Investigation of thigh muscles for events/phases detection using surface electromyography

Introduction: One of the most physically and mentally devastating events that can occur to a person is limb loss. There are more than 32 million amputees all around the world in which 75% accounts for lower limb amputees [1]. The use of prostheses after amputation is one of the major interventions to improve amputees' quality of life. There are different types of prostheses with different control strategies. However, majority of these control strategies lack direct control by users. To be able to control the lower limb prostheses intuitively, use of electromyographic signal (EMG) has been proposed. EMG is one of the major sources of biological signals in neural control of prostheses. This signal can be detected from the muscles of lower extremities using surface EMG electrodes during any activities of daily livings. The human gait is cyclic in nature which consists of different phases and sub-phases. The two phases of the gait cycle are stance and swing. The main events occurring during stance phase are called heel strike (HS) and toe off (TO). The aim of this study is to detect the phases/events occurring in the walking of the healthy subjects using a simple rule based algorithm. **Methodology:** one healthy subject took part in this experiment. EMG signals from seven thigh muscles (sartorius, rectus femoris, vastus lateralis, biceps femoris long head, tensor fascia latae, semitendinosus and semimembranosus) were recorded during level ground walking. The data was sampled at 1500 Hz and a band pass filter (a zero-lag Butterworth filter with a cut off frequency of 20-500 Hz) was used to remove motion artefacts and high frequency noise from the signals. In addition, linear envelope of the signals was obtained performing full wave rectification followed by a zero lag 4^{th} order butterworth low pass filter with cut of frequency of 3 Hz. In order to detect the stance phase, thresholding algorithm based on force plate data was utilised for the instrumented leg. The segmented data was normalised to the maximum peak of each muscle. An algorithm was designed to detect the HS and TO of the normalised linear envelope stance phase. The HS was detected within 0% to 10% of the stance phase by searching for the first peak value. After detection of HS, the algorithm searches for the next peak within 85% to 100% of stance phase to detect TO. **Results:** The results showed high accuracy in detection of the HS (~95%) and TO (~90%) from anterior muscles of thigh during level ground walking. **Conclusion:** Detection of HS and TO from EMG signals of anterior thigh muscles was successful using the proposed algorithm. Future work will include detection of events with more number of participants as well as amputees when performing different locomotive modes.

[1]. Zhang et al. 2012