Heuristic Real-Time Detection of Temporal Gait Events for Lower Limb Amputees

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Abstract

This paper presents a complete system and algorithm to estimate temporal gait events during stance and inner-stance phases using a single inertial measurement unit (IMU) in real-time. Validation of the proposed system was carried out by placing the foot-switches (FSW) directly underneath the foot. The performance of the system was assessed with eleven control subjects (CS), one unilateral transfemoral amputee (TFA), and one unilateral transtibial amputee (TEA), while performing level ground walk and ramp activities. The experimental results showed reasonable agreement in timing differences of all the gait events in both groups when compared against the reference system. However, high data latency was observed for TFA in the case of Foot-Flat Start (FFS) and Heel Off (HO). The slight variation in the positioning of IMU on the shank and the foot-switches underneath the foot and the difference in the kinematics of CS and lower limb amputees are probable reasons for large variations in the time difference. Overall, the detection accuracy was found to be 100% for Initial Contact, FFS, and Toe-Off, and 98.3% for HO. In addition, a high correlation was observed between estimated stance phase duration (SPD) from IMU and the SPD from FSW data. The proposed system showed high accuracy in the detection of temporal gait events which could potentially be employed in the gait analysis applications and the finite-state control of lower limb prostheses/orthoses.

Keywords

Author Keywords: Gait events; lower limb amputees; gyroscope; accelerometer; real-time
KeyWords Plus: PHASE DETECTION; AMBULATORY SYSTEM; WALKING SPEED; ALGORITHM; GYROSCOPE

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