A Review on EMG Signal Classification and Applications

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***Abstract*—Electromyography (EMG) signals are muscles signals that enable the identification of human movements without the need of complex human kinematics calculations. Researchers prefer EMG signals as input signals to control prosthetic arms and exoskeleton robots. However, the proper algorithm to classify human movements from raw EMG signals has been an interesting and challenging topic to researchers. Various studies have been carried out to produce EMG-based human movement classification that gives high accuracy and high reliability. In this paper, the methods used in EMG signal acquisition and processing are reviewed. The different types of feature extraction techniques preferred by researchers are also discussed, including some combination and comparison of feature extraction techniques. This paper also reviews the different types of classifiers favored by researchers to recognize human movements based on EMG signals. The current applications of EMG signals are also reviewed.**

***Index Terms*—classification, electromyography, feature extraction, human movement**

I. Introduction

When muscles are contracted, electrical currents are generated. These currents are known as Electromyography (EMG) signals. The evaluation of EMG signals allows analysis of neuromuscular activities, without the need of complex human kinematics calculations. Hence, EMG signals are widely used by researchers to study human motions or to analyse muscular disorders.

Over the years, EMG-based human movements classification had become an interesting and challenging topic to researchers. EMG signals can be collected from muscles via electrodes. There are two ways to acquire EMG signals from human muscles: (i) needle electrodes where EMG signals are acquired invasively and (ii) surface electrodes where EMG signals are acquired non-invasively. The non-invasive way is more preferred by researchers. The invasive way requires advice and guidance from professionals, and could be painful and uncomfortable since the needle needs to be inserted into the muscle [1]. A report regarding recommendations on surface EMG signals acquisition with the title "Surface EMG for Non-Invasive Assessment of Muscles (SENIAM)" is published and widely used by researchers [2]. The report provides recommendations regarding the type, shape, size, materials of electrodes, and also skin preparation, inter-electrode distance and the placement of electrodes.

EMG signals are weak and contaminated with noises. Noises are present in the signals even during the acquisition stage. Examples of noises that pollute the EMG signals are ambient noise, inherent noise, motion artifact and inherent instability [3]. The presence of noises affects the analysis of the EMG signals, and will have an impact on the accuracy in the classification of human movements. Proper signal amplification, processing and filtering are required before further analysis of the EMG signals can be carried out for pattern classification. Therefore, a lot of research studies has been carried out on topics regarding EMG signal processing, filtering and analysis that can lead to high accuracy in human movement classifications.

The focus of this paper will be on the reviewing of the different kinds of methodologies regarding EMG signal acquisition, processing, feature extracting and classification that are preferred by researchers over the past years. Besides, a review regarding the current applications of EMG signals is also discussed.

II. EMG Signal Acquisition

The placement of electrodes during EMG signals acquisition is an interesting topic. Two common types of electrode placement techniques are observed in research studies: dense sampling approach and precise anatomical positioning approach. For dense sampling approach, no specific muscle location is pointed out. Instead, electrodes are equivalently placed around the limb. For precise anatomical positioning approach, electrodes are positioned precisely at the main activity spot of those chosen muscles. The muscles are usually selected based on the movements of interest in which the research study aims to classify.

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