General Perspectives on Electromyography Signal Features and Classifiers Used for Control of Human Arm Prosthetics

Faruk Ortes
Istanbul University, Turkey

Derya Karabulut
Halic University, Turkey

Yunus Ziya Arslan
Istanbul University, Turkey

INTRODUCTION

Physically handicapped people encounter various kinds of obstacles and difficulties in their daily lives due to the restricted ability of motion. Assistive technologies represent a crucial challenge of scientific studies to overcome such an issue of reducing quality of live. Assistive devices such as wheelchairs, orthoses and prostheses are designed and built to contribute rehabilitation progress and to regain lost functions, as well. Although human body parts have intricate forms and functions, artificial devices and components integrating to the body are anticipated to compensate the fundamental functions related to user's demands. Upper or lower arm amputations also result in severe cosmetic matters. However, what is more important and obtrusive is the loss of primary functions including manipulating and grasping the objects besides the locomotor tasks which are performed by human body during daily activity.

BACKGROUND

Development of human arm prosthetics, which are improved to regain lost functions of amputated limbs, encounters critical and challenging problems to carry out various dexterous tasks. To date, many of revolutionizing design of human arm prosthetics including Boston Arm (Mann & Reimers, 1970), Deka Arm (Resnik, 2010), Otto Bock trans carpal hand (Otto Bock Health Care, Minneapolis, MN), and Shanghai Kesheng Hands (Shanghai Kesheng Prosthese Corporation Ltd.) have been developed. Intuitive and precise control of such prostheses is still one of the main interests of scientific studies. The main deduction from researches could be stated as control of the prosthetics is a particular concern of understanding the nature of the electrical activations of muscles. Imitation of the fundamental patterns of human arm motion depends highly upon the transformation of the neuromuscular activities of residual limbs to a specific control signal for controlling the artificial arm. In this respect, myoelectric signals provide a base of intuitive control, unlike the conventional or direct control. The dexterous control of such myoelectric-based prostheses requires a clear extraction of features from recorded surface electromyography (SEMG) signals and pattern recognition to discriminate the motion and force intentions of the prosthetics users. The progress of feature extraction from SEMG signals has an extensive coverage of myoelectric controlled prostheses studies due to the features in both time and frequency domains have the great potential on representing clear and meaningful information

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of EMG signals. Additionally, the feature classifiers have been given a special scientific interest by researchers. Selection and developing of the case-specific classifiers, which are desired to have the optimal performance to specify motion classes, still continue to be the main goal of current studies. Although, various types of classifiers such as linear discriminant analysis (LDA), support vector machine (SVM), artificial neural networks (ANN) and fuzzy logic (FL) techniques have been utilized to classify human arm motion patterns, merits, shortcomings and pitfalls of the classifiers are still required to be discussed extensively.

FUNDAMENTAL ASPECTS OF EMG

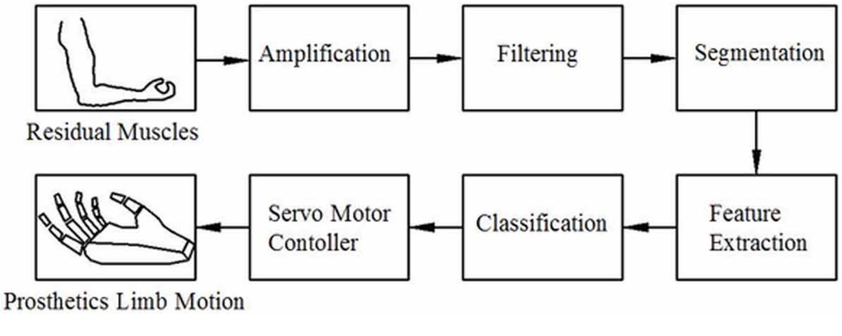
EMG is the electrical activity of skeletal muscles (Basmajian & Deluca, 1985). It represents the summation of the muscle action potentials which cause the contraction of muscle fibers. Recorded EMG data by means of electrodes are amplified and filtered to eliminate the motion artifacts, as well as the environment and device related noises. Rejection of ambient influences on natural muscle activation improves the accuracy and usability of EMG signals. One of the most widely usage of EMG signals is to control the myoelectric-based prosthetics which are used by amputated people. Control scheme for EMG-driven human arm prosthetics includes a sequential series of signal processing (Figure 1).

A condensed and clear control signal is needed to control the EMG-based prosthetics. In order to reduce calculation and to provide stability of signal, EMG data are scanned by sliding segmented windows (Figure 2). Because the raw (amplified+ pre-processed) EMG signal contains a huge burden of data, this signal is needed to be represented in a concise, but accurate ways. Widely used time domain features extracted from signals includes mean absolute value (MAV), root mean square (RMS), Willison amplitude (WAMP), waveform length (WL), variance of EMG (VAR), simple square integral (SSI), zero crossing (ZC) and integrated EMG (IEMG) (Phinyomark et al., 2013). In frequency domain, mean frequency, median frequency, peak frequency, mean power, total power, and spectral power features are commonly preferred (Phinyomark et al., 2013).

EMG SIGNAL FEATURES

Obtained EMG signals during contraction of a muscle or muscle groups are needed to be quantified in order to relate these signals with some certain sets of movement types (Zecca, Micera, Carrozza, & Dario, 2002). Mathematical expression of EMG signals could be defined using feature extraction approach. An EMG signal could be expressed in two domains including time and frequency domains.

Figure 1. Control scheme of multifunctional human arm prosthetics



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