International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 3, Issue 9, pp 23-27, September - 2019

Design of IoT Based Robotic Arm for Health Care

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***Abstract* - In biomedical engineering field, designs of the robots challenges have greater mobility and flexibility. Much kind of robots have been developed for people to keep free from loneliness, to take care of health conditions and monitoring heath issues. But in healthcare applications, lot of robots is involved for surgery, care taking robots, Motion robots, and medication robots. All these robots are designed and programmed for various applications. In a step ahead some robotic features are added for some pathological cases also to compensate for original feature. Our physiological signals also can be used for motion actions related to our day to day activities. Among the signals, Electromyography (EMG) and EEG signals are related to the movement and thought activities. EMG signals are the muscle related signals for movement actions. Various research papers are related to the analysis of EMG signals in paralysis condition, arthritis and amputees. But still lot of challenges exists in the motion analysis through EMG signals. Motivated by all these issues, this paper is focused on the design of a robotic arm for amputees based on a DSP processor TMS320C5X and the actions are all transferred to the physician to know their condition. This simple, painless arm and gives better relief to the amputees.**

Keywords: IoT, Robotic, Arm, Health Care, EMG, EEG.

1. INTRODUCTION

Various types of electrical signals are produced from different organs which are a physical variable and denoted as biomedical signal. These signals are generally notated as meaning of time. In general, it is represented in its amplitude, frequency and phase. Muscle movements are recorded by means of an activity called as Electromyography. During the contraction of the muscle, the surface electrodes are used to acquire the signals from the muscles and the graph is plotted. These signals are the EMG signals. In the new era, most of the people are with challenging issues like amputees, paralysis, neurological disorders etc., In the world population, among the 1 billion population 15% are disabled. So in our global market, Assistive technologies play a major rule. To improve the life of the physically challenged as well as to make them comfortable, World Health Organization (WHO) has projected a lot of policy. EMG signal analyses are done with various powerful detection techniques and processing method as its analysis plays a major role in biomedical field. Rehabilitation engineering is a booming field with lot of research challenges and scope. Motor Unit Action Potentials (MUAPs) in EMG signals details the actions of the muscles and act as features for the identification of neuromuscular turmoil. Before boosting of the EMG signal, the basic range of the signal if from 0-10mv sometimes in microvolt range also. Due to the motion action, there are some noises present in the EMG signal. The various noises present in the EMG signals are inherent noise, ambient noise, Motion artefact and Inherent instability of signal [1].

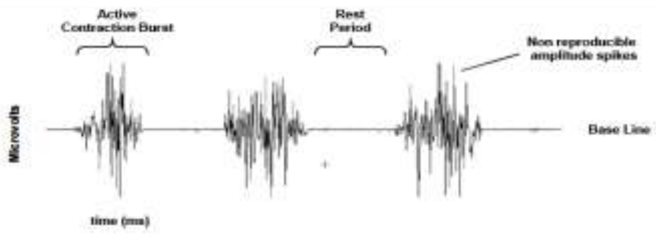

Figure 1: A raw EMG Signal

The organization of the papers is as follows: Section I involves the introduction to the robotic research and details of EMG signals. Section II deals with various literature reviews of the papers related with Prosthetic and EMG signals. Section III explains the proposed methodology based on the gap in the prosthetic research. Section IV discusses the results of the proposed methodology as well as its accuracy. Section V concludes the work with its advantages and positive results.

II. LITERATURE SURVEY

Only a few papers explain the EMG signal processing in the robotic research challenges. Those papers are reviewed in this literature review.

In paper [2], the authors explained the basic process involved in the signal acquisition, processing and classification. Higher Order Statistical methods are used for the analysis of the EMG signals and all sequences are validated in the time series. The EMG signal temperament and their analysis shows its involvement in the applications such as artificial arm control, grab detection, and computer interaction. Also the paper deals with artificial neural network

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(ANN) for classification purposes. In paper [3], the author point out the extraction of EMG signals from anterior and posterior forearm for controlling the prosthetic arm. The motion is based on the mobility of the wrist hand. Surface electrodes are used for the EMG signal acquisition and based on the set threshold the movements are analyzed. Linear Discriminant Analysis (LDA) is executed for higher classification rate. The authors in paper [4], explained the comparative results of EMG signals in Healthy and neuropathic subjects. Based on the study, the authors proposed a prosthetic device for the persons with neuropathic disability. The comparative study involves RMS and ARV values for both the cases to compare the EMG signals.

