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Overview on Literature Survey towards EMG Interpretations Technique in Addition to Several Interdisciplinary Work Related to EMG Interpretations

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Abstract— This paper presents the overview on literature survey towards the EMG Signal interpretation techniques. The electromyogram is the summation of the motor unit action potentials occurring during contraction measured at a given electrode location. Several investigations assist the relationship between human's muscles activity and generation of electricity. Electromyography is measuring the electrical signal associated with the activation of the muscle. This may be voluntary or involuntary muscle contraction. The EMG activity of voluntary muscle contractions is related to tension. The functional unit of the muscle contraction is a motor unit, which is comprised of a single alpha motor neuron and all the fibers it enervates. The goal of this paper is the brief literature survey and parametric study of EMG signal & this phenomenon has been explained in the form of EMG interpretation technique. The idea emanated from the innovative and creative articles and objects of different scientists & research work.

Index Terms— Central Nervous System (CNS), EMG, Integral of the absolute Value(IAV), Motor Unit Action Potential (MUAP), Myoelectricsignal (MES), Prosthesis,

1 Introduction

Electromyography (EMG) is a unique technique for specifying muscle activation. The area of EMG interpretation and pattern reorganization of bio signals have gained the fast popularity during past few years. This kind of research presents a smooth path to interface with the neuromuscular handicapped people with external world. Human body gener-ates myoelectric signals and by using this signal the powered external device can be controlled. This process is referred to as myoelectric control (MEC).[1]EMG signal is one of the important bio signals which is generated by human body, confirms the muscles activity or summation of various motor units action potentials.[2]Electromyography (EMG) sig-nals have the properties of non-stationary, nonlinear, complexity, and large variation. The Mio Electric Signal (MES) is a complicated signal controlled by the central nervous system (CNS). It is affected by anatomical and physiological properties of muscles of human body, the control scheme of the peripheral nervous system, and the characteristics of the Instrumentation is used to detect and measure this signal.

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2 EMG Signal Generation in Human Body-Informative Study

Biomedical signal is a collective electrical signal, acquired from any parts of our body that represents a physical varia-ble of interest. EMG signal is normally a function of time and it is describable in terms of the parameters amplitude, frequency and phase. Electromyography signal also measures electrical currents generated in muscles during its neuro-muscular activities. The nervous system always controls the muscle activity (contraction/relaxation). So the EMG signal is a complicated signal that is controlled by central nervous system and is dependent on the anatomical and physiological properties of muscles. EMG is acquired from electrodes and mounted directly on the skin, the signal is the combination of all the muscle fiber action potentials which are random in nature. At any one moment, the EMG signal may be either positive or negative. Individual muscle fiber action potentials are sometimes acquired using wire or needle electrodes placed directly in the muscle. The signal is picked up by the electrode and amplified. Typically, a differential amplifier is used as a first stage amplifier. Additional amplification stages may follow. Before being displayed on the screen, the signal can be further processed to eliminate low frequency or high frequency noise. But the user is interested in the amplitude of the signal. The signal is frequently rectified and averaged in some format to obtain the EMG amplitude. The EMG is applied to the study of skeletal muscle. The skeletal muscle tissue is attached to the bone and its contraction is respon-sible for supporting and moving

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the skeleton. The contraction of skeletal muscle is initiated by impulses in the neurons to the muscle. EMG signal is the train of Motor Unit Action Potential (MUAP), which shows the muscle response. The EMG signal appears random in nature and is generally modeled as a filtered impulse process.

