Bio-Signals: Conceptual Framework and Significance Processing

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Abstract- This paper illustrates the concept of bio-signals, identifying some of the most prevalent forms of bio-signals. Besides that, describing the prime features of this term in both time and frequency domains. In addition, identifying systematic processing approaches for the removal of mutual artifacts and noise.

Index Terms- Bio-signal, time-domain, frequency-domain and filters.

I. Introduction

The evolution of bio-signals technology has gained interest amongst biomedical engineering community. This technology has transformed the medical sector and moved it to advanced places among other sectors. Before starting to illustrate bio-signals, it is important to recognize the definition of signals. In fact, signals are defined as functions that transmit information about the manners or attributes of certain phenomenon. Admittedly, there are some terms that have been used recently which convey the same meaning of bio-signals such as biomedical signals, bioelectrical signals and physiological signals. Bio-signal is defined as any biological quantity or magnitude offering divergence in either time or space or in time or space together. In addition, it is potentially a signal that assorts information on the state of a biological system [1, 2]. Variations in time or space can provide different dimensions to bio-signals such as:

1- In-time: variation in time is often called 1-dimensional signal. A very well-known example of such signals is the electrocardiogram (ECG). The signal here represents the heart activity by measuring changes associated with heart muscle contractions according to time [2].

2- In-space: variations in space are often called 2-dimensional signals. An example of these bio-signals is functional magnetic resonance imaging (FMRI) where the bio-signals convey brain activity by measuring variations associated with blood flow [3].

3- In time and space: variations in time and space are always called 3-dimensional signals. An example of these 3D bio-signals are the signals associated with ultrasounds where it measures the dimensions and location of tissues and organs via measuring the reflection of sound waves [4].

Medical field implies a lot of examples that utilize bio-signals such as electroencephalogram (EEG), electroretinogram (ERG), electrooculogram (EOG), electroneurogram (ENG), electrogastrogram (EGG), phonocardiogram (PCG), photopletismogram (PPG), vibromyogram (VMG) and vibroarthrogram (VAG).

II. Time and Frequency Characterization of Bio-Signals

There are some types of bio-signals in time domain such as continuous-time domain, discrete-time domain and digital-time domain.

1- Continuous time domain: signals in this type appears as a function of time. Examples of this type of signals are a lot like measuring the heart rate with each pulse and measuring the temperature effortlessly [5]. Figure (1) below illustrates f(t) which represents continuous time domain signal.

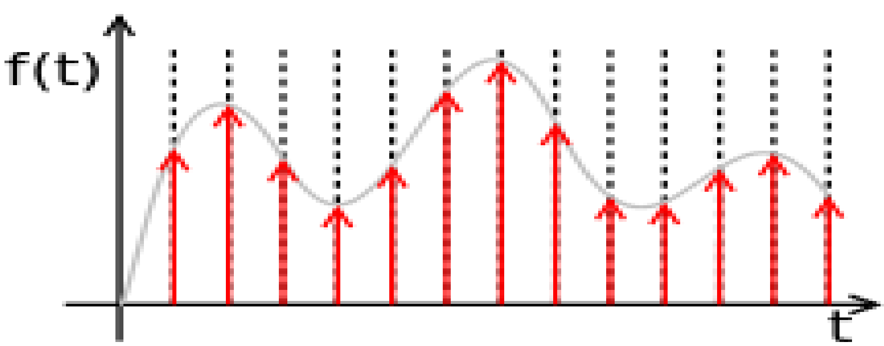

Fig (1): Continuous Time Domain

2- Discrete time domain: signals in this type look like a function of samples. An example of this type of bio-signals is measuring the glucose of a patient every hour. Figure (2) illustrates a discrete time signal.

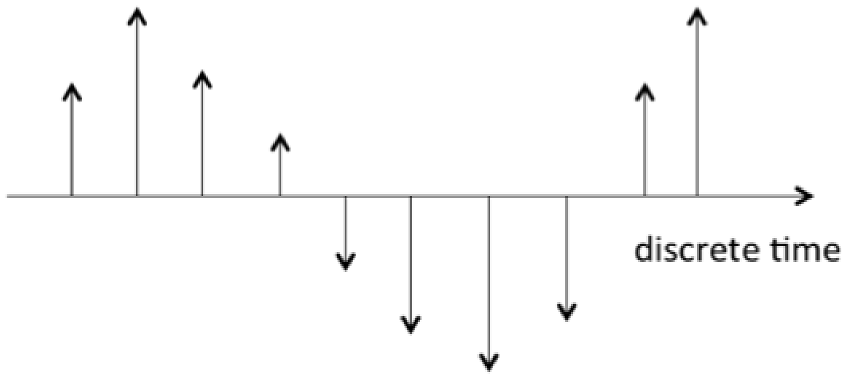

Fig (2): Discrete Time Domain

3- Digital domain: signals in this type combine a representation of signals in type 2 (i.e. discrete time domain) with values limited to quantized levels. An example of this type is measuring temperature hourly with a resolution of 1° C. Figure (3) below illustrates a digital signal

