

CLASSIFICATION OF HUMAN GAIT FROM THE TIME-DOMAIN DESCRIPTORS OF SURFACE EMG SIGNALS

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ABSTRACT

Technological advancements in the design of powered above-knee prostheses could achieve an optimal performance when they are combined with an efficient gait phase detection algorithm. The identification and classification of gait phases play a vital role in the precise movement control of prostheses. In this study, an attempt was made to develop a classification model based on signatures obtained from gait phases during level walking using surface electromyogram (sEMG) signals. For this purpose, sEMG signals from quadriceps and hamstrings, which have a higher order of innervation ratio, were considered. In the study, four muscles were considered for the analysis: rectus femoris (RF), vastus lateralis (VL) from the quadriceps, biceps femoris (BF), and semitendinosus (SEM) from the hamstrings. Simultaneous sEMG was recorded from four muscles to provide signatures at knee flexion/extension for achieving time synchronization of the gait events. The data for the study was collected from a group of 5 healthy volunteers with a total of 350 gait cycles. The EMG signals were subjected to segmentation and labeled into two distinct gait phases, namely, stance and swing. Four prominent time domain descriptors, mean absolute value (MAV), slope sign change (SSC), waveform length (WL), and zero crossing (ZC), were considered for training the random forest. Test results showed that the order of values with respect to ZC and SSC was found to be higher in the stance phase than the swing phase. The accuracy of the model was found to be higher for the SSC feature. Further, the random forest achieved an accuracy of 98.57%, F1-score of 98.55% and MCC of 97.18% in classifying the stance and swing phases. It appears that the proposed model could be useful for the movement control of powered above-knee prostheses.

Keywords: Prosthesis, gait cycle, SSC, random forest, stance, swing

INTRODUCTION

Walking is an integral part of daily routine for human life. Walking, a seemingly simple task for most people, becomes a daunting challenge for certain groups, especially those who have undergone lower-limb amputation [1]. Technological advancements in prosthesis design are aimed at enhancing functionality by incorporating innovative mechanisms and robust motors [2-4]. However, a prosthesis can achieve an optimal performance when they are combined with an efficient gait phase detection algorithm. Gait detection was utilized to obtain the necessary parameters in order to effectively manage and control the torque of the motor. Therefore, including a precise gait detection strategy within the prosthesis can elevate the performance of the control system [5-6]. Typically, gait portioning models consist of two primary phases, namely stance and swing [7-9]; however, some studies include three or more phases [10-12].

In previous studies, a range of wearable sensors, such as inertial measurement units (IMUs) [13-15], gyroscopes [16-18] and accelerometers [19-21] were employed to detect different phases of human gait. These sensors have proven to be effective tools in accurately identifying and distinguishing among various gait phases. Nevertheless, when it comes to evaluating abnormal gait