Stride-to-stride gait variability in daily life measured using accelerometers attached to the wrist

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Introduction

A stride-to-stride gait variability is an important predictor for various neurological and age-related diseases [1], [2]. Stride-to-stride variation is generally estimated from the gait cycle time measured at each gait cycle. Foot-worn sensors provide an accurate estimation of gait cycle time, however, the sensors may be removed multiple times a day. An ideal sensor location for activity monitoring is the wrist. Although today's wrist fitness trackers are used for step counting they are not able to provide gait variability. In this study we propose a new method to detect locomotion and accurately estimate stride-to-stride variability using a wrist sensor.

Methods

Acceleration of the left wrist was recorded with Physilog® (GaitUp, CH) at 20Hz for 25 healthy persons during daily activity including walking and break periods. Locomotion was detected at one second intervals using the acceleration norm of the six previous seconds as input. It was detected using a Hidden Markov Model with Viterbi decoder and a Naïve Bayesian Classifier based on the signal energy and a maximum likelihood harmonics estimator adapted from [3]. During locomotion, walking cadence was estimated using the same harmonics estimator used for locomotion detection. Stride-to-stride variability was defined as the coefficient of variation of the estimated walking cadence over a 60 seconds period of regular, flat walking. Physilog® fixed to the feet were used as reference [4].

Results

27.7 hours of data were analyzed (23.0 hours locomotion). The activity detector showed a sensitivity and specificity of 98.46% and 95.66%, respectively. Accuracy (precision) of the cadence estimate and stride-to-stride variability was 0.01 (0.15) steps/seconds and 0.06 (0.32) %, respectively.

Discussion

The algorithm was able to accurately detect the locomotion periods and to provide a valid cadence estimate. The cadence variability obtained in this study successfully estimated the stride-to-stride variability obtained with the reference system. The algorithm can be used for real-time monitoring of locomotion with wrist sensors and provides instantaneous cadence and gait variability.

References

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