WEARABLE SENSOR NODES FOR AUTOMATIC DETECTION OF HIKE EVENTS AND PARAMETERS: A PILOT STUDY

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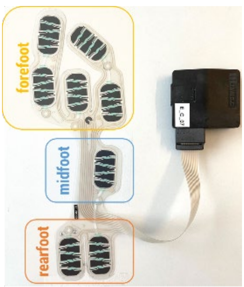
Human walking and running is mostly studied with optical motion capture systems. These systems are expensive and require specialized laboratories. In contrast, wearable sensors allow both field testing and longer/continuous acquisitions. Moreover, different sensor principles and nodes can be used to form, for example, a body-attached sensor network (BASN). The aim of this pilot study was to use a BASN to analyze a hiking trip of a test person in order to automatically detect hiking events and determine quantitative hiking parameters by means of an algorithm.

The BASN used for this purpose consisted of two self-developed wearable sensor nodes connected to two instrumented pressure insoles (Fig. 1a). The sensor nodes represent a newer version of the system already presented in 2016 [1]. Although the revised system has significantly less computing power, the data of external (e.g. insoles) and internal sensors (e.g. accelerometer, gyroscope, magnetometer), can be measured with sufficient accuracy thanks to the highly adapted hardware. Specifically, for example, the voltage divider used in combination with the ADC was replaced by a timing system to measure the resistance of the insole sensors. With such a system, the time to charge a capacitor is measured rather than the current-induced voltage drop. This results in exceptionally low power consumption, enabling all-day data acquisition, and a very flexible system in terms of resolution/sampling frequency ratio.



(a) (b)

Fig. 1: Measurement system, (a) sensor node and pressure insole, (b) subject wearing the test equipment, the pressure sensors are located below the shoe insole.

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One male subject (age 37 years, height 1.80 m, body weight 71 kg) participated in the study. The study was in accordance with the Declaration of Helsinki. The subject was asked to take a 7.5 km hike with the BASN. The hiking shoes were equipped with the pressure insoles and the sensor nodes (Fig. 1b).

Data analysis and signal processing were performed using MATLAB (R2020b, The MathWorks, Inc., Natick, MA, USA). The data sampled at 100 Hz from each pressure sensor were converted to pressure signals. These signals were summed to pressure totals for each leg side separately to automatically detect the hiking events. Based on these data, the state levels of a two-level rectangular waveform were estimated. These levels were used as input variables to obtain the transition metrics of the two-level waveform. The foot contacts (FC) and foot offs (FO) were determined as the linearly interpolated times at which the signal crossed the calculated lower reference with positive and negative polarity, respectively.

After automatic detection of the hiking events, the individual gait cycles were normalized and then the mean values and standard deviations were calculated. By assigning each sensor to the forefoot, midfoot, or rearfoot, the plantar pressures of each foot segment could be determined separately (Fig. 2a/b). The hiking parameters, i.e. stance phase, swing phase, stride time and cadence, were calculated from the hiking event data (Fig. 2c).

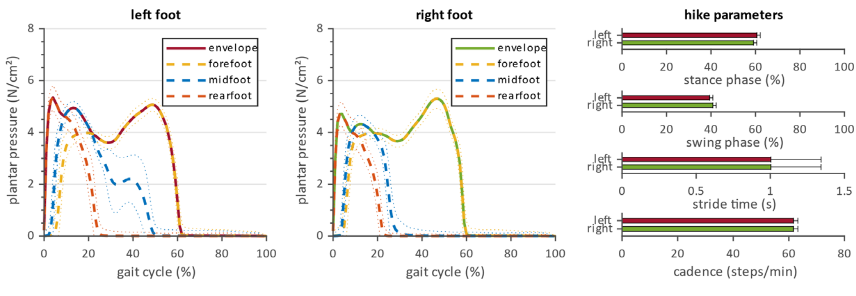

Fig. 2: Plantar pressures for normalized gait cycles (n = 4180) and hiking parameters of the subject during a hike with an average speed of 6.2 km/h, (a) envelope, mean, and standard deviation of plantar pressure separately by foot segments for the left foot and (b) the right foot, (c) mean and standard deviation of the hiking parameters for the left and right foot.

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