DETECTING NEAR FALLS FROM ACCELEROMETER DATA USING ORTHOGONAL WAVELETS

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INTRODUCTION

Falling is one of the leading causes of hospitalization in people over 65 years of age. The increased risk of falling in the elderly could be attributed to a higher probability of experiencing near falls in daily life [1]. Inertial sensors offer the possibility to monitor the incidence of near falls during activities of daily life (ADL). The challenge here is to isolate a rare and brief event (a near fall) from a continuous stream of motion data corresponding to regular daily activities. The wavelet transform [2] is a relatively new technique in the field of signal processing. An advantage of wavelets is that one can choose the basis, so that the appropriate wavelet for the given application and morphology of the signals at hand, can be selected. The choice of basis allows for the design of wavelets [3]. The key idea is to ensure that the signal at hand has a sparse representation in the wavelet domain. This ensures that the prototype signal is well visible in the wavelet domain and can be extracted. The aim of the present study was to design and evaluate a robust wavelet based approach to detect near falls from accelerometer data.

METHODS

Acceleration data on near falls was acquired using an inertial measurement unit (Xsens, MT9-B, 100 Hz), placed on the lower back of healthy elderly subjects (n=3). The subjects walked on a treadmill at 60% of their preferred walking speed. At random moments trips were induced by pulling a rope attached to the subject's ankle.

A smoothed three-dimensional acceleration vector (superior/inferior, lateral & posterior/anterior) representing 4096 samples of unperturbed walking of one subject was used to design three orthogonal wavelets (Figure 1) according to the method described in [3].

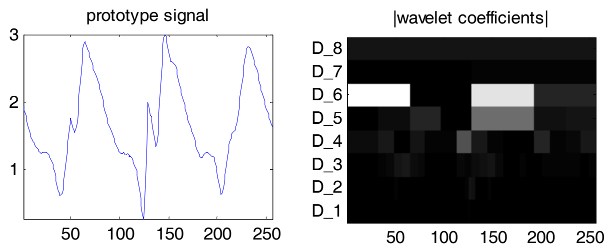

Figure 1: Example of wavelet design. Left: prototype signal. Right: Absolute value of wavelet decomposition coefficients from coarse scales (top) to fine scales (bottom). The gray level indicates the absolute value of the coefficients, where black corresponds to zero value.

A stationary wavelet transform was employed to have full time resolution at each scale as well as to have a transform that is also time-invariant [4]. The wavelets are designed in such manner that the normal gait pattern manifests in the wavelet decomposition in a sparse way in a few scales. The disruptions in the normal gait pattern can be distinguished in other scales. After transforming the acceleration data into the wavelet domain, the locations of near-falls can be identified by using thresholding at the appropriate scales. The robustness of this approach was evaluated via a comparison with a simple peak detection algorithm applied to the raw acceleration data of the vertical axis (superior/inferior).

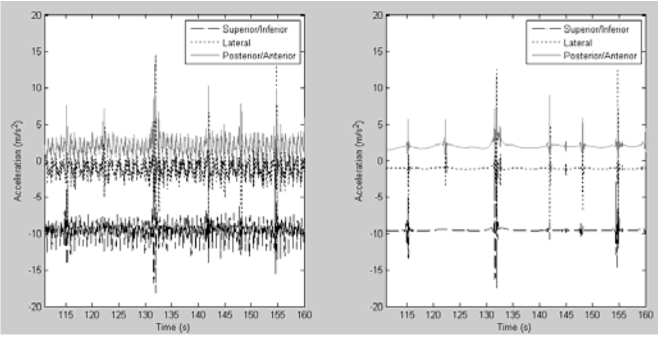

Figure 2: Left: Example of raw acceleration data. Right: Acceleration data after removing scales in wavelet domain that relate to normal gait pattern, hard thresholding the remaining scales and reconstructing the signal.

RESULTS AND DISCUSSION

With the wavelet approach it is possible to accurately isolate the near falls from acceleration induced by the normal gait (Figure 2). The wavelet detection was superior over simple peak detection method (100% vs. 51% sensitivity), particularly when subjects recovered from a near fall using an elevating strategy [1]. The detection was most sensitive on the posterior/anterior and lateral axes. As a result the detection algorithm on each of the axis needs to be combined. Further testing on larger datasets of various walking speeds is necessary to further investigate the robustness of this method.

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