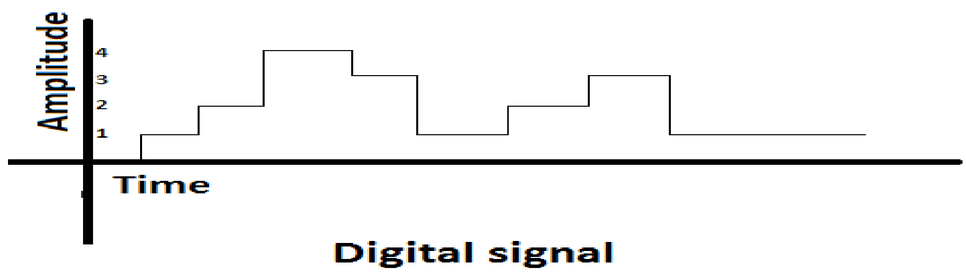

Fig (3): Digital Signal

Moreover, there are some features should be considered regarding bio-signals. The first characterization associated with bio-signals is the sampling rate. The sampling rate is defined as the frequency at which a continuous signal is sampled. The rate of this frequency in accordance with time is the sampling rate. Another characterization associated with bio-signals is the amplitude. However, amplitude is defined as the intensity of any biological phenomenon. The third characterization of bio-signals is the duration. In fact, signals are supposed to be available all the time of measurement, but researchers are considered often with samples of signals in certain duration [6].

Furthermore, periodicity is considered significant characterization of bio-signals. Indeed, periodic signals are signals that repeat itself every certain period like every minute or every hour. On the other hand, aperiodic signals are signals where the shape of the signals never repeats. Additionally, predictability is another characterization of bio-signals. This characterization has some important forms such as deterministic where the signal can be predicted within a forecast window. The signal can also be random where the values of the signal cannot be exactly estimated.

III. Bio-Signals Processing

Bio-signals are always having a lot of information which need to be extracted and recognized. Artifacts, noise and missing values can affect badly the information embedded in any signal. Hence, processing of bio-signals aims to extract clinically important information existed but hidden in the signal. Processing of bio-signals aspires to achieve clear and novel goals and achievements to advance the development of engineering sector in general and biomedical engineering specifically. Bio-signal processing tries to eliminate the bias of manual measurements to advance measurement's precision as well as reproducibility [7]. Bio-signal important is with great importance and this can be seen in its ability to extract variables and values to support illustrate and comprehend the information embedded in a signal. For the most part, processing tries to eliminate noise to moderate the technical insufficiencies of readings and measurements, and to distinct the desired physiological process from meddlesome processes. In fact, there are several methods to employ bio-signals processing such as

1- Filtering for removal of artifacts: there are some filters associated with time as well as frequency.

In time domain digital filter, it is important to mention that it has some forms of filters like

a- Offset filter: it can be seen in different applications such as eliminating offset introduced during acquisition.
b- Moving average filter: it is an important filter which can be used to eliminate high frequency noise with minimal loss of signal components in the pass band like ECG signal dirtied with EMG artifact.
c- Median filter: this filter picks the median value. It is considered very important in application where there are some outliers. It can be used in regular power source which may lead to ripples riding on top of the signal.
d- Detrending filter: this filter can help to shift low-frequency artifacts which may lead to improper amplitudes like filtering of breathing noise during detecting of ECG signal [8].

In frequency domain digital filter, it has some filters like

a- Butterworth filter: this filter is considered simple, monotonically decreasing magnitude response. An application of this filter is using it to eliminate high-frequency noise with minimal loss of signal components in the pass band such ECG signal contaminated with EMG noise.
b- Notch filter: this filter can be used to eliminate power-line interference in ECG signal.

2- Event detection: an event is often referred to a part of the signal where the researcher is usually interested in. This part of interest is called an epoch. Hence, event detection filters are normally used to identify and recognize epochs. Some applications of event detections are Envelop Estimation, Wave Delineation, Peak Detection and Cross- Correlation.

3- Compression: This filter aims to reduce the amount of data in a given signal and this is done to lower resource usage. There are some significant techniques that considered a significant example of this type of filters such as sampling and quantization. The signal that processed using this filter may acquire some advantages like

a- Less capacity
b- Less bandwidth
c- Faster processing

But the signal may suffer from losing some information which may be considered for one researcher as important information while others may consider it as not important [9].

IV. Conclusions

With the developments of approaches in medical fields such as using remote sensors, remote monitoring of brain waves and heart rates of patients, the importance and significance of acquiring signals that have a lot of information with less noise become a necessity. Therefore, bio-signals is considered one of the most important sectors in biomedical engineering as it obtains, transmits and conveys information with all its contents and eliminate noise.

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