.
- Examples include **ECG** (Electrocardiogram), **EEG** (Electroencephalogram), **EMG** (Electromyogram), and **EOG** (Electrooculogram).
- These signals vary in origin, characteristics, and applications in healthcare.

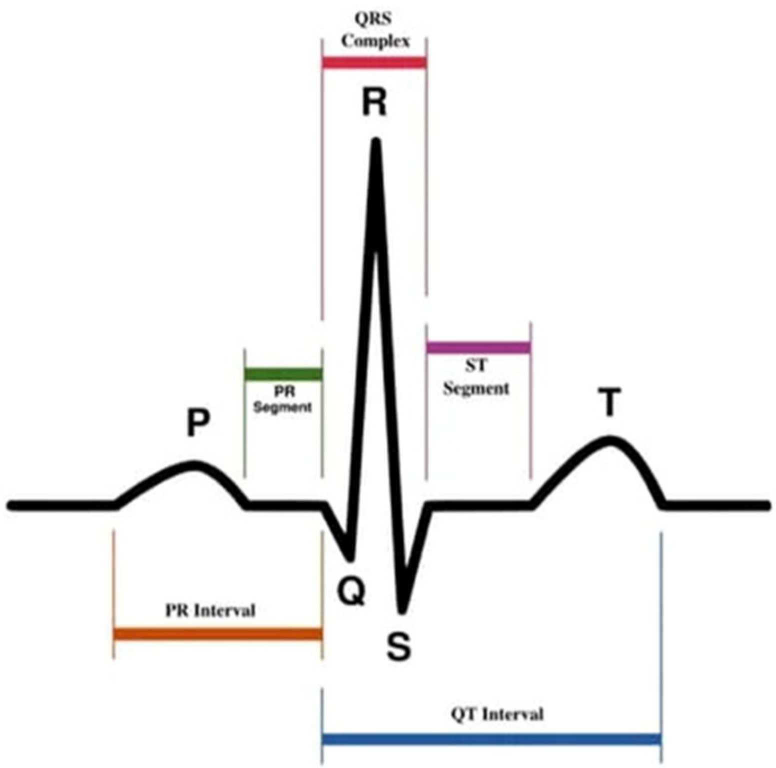


Types of Biomedical Signals

- **Bioelectric Signals**: Arise from electrical activities of cells, tissues, or organs (e.g., ECG, EEG, EMG).
- **Biomechanical Signals**: Result from movements or forces in the body (e.g., blood pressure, respiration).
- **Biochemical Signals**: Reflect chemical concentrations (e.g., glucose levels in blood).
- **Bio-optical Signals**: Generated by interactions of light with biological tissues (e.g., pulse oximetry).
- **Biomagnetic Signals**: Produced by magnetic fields from physiological activities (e.g., magnetoencephalography - MEG).

Amplitude

- The **amplitude** of a biomedical signal refers to its strength or magnitude, often measured in units like volts or millivolts.
- Different signals have specific amplitude ranges:
  - **ECG**: Typically 1–5 mV
  - **EEG**: Usually in the microvolt range (10–100 µV)
  - **EMG**: Variable, depending on muscle activity, can be from microvolts to millivolts.



Frequency Content

- Biomedical signals can vary widely in frequency, depending on their source and the physiological process involved.
  - **EEG**: Has frequency bands like alpha (8–13 Hz), beta (13–30 Hz), delta (0.5–4 Hz), etc., which correlate with brain activity levels.
  - **ECG**: Has a frequency range of about 0.05–150 Hz, covering heart rate and rhythm.
  - **EMG**: Has a frequency range of about 10–500 Hz, reflecting muscle activity.
- Frequency analysis is essential for interpreting biomedical signals and separating meaningful information from noise.

Signal Shape and Morphology

- The shape of a biomedical signal wave can provide insight into physiological health and function.
  - **ECG**: Has characteristic P-QRS-T waves, representing different phases of the cardiac cycle.
  - **EEG**: Exhibits various waveforms (e.g., spikes, sharp waves) associated with mental states and neurological disorders.
  - **EMG**: Irregular spikes representing muscle contractions.
- The morphology of these waveforms is used in diagnostic applications, such as identifying heart abnormalities or brain disorders.

Stationary vs. Non-Stationary Nature

- **Stationary Signals**: Remain constant in their statistical properties over time (e.g., steady-state evoked potentials).
- **Non-Stationary Signals**: Change over time, which is common in most biomedical signals (e.g., ECG, EEG) due to varying physiological conditions.
- Advanced signal processing techniques, like wavelet analysis, are often needed to analyze non-stationary biomedical signals effectively.

Signal Complexity and Nonlinearity

- Biomedical signals are typically **complex** and **nonlinear**, reflecting the intricate nature of physiological systems.
- Nonlinear dynamics and chaos theory are sometimes applied in analyzing biomedical signals to understand underlying physiological mechanisms better.

Noise and Artifacts

- Biomedical signals are often contaminated by **noise** and **artifacts**, which can obscure meaningful information.
  - **Common Noise Sources**:
    - **Powerline interference** (50 or 60 Hz) in ECG.
    - **Muscle activity artifacts** in EEG.
    - **Motion artifacts** in wearable sensor data.
  - Signal processing techniques (e.g., filtering, signal averaging) are applied to reduce noise for accurate interpretation.

Temporal and Spectral Properties

- Temporal properties relate to how a signal changes over time, important for dynamic processes like heart rate or brain activity.
- **Spectral properties** refer to the distribution of signal power across different frequency components, essential for identifying specific physiological states (e.g., alpha or beta waves in EEG).

Periodicity and Cyclic Patterns

- Some biomedical signals exhibit periodic or cyclic patterns, important in diagnosing and monitoring conditions.
  - **ECG**: Displays a repeating cycle with P, QRS, and T waves corresponding to heartbeats.
  - **Respiration signals**: Show a regular cycle of inhalation and exhalation.
- Detecting irregularities in these cycles is crucial for identifying arrhythmias in ECG or abnormal breathing patterns.

Signal Acquisition and Sampling

- Biomedical signals are often sampled at specific rates to accurately capture their characteristics.
  - **EEG**: Typically sampled at 256 Hz or higher.
  - **ECG**: Sampling rates around 500 Hz are used to capture the detail of cardiac waveforms.
- High sampling rates are necessary for capturing signals with higher frequencies, like EMG.

Clinical Significance of Biomedical Signals

- Biomedical signals provide invaluable data for diagnostics, monitoring, and treatment:
  - **ECG**: Diagnoses heart diseases, arrhythmias, and ischemia.
  - **EEG**: Assesses brain health, detecting epilepsy, sleep disorders, and brain activity levels.
  - **EMG**: Evaluates muscle function, detecting neuromuscular diseases and motor control issues.

Signal Processing Requirements

- Biomedical signals often require processing for interpretation:
  - **Filtering**: Removes noise (e.g., low-pass, high-pass filters).
  - **Feature extraction**: Identifies relevant patterns (e.g., R-peak detection in ECG).
  - **Spectral analysis**: Analyzes frequency components for patterns like EEG frequency bands.

Thank You!