In paper [5], the authors discuss the various EMG signal analyzing techniques. As the analysis and interpretation is complex in this EMG signals, decomposition methods, transform methods are explained in this paper in detail. The filtering methods are explained in detail. In paper [6], the authors presented a method for denoising of EMG signals also the enhancements of EMG signals are featured out. For amplification of the EMG signals Instrumentation amplifier is used and the EMG signals are enhanced in their voltage range. Multiple active filters with Sullen Kelly architecture is proposed to remove the noise present in EMG signals. In the upward and downward movement, amplification is done and filtering process is done. In paper [7], review of various muscular disorders based on the EMG signals is carried out. The feature selection method for various types of disorders and their analysis is narrated.

The above literature survey only finds its scope in analysis, but not come up with the solution to the amputees for their regaining muscle strength. So based on the above challenges, the main contributions of our paper are:

1. Acquisition of EMG signals from Forearm using surface electrodes.
2. Design of a motors and servo based arm & processor to provide commands for moving and picking.
3. The motion details are connected to the cloud computing server to provide information to the physicians.

III. PROPOSED METHODOLOGY

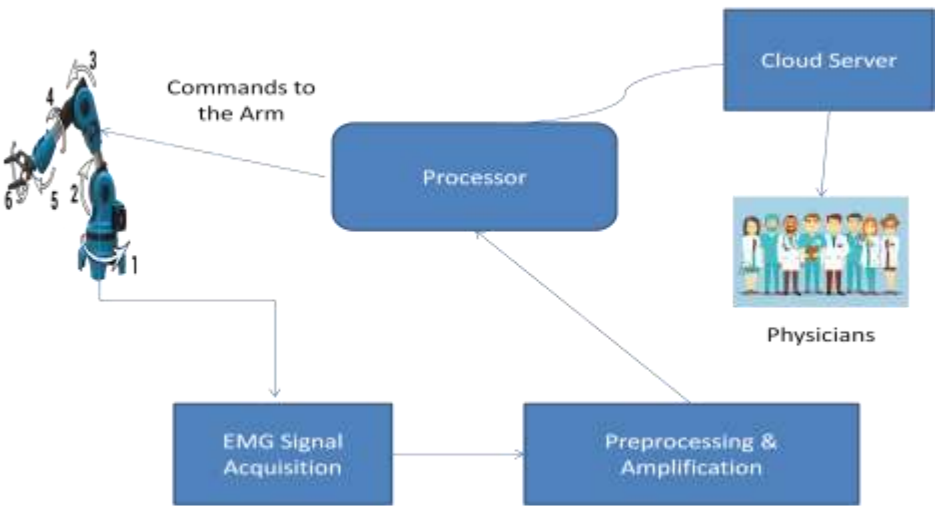

Figure 2: Proposed Method

The major process involved is split in to two phases: Phase I and Phase II, where Phase I involves EMG signal acquisition, preprocessing and amplification, Processor execution for commanding the Arms. In phase II, the information about the arm movements is given to the remote physician through Cloud server.

a) EMG signal Preprocessing & Amplification

EMG signals are acquired through the Surface electrodes. During the acquisition, some environmental noises are present in the EMG signal. So an active low pass filter is used to remove the higher frequency noises. Since the acquired signal is of minimal low level voltage in the ranges of micro volt, an instrumentation amplifier with a gain of 20 is used to boost the signal voltage level. The original signal and the pre-processed signal are shown in figure 3.

