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Postgraduate Certificate in Biomedical Signal Processing

# Biomedical Signal Acquisition and Preprocessing

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## Biomedical Signal Acquisition and Preprocessing

Biomedical signal processing involves the acquisition, analysis, and interpretation of physiological data to extract meaningful information for clinical diagnosis, monitoring, and treatment. In this postgraduate certificate course, we will focus on the key terms and vocabulary related to Biomedical Signal Acquisition and Preprocessing to provide you with a solid foundation in this field.

### 1. Biomedical Signal:

A biomedical signal is a measurable quantity that reflects the physiological processes within the human body. These signals can be electrical, mechanical, or chemical in nature and are typically acquired using sensors or electrodes. Examples of biomedical signals include Electrocardiogram (ECG), Electromyogram (EMG), Electroencephalogram (EEG), and Blood Pressure.

### 2. Signal Acquisition:

Signal acquisition is the process of capturing biomedical signals using specialized sensors or electrodes. This involves converting the analog signals from the body into digital form for further processing and analysis. The quality of signal acquisition plays a crucial role in the accuracy and reliability of the subsequent signal processing tasks.

### 3. Analog Signal:

An analog signal is a continuous representation of a biomedical signal in the form of a voltage or current waveform. Analog signals are susceptible to noise and interference, requiring careful signal conditioning and amplification before digitization.

### 4. Digital Signal:

A digital signal is a discrete representation of a biomedical signal in the form of binary numbers. Digital signals are more robust against noise and can be easily processed using digital signal processing techniques. Analog-to-digital conversion is essential for capturing and processing biomedical signals in digital form.

### 5. Sampling Rate:

The sampling rate refers to the number of samples taken per second to represent a continuous biomedical signal in digital form. It is measured in Hertz (Hz) and determines the frequency resolution of the digital signal. A higher sampling rate provides better signal fidelity but requires more storage and computational resources.

### 6. Nyquist Theorem:

The Nyquist theorem states that to accurately reconstruct a continuous signal from its samples, the sampling rate must be at least twice the maximum frequency component of the signal. This ensures that no

information is lost during the analog-to-digital conversion process and prevents aliasing artifacts in the digital signal.

#### 7. Signal Preprocessing:

Signal preprocessing involves applying various techniques to clean, enhance, and prepare biomedical signals for further analysis. This includes noise removal, baseline correction, filtering, artifact removal, and normalization to improve the quality and reliability of the signals.

#### 8. Noise:

Noise refers to unwanted interference or disturbances in biomedical signals that can obscure the underlying physiological information. Common sources of noise include electrical interference, motion artifacts, muscle activity, and environmental factors. Signal preprocessing techniques are used to reduce noise and improve signal quality.

#### 9. Filtering:

Filtering is a signal processing technique used to remove unwanted noise or frequency components from biomedical signals. Low-pass filters attenuate high-frequency noise, while high-pass filters suppress low-frequency artifacts. Band-pass filters selectively pass a specific range of frequencies, while notch filters eliminate narrowband interference.

#### 10. Baseline Correction:

Baseline correction is a preprocessing step that adjusts the signal baseline to zero or a reference level. This is essential for removing drifts or offsets in the signal caused by instrument noise, electrode polarization, or sensor calibration errors. Baseline correction ensures the accurate analysis of signal features and abnormalities.

#### 11. Artifact Removal:

Artifact removal is the process of identifying and eliminating non-physiological signals or artifacts from biomedical recordings. Common artifacts include electrode pops, motion artifacts, electrode drifts, and power line interference. Advanced signal processing algorithms such as Independent Component Analysis (ICA) and wavelet denoising are used for artifact removal.

#### 12. Feature Extraction:

Feature extraction involves extracting relevant characteristics or parameters from biomedical signals to quantify physiological phenomena or abnormalities. Features can include amplitude, frequency, time domain statistics, spectral content, entropy, and heart rate variability. Feature extraction facilitates signal classification, pattern recognition, and decision-making in clinical applications.

#### 13. Signal Normalization:

Signal normalization is a preprocessing technique used to scale or standardize biomedical signals to a common amplitude or range. Normalization ensures that signals from different subjects or recording devices are comparable and consistent for analysis. Common normalization methods include z-score normalization, min-max scaling, and percentile normalization.

#### 14. Challenges in Biomedical Signal Processing:

Biomedical signal processing poses several challenges due to the complexity and variability of physiological signals. Challenges include noise reduction in low-quality signals, artifact removal in contaminated recordings, feature selection for optimal classification, signal fusion from multiple sensors, real-time processing for clinical applications, and validation against ground truth data.

#### 15. Practical Applications:

Biomedical signal processing has diverse applications in healthcare, including disease diagnosis, patient monitoring, rehabilitation, and personalized medicine. Examples of practical applications include arrhythmia detection using ECG signals, seizure prediction from EEG recordings, muscle activity analysis with EMG signals, blood pressure monitoring, sleep staging, and brain-computer interfaces for assistive technology.

In this course, you will learn the fundamental principles and advanced techniques of Biomedical Signal Acquisition and Preprocessing to analyze and interpret complex physiological data for clinical insights and decision-making. By mastering the key terms and vocabulary discussed in this overview, you will be well-equipped to tackle the challenges and opportunities in biomedical signal processing and contribute to advancements in healthcare technology and patient care.