Instantaneous walking speed estimation for daily life activity monitoring based on wrist acceleration

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Introduction

Walking is the main activity of daily life, and there is a great interest to characterize this activity by instantaneous walking speed and travelled distance per day. An ideal way to monitor daily activity is using accelerometer on the wrist like a watch. However, for estimating the walking speed, accelerations cannot simply be integrated because of sensor drift and arm movement artifact. Moreover, counting the total number of steps and multiplying it by a subject dependent coefficient is not practical as it requires a subject specific calibration and does not provide an instantaneous estimate of walking speed. In this study we train a linear regression model to obtain a calibration free estimate of the instantaneous walking speed based on the movement of the wrist.

Methods

Left wrist acceleration data has been recorded at 20Hz for 25 healthy persons (20-65 years, 155 – 192cm, 7 women) walking outdoors over 4.7km (e.g. level, inclined, different speeds, holding objects). A miniature global navigation satellite system was fixed to the head to provide the ground truth for instantaneous walking speed. Acceleration data was segmented into 6 second windows and walking cadence was extracted using a maximum likelihood estimator [1]. A linear model was then used to map walking cadence, acceleration norm and standard deviation, and the person's height to instantaneous walking speed. The algorithm was validated with the leave-one-out cross validation procedure.

Results

Accuracy and precision of instantaneous walking speed were 0.02 and 0.26 km/h, respectively. Relative accuracy and precision were 1.27% and 5.36%, respectively.

Discussion

The proposed linear regression model was able to estimate the instantaneous walking speed accurately and precisely for all walking types. The presented method does not require any user calibration and can be easily adapted for real-time application for an on-chip estimation of instantaneous walking speed in daily life.

References

[1] B. Doval and X. Rodet, "Fundamental frequency estimation and tracking using maximum likelihood harmonic matching and HMMs," in *IEEE International Conference on Acoustics Speech and Signal Processing*, 1993, pp. 221–224.