Extraction of Gait Features by Using Seismographs

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Introduction

Gait is a health parameter for the function of the locomotor and neurological system. An impairment can often result in a reduction of quality of life and a decline in independency [1]. Mostly, gait is measured by accelerometers placed at key locations on the body (for example feet, knee joints, lumbar region). Another method, often used in a clinical setting, are plates or mats, where gait is analyzed on a small, selected trace by ground reaction forces. However, there is a lack of methods that can cover larger areas and do not need the use of body-attached sensors. One promising alternative is the assessment of gait by seismographs, which does not require direct patient contact and is not restricted to a designated area.

Therefore, the aim of this work was the development of algorithms to detect gait parameters assessed by seismographs.

Materials and Methods

The used data was provided by a pre-conducted study, where the goal was to assess gait parameters by different sensor technologies in a home-like environment. This dataset consists of the measurement of 60 participants (M = 34.5 years, SD = 11.8 years), where they had to perform 13 different walks, with varied step length, cadence, step width and foot contact with the floor (heel strike or forefoot strike). As a gold standard reference system, accelerometer sensors were used (Physilog 5, Gait Up SA, Lausanne, Switzerland).

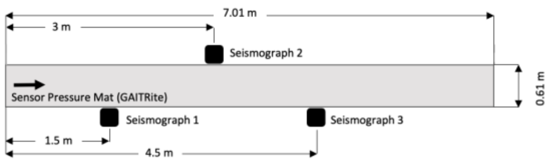

Fig. 1 Placement of the three seismographs along the mat (schematic overview).

The developed algorithm to assess gait parameters required the following four processing steps. First, the signal was pre-processed (i.e., temporal alignment, normalization, and region detection). Secondly, the signal was bandpass-filtered (0.5 to 5 Hz) and amplified via gaussian weighting. Thirdly, the steps were extracted by an adapted peak detection. Lastly, gait parameters were extracted based on the detected peaks (i.e., number of steps, step length, cadence, and velocity). For an evaluation of the algorithm, the results (i.e., sub-set of four tasks) were compared to the gold standard by performing a t-test whereas the pre-processed signal was evaluated in terms of precision and recall.

Results

The results showed that the number of steps was assessed accurately (M=5.8%, SD=5.3%), but there were differences between performed tasks (min. t(n=34)=-0.11, p<.01; max. t(n=34)=4.19, p<.01;). Furthermore, the algorithm showed a high sensitivity for the detection of footsteps (0.88). Furthermore, there was no significant difference in the detected number of steps compared to the gold standard.

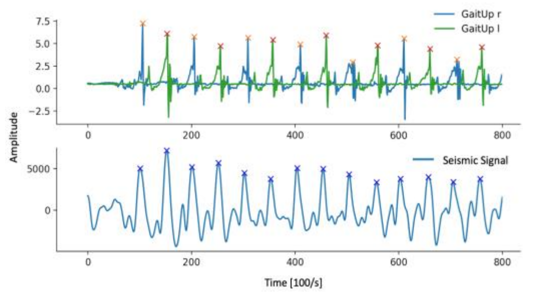

Fig. 2 Detection of steps during task 08: displayed are the gold standard acceleration signal (upper figure, Gait Up, l = left foot, r = right foot), and the seismic signal (lower figure), as well as detected steps in both signals.

Discussion

Overall, a detection of gait by seismographs is feasible and accurate. However, the current algorithms lack accuracy (i.e., temporal alignment decreases) in sequences with high seismic noise or temporal drifts. One possibility to increase the stability of algorithms is the filtering based on a Hilbert- or wavelet-transform or the detection of noisy sequences. In addition, the algorithm could be further improved by recognizing different modes of gait according to different gait patterns.

References

[1] M. Y. Osoba et. all, 'Balance and gait in the elderly: A contemporary review', Laryngoscope Investig. Otolaryngol.,vol.4, no.1, pp. 143–153, 2019.

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