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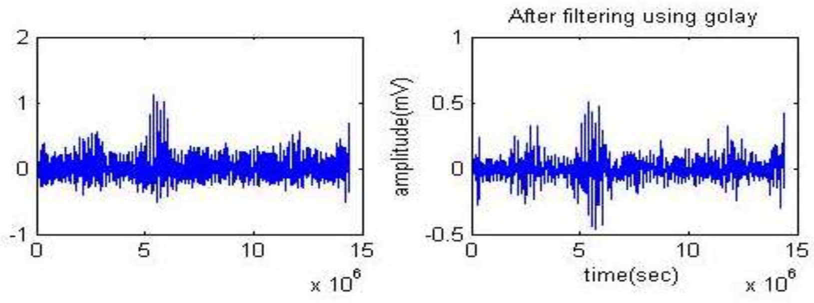

Figure 3: Input EMG Signal, preprocessed and amplified signal

After the amplification process, the signal is processed for upward and downward movement of the arm in terms of its Root Mean square value, mean value, Length of the EMG signals in terms of segments, null crossings for particular frequency range and Mean Absolute Value (MAV) calculated from the acquired EMG signal.

b) Root mean Square

The root mean square value for upward and downward movement is classified and given as command to the arm for motion. It is denoted as a subset of frequency feature. It is defined as the square root of the mean square of the segment.

$$RMS=\sqrt{\frac{1}{N}\sum_{K=1}^{N} f_k^{2}} \qquad (1)$$

Where,

f_k is the surface EMG signal in each segment, and
N is the number of samples

c) Mean

Mean is defined as the average of all the magnitude of the surface EMG signals.

d) Length of the EMG Signals

It is defined as the sum of the all the EMG signals in the segments with respect to the number of samples.

e) Null crossings

This parameter is defined with respect to the frequency range. It is represented as how many amplitude EMG signals cross the Zero for a particular frequency range.

f) Mean Absolute Value (MAV)

This parameter is defined with respect to the amplitude levels, which is represented by mean absolute value of the segment. The formula for MAV is [8, 9].

$$MAV=\frac{1}{N}\sum_{K=1}^{N-1}|f_k| \qquad (2)$$

After the estimation these features and classification of the movement, the movement condition is also transferred to the cloud server to inform the working condition of the arms to the physicians.

IV. RESULTS AND DISCUSSION

The upward and downward arm movements of RMS values are tabulated in the table1. From the table 1, it is shown that for the RMS value from to range, the arm are moved in the upper direction and for the RMS value from to range, the arm are moved in the downward direction.

TABLE 1
RMS values and their respective arm movement

RMS Value	Movement
0.0645	Upward
0.0765	Upward
0.6793	Upward
0.0012	Downward
0.0056	Downward
0.0093	Downward

TABLE 2
Mean values and their respective arm movement

Mean	Movement
100.6	Upward
98.5	Upward
121	Upward
43	Downward
21.4	Downward
23.2	Downward

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TABLE 3
Length of the signal and their respective arm movement

Length of the signal	Movement
23	Upward
23	Upward
21	Upward
31	Downward
32	Downward
34	Downward

TABLE 4
Null Crossings and their respective arm movement

Null Crossings	Movement
40	Upward
44	Upward
50	Upward
22	Downward
20	Downward
21	Downward

TABLE 5
Mean Absolute Value (MAV) and their respective arm movement

MAV	Movement
82.4	Upward
98.6	Upward
94.3	Upward
67	Downward
42.5	Downward
43.6	Downward

From the table 2, it is understood that, mean values are very higher during the upward movement when compared with the downward movement as the amplitude of the signal is higher for the upward movements. From the table 3, it is clear that the length of the signal is higher for the downward movement as it is a slow varying signal during slow movements. So, the length is lesser for upward movements. From the Table 4, it is proved that null crossings are more, that is higher variations are noticed during the upward movement and lower variation during the downward movements. From the table 5, it is understood that the MAV value is greater from high amplitude signals and lower for low amplitude signals. Based on these conditions the working status and condition is also sent to the physician.

V. CONCLUSION

Even though a lot of research is ahead in medical health and robots, still now a exact solution to the prosthetics is a great challenge. So our paper is focused on robot design based on Internet of Things. A challenged people are always needed to be monitored as well as they should be taken care. The parameters needed for describing the movements such as length, RMS value, MAV, mean and null crossings are estimated for the subjects. So the paper is focused on the moving arm for amputees. Also the conditions are sent to the physicians.

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Citation of this Article:

S.M.Seeni Mohamed Aliar Maraikkayar, R.Tamilselvi, M.Parisa Beham, M.Bharkavi Sandhiya, A.Sabah Afroze, "Design of IoT Based Robotic Arm for Health Care" Published in *International Research Journal of Innovations in Engineering and Technology (IRJIET)*, Volume 3, Issue 9, pp 23-27, September 2019.

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