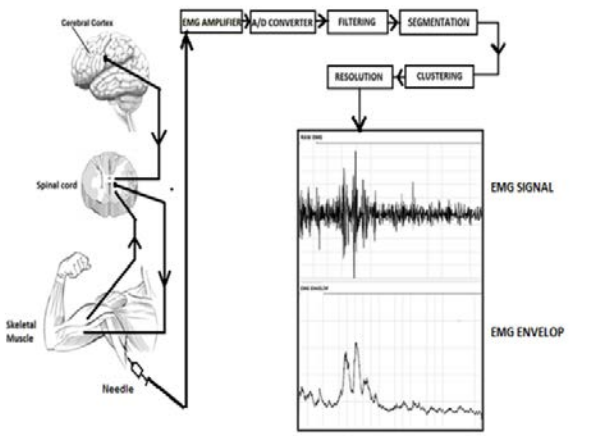

Fig. 1. Generation of EMG in human body

A simple model equation of the EMG signal is

$$x(n)= \sum_{r=0}^{N-1} h(r)e(n-r) + w(n)$$

here x(n), modeled EMG signal, e(n), point processed, represents the firing impulse, h(r), represents the MUAP, w(n), zero mean addictive white Gaussian noise and N is the number of motor unit firings.[3]

3 Parametric Study of EMG Signal

EMG signal is the measurement of electrical current that is generated by the muscle fibers during their contractions period which represents the neuromuscular activities. This signal is complicated and non-stationary which is controlled by nervous system because the nervous system is always responsible for muscle activity. The amplitude of EMG signal is very small (50µv to 1mv) with frequencies varying from 10Hz to 3000Hz [1].EMG Signal analysis is based in differ-ent slandered parameters. There are three types of parameters

a) Amplitude related parameters
b) Frequency related parameters
c) Time related parameters

These parameters are measured from rectified EMG Signal, which is obtained after the conversion of raw EMG Signal. Amplitude related parameters are EMG peak, mean, integrated EMG, rms value of EMG; frequency related parameters are mean frequency, median frequency, total power spectrum and time related parameters are onset time, offset time.

4 Brief Literature Survey towards EMG Signal Interpretations

EMG signal interpretation is a growing and modern research domain today. Lot of research works have been carried out by different scientists in this domain from the previous decade. Some of the biomedical engineering labs in our country also have shown their interests in this research domains and started work. Still ergonomics has not been carried out on this research field. The brief literature survey towards EMG signal related to interdisciplinary work and signal interpretation techniques are characterized below.

Documentation of experiments were beginning with discovering the generation of electricity from specialized muscle of electric eel by FranescoRedi's initiative research proposal in 1666. In research field, a new chapter was released with his noble work. Different scientists, research workers proposed and demonstrated various innovative and creative articles and objects with an influence of Redi's work. In 1890, Marey introduced the term 'electromyography' and its activity behind actual reading. In the short review consideration it proceed to conclude that though the actual idea originated from Redi's work but the term EMG was introduced by Marey. A new era became started with the visualization of electrical signals from muscles by oscilloscope in 1922 by Gasser and Erlanger. Though improvement of science and technology more new little inventions regarding electromyography signal was done, but the important work began in 1960 with clinical usage of surface EMG. Hardyck and his research group were the first practitioners to use of Surface EMG. J.G. Kreifeldt of Tufs University was represented a method to identify the signal-to-noise ratio characteristics of surface detected electromyography for amplify, rectify activities [5]. A common method of initially processing surface-detected electromographic (EMG) activity was to differentially amplify, rectify, and then smooth (using a low-pass filter) the rectified activity .The SNR depends, at least, upon the contraction level, type of smoothing filter, and the amount of smoothing for the particular filter. This defined SNR is important in signal communication problems of both a design and a theoretical nature. In 1975, D. Graupe et al. mentioned an approach to overcome the recognition prob-lems using autoregressive-moving-average parameters and the kalman filter parameters of the EMG time series apply-ing on prosthesis control purpose [6]. It was shown that the resulting identified parameters yield sufficient information to discriminate between a small numbers of upper extremity functions. After that proposed work, the characteristics of surface EMG signals from different stepping of human locomotive activities were represented by Cecil Hershler and M.Milner [7]. Emphasizing consistency and repeatability of acquired data, it was presented the characteristics of sur-face EMG signals from m. vastus lateralis and m. rectus femoris during several steps of level walking under controlled repeatable gait conditions at three different speeds for several subjects. The statistical analysis and the pattern classifi-cation of electromyographic signals from the biceps and triceps of a paralyzed person generated by discrete lower arm movements. The contribution of this work was to enlighten the controlling purpose of prosthetic or amputee arm with minimal mental effort [8].The idea of prosthesis using surface EMG gradually began from the year 1975. The ap-proach of an extended work of Graupe and Cline, Peter C. Doerschuk et al. designed a system using digital signal pro-cessing techniques for generating control signals for a multifunction lower arm prosthesis using surface electromyogra-phy [9]. Although the main idea originated from Graupe and Cline's work but this

