Chapter 40
Development of a Surface EMG-Based Control System for Controlling Assistive Devices:
A Study on Robotic Vehicle

Uvanesh K.
National Institute of Technology, India

Suraj Kumar Nayak
National Institute of Technology, India

Biswajeet Champaty
National Institute of Technology, India

Goutam Thakur
Manipal Institute of Technology, India

Biswajit Mohapatra
Vesaj Patel Hospital, India

D. N. Tibarewala
Jadavpur University, India

Kunal Pal
National Institute of Technology, India

ABSTRACT

The current study discusses about the development of an EMG based wireless control system for the patients suffering from high-level motor disability. Surface EMG (sEMG) signals were processed in the time domain and using discrete wavelet transforms (DWT). The statistical features of the signals (sEMG, envelope of the squared sEMG and wavelet processed sEMG) were determined and analyzed. The analysis of the features suggested that the features of the envelope of the squared sEMG signals were sufficient to be used for high-efficiency classification and control signal generation. A hall-effect sensor based switching mechanism was introduced for controlling the duration of the activation of the device. The control signals were wirelessly transmitted to the assistive device (robotic vehicle). The training and the subsequent use of the developed control system were easy.

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INTRODUCTION

Biosignals may be defined as the electric potentials associated with the physiological functioning of the tissues and the organs (Sanei & Chambers, 2013). The biosignals are time-variant signals and can be described using signal amplitude, frequency and phase, like any other electronic signals (Semmlow & Griffel, 2014). Unlike the electronic signals, whose existence is due to the flow of electrons, the biosignals are associated with the flow of ions (sodium, potassium and chloride). Hence, the potential associated with the biosignals are ionic in nature. The generation of the biosignals is due to flow of ions across the cell membrane and hence, results in the electrochemical activity. Some of the common biosignals include electrocardiogram (ECG), electroencephalogram (EEG), electrooculogram (EOG) and electromyogram (EMG).

Recent years have seen a rise in the development of biosignal controlled assistive devices/aids. This has been made possible due to the advancements in the technology related to the biosignal acquisition and transmission. The use of biosignals for controlling the functions of the assistive devices has opened up a new research area, which is regarded as “Body-Computer Interface” (BCI) or “Human-Machine Interface” (HMI). This field of study uses the residual signals of the incapacitated persons for controlling the machines (assistive devices). Such devices have been reported to improve the quality of the life of the incapacitated persons and drastically reduce their dependence on the caretakers. Amongst the various biosignals, the use of EEG, EOG and EMG has received much attention for devising HMI control systems (Allison et al., 2012; Rafael Barea, Luciano Boquete, Manuel Mazo, & Elena López, 2002a; Chen & Newman, 2004; Moon, Lee, Chu, & Mun, 2005; Tanaka, Matsunaga, & Wang, 2005). As per the reported literature, the use of EMG and EOG biosignals are comparatively easier for devising HMI control systems as compared to the EEG biosignal. This is due to the fact that the processed EMG and EOG biosignals represent themselves with definite patterns.

The EEG biosignals are acquired by placing the measuring electrodes over the scalp. The frequency of the EEG biosignal range is normally in between 0.1 Hz and 100 Hz (Lim & Hong, 2009). The generation of the EEG biosignals is due to the neuronal activity within the cerebral cortex region of the brain. Unfortunately, the signals perceived by the electrodes are due to the neuronal activity of a number of neurons beneath the electrode and not due to the activity of a single neuron. Hence, the analysis of the EEG signals is quite complicated. Another problem associated with the measurement of the EEG biosignals is the placement of the electrodes due to the presence hair. This increases the chances of incorporation of the artifacts. Even though the EEG signal can be acquired in a non-invasive manner, due to the above reasons the use of EEG signal based human-computer interface (HCI) system is not preferably used for the development of control system for the assistive devices (Ferreira et al., 2008; Ferreira, Silva, Celeste, Bastos Filho, & Sarcinelli Filho, 2007). But with the advent of advancements in the rehabilitative technology front, many researchers are trying to develop human-machine interface (HMI) systems for the neuromuscular incapacitated patients using EEG signals (Raya et al., 2015; Sellers, Ryan, & Hauser, 2014).

The generation of the EOG biosignals is due to the natural existence of corneo-retinal potential difference. The potential difference is usually in the range of 0.05 mV and 3.5 mV (Dey, Biswas, Das, Das, & Chaudhuri, 2012). The corneal tissue is relatively positive in nature as compared to the retinal tissue. This results in the formation of a dipole. The movement of the eyes in different directions consequently results in the movement of the dipole in different directions. The EOG signals are acquired by placing 2 electrodes vertically (orbital positions: below and above the orbit) and 2 electrodes horizontally (canthus