Chapter 14
Design and Development of EMG Conditioning System and Hand Gesture Recognition Based on Principal Component Analysis Feature Reduction Technique

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ABSTRACT
This chapter discusses design and development of a surface Electromyogram (EMG) signal detection and conditioning system along with the issues of gratuitous spurious signals such as power line interference, artifacts, etc., which make signals plausible. In order to construe the recognition of hand gestures from EMG signals, Time Domain (TD) and well as Autoregressive (AR) coefficients features are extracted. The extracted features are diminished using the Principal Component Analysis (PCA) to alleviate the burden of the classifier. A four-channel continuous EMG signal conditioning system is developed and EMG signals are acquired from 10 able-bodied subjects to classify the 6 unique movements of hand and wrist. The reduced statistical TD and AR features are used to classify the signal patterns through k Nearest Neighbour (kNN) as well as Neural Network (NN) classifier. Further, EMG signals acquired from a transradial amputee using 8-channel systems for the 6 amenable motions are also classified. Statistical Analysis of Variance (ANOVA) results on classification performance of able-bodied subject divulge that the performance TD-PCA features are more significant than the AR-PCA features. Further, no significant difference in the performance of NN classifier and kNN classifier is construed with TD reduced features. Since the average classification error of kNN classifier with TD features is found to be less, kNN classifier is implemented in off-line using the TMS2407eZdsp digital signal controller to study the actuation of three low-power DC drives in the identification of intended motion with an able-bodied subject.

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INTRODUCTION

Analysis of muscular activity such as force developed for a specific movement, evaluation of fatigue, type of movement etc., can be divulged from Electromyogram (EMG) signals. EMG signals are electrical signals that are generated in all living beings, in particular human beings and are obtained from body movement through the contraction and relaxation of skeletal muscles. These EMG signals are utilized for exploratory or diagnostic purposes when the technology is inchoate. However, with the advancement of technology, EMG signals have found to be of paramount importance in different fields of applications such as rehabilitation medicine, ergonomics, sports and space medicine and neurophysiology. In order to divulge the information effectively from EMG signals in different fields of application, it is necessary to detect and condition the EMG signals for further processing. EMG signals are generated during contraction of muscles and can be detected either invasively or non invasively. Detection of EMG signals by inserting the electrodes in the muscles are known as intramuscular EMG. Surface EMG (sEMG) signals are obtained by fixing electrode over the skin surface. The sEMG is widely used method in research as it is simple and non-invasive. However, the procurement of the EMG signal acquisition system is still a problem especially in electrophysiological research which involves EMG. Due to the advancement in technology, it is possible to fabricate portable EMG signal conditioning system at an affordable cost. One of the problems with the recording of physiological signals is various sources of noises. The noises include both high frequency and low frequency components. In addition, the powerline noise from the EMG system has been the focus of researchers for some time. Further, proper grounding and electrical shielding are suggested by the researchers to rectify the power line interference problem. The low frequency noises are generated due to electrode polarization and electrode cable artifacts.

This EMG signal normally comprises two states i.e., (i) A transient state emanating from a burst of fibers (ii) A steady state during constantly maintained contractions in the muscle. Hudgins, Parker, and Scott, (1993) were the first to consider the information content in a transient signal that comes with the onset of a contraction. The main weakness in using a transient state in EMG control is that contractions should be initiated from rest and precludes switching from class to class in an effective or intuitive manner. Englehart, Hudgins, and Parker (2003) have shown that steady state data is classified more accurately than transient state. Hargrove, Losier, Englehart, and Hudgins (2007) have shown real-time performance of a clinically-supported classifier with transient and steady state is always better than that of either transient or steady state alone. The process of identifying the intended limb motion from stored digitized EMG data consists of three stages: feature extraction, feature reduction and classification. Several techniques such as time domain (TD) statistical features (Hudgins, Parker, & Scott, 1993), auto regressions (AR) coefficients (Huang, Liu, Liu, & Wong, 2003), frequency domain techniques (Yazama, Mitsukura, Fukumi, & Akamatsu, 2003), time-scale techniques (Englehart, Hudgins, & Parker, 2001; Chu, Moon, & Mun, 2005), spectral components (Du & Vuskovic, 2004) etc. have so far been utilized for feature extraction. These extracted features are used in a classifier, such as, artificial neural network (NN) (Hudgins, Parker, & Scott, 1993), fuzzy logic (Ajiboye & Weir, 2005), Neuro-fuzzy (Kiguchi, Iwami, Yasuda, Watanabe, & Fukuda, 2003), kNN (Geethanjali, Ray & Shanmuganathan, 2009), state vector machine (Naik, Kumar, & Jayadeva, 2010) etc. to classify the intention hidden in the EMG.

One of the intricacies in the development of EMG controlled prosthetic hand is the classification of copious amount of features. The classification of larger number of features will