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little review concludes that a signal analysis technique is developed for discriminating a set of lower arm and wrist functions using surface EMG signals. Data were obtained from four electrodes placed around the proximal forearm. The functions analyzed included wrist flexion/extension, wrist abduction/adduction, and forearm pronation/supination. Experimental results on-normal sub-jects are presented which demonstrate the advantages of using the spatial and time correlation of the signals. This technique should be useful in generating control signals for prosthetic devices. Eric Hultman et al. implemented a tech-nique for recording sEMG simultaneously with electrical stimulation of human skeleton muscle [10]. R.M. Studer and his research group was represented an algorithm for optimal adaptation of the signal of matched filter bank using the detection of the motor unit action potential waveforms by electromyogram. In clinical diagnosis and therapy, its con-tribution was very high [11]. Swiss researcher Andreas Gerber et al. created a new framework incorporated in computer program using for quantitative EMG analysis [12].In this review context it can be concluded that modification and alteration are going on. In International Acoustics, Speech, and Signal Processing Conference, 1986, Zhou Yitong pre-sented a method for intramuscular electromyographic signals from the surface EMG signals using EMG waveforms. In this method he demonstrated the intramuscular signal from the surface signal which is more important for the future researchers. [13]. OmryPaiss and G.F. Inbar investigated on the ability of the autoregressive model of surface EMG to describe the process spectrum [14]. In 1986, D.A. Winter and H.J. Yack designed the EMG patterns for 16 muscles in-volved in human walking and the variability of patterns were also measured by them. They also implemented the pat-terns in several mechanical tasks of each muscle [15].This review section concludes that pattern recognition concept of several mussles in our body originated from this innovative idea. The technique of spatial filtering offered a new flexi-bility in measuring of selective EMG measurement configurations. HaraldReucher observed the performance of the configurations using two dimensional spatial filters and compared the modeling results with experimental ones [16]. G. Hefftner et al. mentioned the application of functional neuromuscular stimulation to the muscles by movement and analyzed the control system by investigating the electromyographic signals processing [17]. In 1989, D.Graupe et al. described the usage of electromyographic signatures for controlling the electrical simulation in upper motor neuron par-aplegics to enable them to walk with the help of a walker. Here it was also shown that the above lesion EMG control and the below lesion EMG control serve complementary and the crucial roles in FES, regard less of above lesion EMG control [18].Gradually several methods of EMG Control originated from the year 1989. A fast, simple EMG burst waveform recognition algorithm had been developed by G. Dwyer with interpreting the signal to yield the position, du-ration and strength of individual EMG bursts [19].The idea of various algorithm originated to analyze the EMG sig-nal.After this algorithm, the EMG pattern was analysed to provide upper-motor-neuron paraplegics with patient-responsive control of FES (functional electrical stimulation) for the purpose of walker-supported walking [20]. In An-nual International Conference of the IEEE Engineering in the field of Medicine and Biology Society, 1989; M.Z. Ker-mani proposed a heuristic rule based strategy for the interpretation of motion patterns in an electromyogram (EMG)-controlled upper extremity prosthesis [21]. Akira Hiraiwa et al. proposed the analysis and classification of electromyo-graphic signal pattern of prosthetic members by neural networks [22]. In IEEE conference, M. Bodruzzaman demon-strated a set of intramuscular electromyographic signals that were collected from various patients' ramp muscle con-traction. The signals were tested for the chaotic behaviour using spectral analysis and Poincare map techniques [23]. On the same year, in another conference K. Ito discussed an EMG controlled prosthetic forearm with three degrees of freedom using small size ultrasonic motors [24]. This review discussion concludes that EMG Controlled prosthesis ap-proach started to explore.A sensitivity function was defined in the journal entitled "Boundary element analysis of the directional sensitivity of the concentric EMG electrode". The preferential direction of sensitivity, blind spots, phase changes, rate of attenuation, and range of pick-up radius can be derived from that function [25]. In 1994, Z.M Nikolic described an electronic circuit for analog processing of neural (electroneurogram or ENG) and muscular (electromyo-gram or EMG) signals in functional electrical stimulation (FES) systems [26].Temporal whitening of individual surface electromyograph (EMG) waveforms and spatial combination of multiple recording sites were separately been demon-strated by Edward A. Clancy to improve the performance of EMG amplitude estimation [27]. The graphical simulator using prosthesis was introduced where the idea of artificial intelligence and fuzzy logic used.A graphical simulator using prosthesis was controlled by electromyogram (EMG) processing, discussed by E. Zahedi and H.Farahani. The integral of the absolute value (IAV) of the biceps and triceps of EMGs were used here and also a fuzzy k-means scheme was used to classify the motion before actuating a 3-degrees-of-freedom arm graphically on a computer monitor [28].A variety of EMG features had been evaluated by M. Zardoshti-Kermanifor for the control of myoelectric upper extremi-ty prostheses [29]. E.W. Abel et al. incorporated the neural network analysis and classification of the EMG signal inter-ference pattern comparing with healthy people with myopathic and neuropathic disordered patients [30].Neural net-work analysis was also incorporated for comparative study of healthy people and dis ordered people. Three types of discrimination methods were used for comparison. Identification of motions of the neck and shoulders using the elec-tromyographic (EMG) signal using three discrimination methods, the Euclidean distance measure (EDM), the weighted distance measure (WDM) method and the modified maximum likelihood method (MMLM), were used to compare the conventional autoregressive (AR) and cepstral coefficients with closely positioned (C-type) and separately located (S-type) electrode arrangements in 1996 [31]. Gwo-Ching Chang and his group developed real-time electromyogram (EMG) discrimination system to provide control commands for man-machine interface applications [32]. The contro-versial areas regarding the use of the EMG was discussed by Gary Karmen and Graham E. Caldwell in 1996 [33]. From 1996 the most innovative and interesting idea of providing commands for man

machine interface application intro-duced. An adaptive human-robot interface using a statistical neural network that consists of a forearm controller and an upper arm controller and the driving speed or grip force were controlled by EMG signal processing was discussed in a workshop on Robot and Human Communication [34]. In 1998, the concept of a human-robot interface was devel-oped and demonstrated by O. Fukura in IEEE international conference on robotics and automation [35]. An EMG sig-nal recognition method to identify the motion commands for controlling the prosthetic arm based on artificial intelli-gence with multiple parameters were discussed by Sang-Hui Park and Seok-Pil Lee [36]. The prosthetic arm control mechanism and adaptation had been done with suitable real time learning methods using the electromyographic sig-nals by varying the motion of object [37, 38]. Hae-Jeong Park and his research groups discussed about a communica-tion method used for severely disabled person. They developed a portable system that comprises EMG amplifier, A/D conversion, text-to-speech module, remote control module and serial communication to the host system [39]. EMG signals consist of a superposition of delayed finite-duration waveforms that carry the information about the firing of different muscle fibre groups. The new approach of that EMG Interpretation technique was represented by R. Gut in 2000 [40].From this research analysis the concept of the parametric study of EMG Signal and analysis were obtained. Dario Farina had been described and compared among several algorithms used for estimating the values of amplitude, frequency, conduction velocity of the surface electromyographic signal during voluntary contractions [41]. Different controlling methods of movement of prosthetic arms were proposed. The prosthetic hand was driven based on EMG pattern discrimination using neural network and the feedback error learning scheme was incorporated with it [42, 43]. Neuro-fuzzy technology was used to classify the electromyography signal control using wavelet transformation to train the controller and modified the learning mechanism [44, 45]. The power assist control for walking aid based on EMG and impedance adjustment with HAL-3 had been described by S. Lee and Y. Sankai in an International Conference in 2002. They derived the virtual tongue from EMG that was adopted in a control method and also motion assist control for operator's intention had been realized by this method [46]. D.Zennaro presented a method to decompose multi-channel long-term intramuscular electromyogram (EMG) signals in 2003 [47]. H. Manabe proposed a technique for improving the recognition accuracy of EMG-based speech recognition by applying existing speech recognition technol-ogies in his journal titled "Multi-stream HMM for EMG-based speech recognition" [48]. Most of the models for surface electromyography signal generation were based on the space invariance of the system in the direction of source propa-gation. But L. Mesin and D. Farina proposed a model that was not space invariant and the surface signal was detected along the direction of the muscle fibres, which may significantly change shape along the propagation path [49]. In IEEE international conference Zhao Jingdong presented a five-fingered underactuated prosthetic hand controlled by surface electromyographic (EMG) signals. The control part of prosthetic hand was based on neural network learning techniques and the parametic autoregressive model [50]. It was mentioned that the prosthetic hand control part is based on an EMG motion pattern classifier which combines Levenberg-Marquardt (LM) or variable learning rate (VLR) based neural network with parametric autoregressive (AR) model and wavelet transform.This motion pattern classifier can successfully identify flexion and extension of the thumb, the index finger and the middle finger ,where the experimental results show that the classifier has a great potential application to the control of bionic man-machine sys-tems because of its fast learning speed, high recognition capability. Jun-Uk Chu and his research group developed an efficient feature- projection method that utilized a linear discriminant analysis for EMG pattern recognition [51].The main goal of this research study was to develop an efficient feature projection method for EMG pattern recognition. To this end, a linear supervised feature projection is proposed that utilizes a linear discriminant analysis (LDA). In the paper titled Signal processing of the surface electromyogram to gain insight into neuromuscular physiology, an overview of important advances in the development and applications of sEMG signal processing methods, including spectral estimation, higher order statistics and spatio-temporal processing were discussed [52].This section concludes that these methods provide information about muscle activation dynamics and muscle fatigue, as well as characteristics and control of single motor units (conduction velocity, firing rate, ampli-tude distribution and synchronization). Geoffrey L. Sheean described the Application of time-varying analysis to diag-nose needle electromyography using motor unit action potential analysis and interference pattern analysis [53].Gradually the most innovative topic related time-varying analysis to diagnose needle electromyography using mo-tor unit action potential analysis and interference pattern analysis were obtained. Improvement with science and tech-nology the signal processing with electromyogram has become very much advanced. Though recognizing human hand grasp movements through surface electromyogram (sEMG) is a challenging task, Gaoxiang Ouyang investigated non-linear measures by four different hand movements based on recurrence plot using a tool in surface electromyogram [54]. In this paper, it was investigated the nonlinear measures based on recurrence plot, as a tool to evaluate the hidden dynamical characteristics of sEMG during four different hand movements. A series of experimental tests in this study show that the dynamical characteristics of sEMG data with recurrence quantification analysis (RQA) can distinguish different hand grasp movements. Recently in 2014, G.M. Paul investigated about a wearable approach to facial elec-tromyography and electrooculography. The effect of a wearable approach on pressure variations and motion artefact was examined by electromyography & Anjana Goen described the Classification of EMG Signals for Assessment of Neuromuscular Disorders [55] [58]

5 Conclusion

EMG Signals in raw and processed form are used for the assessment of muscular activities.EMG signal also carries valuable information regarding the nerve system.EMG is the study of muscle function through analysis of electrical signals emanated during muscle contraction. The aim of this paper was to give the brief idea about some literature survey of EMG Signal interpretation and several works related to it. This paper also presented the concept of EMG Signal genera-tion and a brief parametric study. This overview is not supposed to be the complete survey on this topic, but a contin-uous and sincere effort has been made to cover all the works related to the field of EMG Signal interpretations as much as possible. However, it gives a good overview and when augmented with other readings and material the reader should be able to utilize electromyography as a tool in their research.

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