REAL-TIME ANALYSIS OF EMG SIGNALS USING NON-LINEARLY SCALED WAVELETS ON MOBILE DEVICES

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Introduction

Surface Electromyography (sEMG) is a valuable tool to measure muscle activation during static and dynamic movements [Nigg, 2007]. Analysis methods include root-mean-square, autoregression, autocorrelation or the spectral energy distribution. Time-frequency methods include Fourier and Wavelet transform. Especially non-linearly scaled Wavelets [von Tscharner, 2000] are able to resolve muscular activation patterns. Those are used for pattern recognition to show changes due to shoe [Kugler 2010], training [Huber, 2010] or fatigue [Stirling 2011]. However, computational demand is high and analysis is usually offline. Today small wireless EMG sensors allow real-time applications on mobile phones [Kugler 2011]. As a first step, the purpose of this paper was an implementation of the non-linearly scaled Wavelet analysis that can process EMG signals in real-time on mobile devices.

Methods

The Wavelet transformation as described in [von Tscharner, 2000] applies a series of Wavelet filters to the raw EMG signal. This algorithm was implemented in JAVA using the JTransforms FFT library. Different windowing methods were added to allow processing without the whole signal in memory. The algorithm was ported to the Android platform using a mobile sensor framework [Kugler 2011]. EMG data could be read from a pre-recorded file or a Shimmer sensor. The app transformed the incoming signal in real-time and showed the result on the screen (Fig. 1). Evaluation was done using a test signal at various frequencies and a real EMG signal. Runtime and delay was measured on different mobile devices.

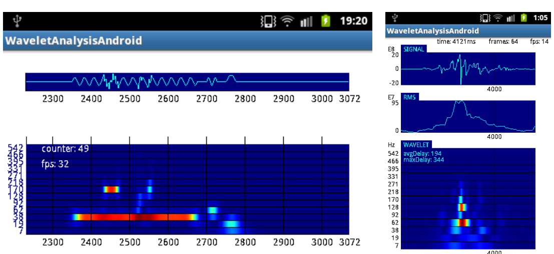

Figure 1: Implementation of the Wavelet transformation algorithm on an Android mobile phone.

Results

Tab. 1 and 2 show the results of the runtime evaluation, Fig. 2 shows the relative error compared to the gold standard implementation.

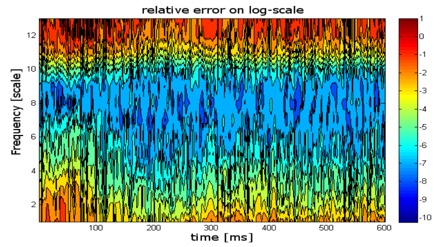

Figure 2: Relative error between the MATLAB reference and the JAVA real-time implementation.

Device (CPU cores)	1000 Hz	500 Hz
Samsung Galaxy Ace (1)	157 ms/s	57 ms/s
Samsung Galaxy Tab 10.1 (2)	6.9 ms/s	0.6 ms/s
Asus Transformer Prime (4)	7.5 ms/s	0.6 ms/s

Table 1: Runtime of the mobile Wavelet analysis shown in ms runtime per second of raw signal.

Windowing Method	Runtime	Delay
No windowing	6.0 ms/s	signal length
Performance	7.5 ms/s	260 ms
Low Delay	36 ms/s	70 ms

Table 2: Comparison of runtime and delay of the Wavelet analysis for different windowing methods.

Discussion

We have shown a real-time implementation of the non-linearly scaled Wavelet transformation for the Android platform. Runtime was better than real-time for on all devices and the algorithm scales with sampling rate and processor power. Results from the mobile algorithm were almost identical to the gold standard. Only very small rounding errors were present in the middle wavelet scales. Errors outside the important EMG frequency range are most likely due to the low signal to noise ratio. Processing delay depended on the windowing method, but it is small enough for most applications. In future this will allow mobile analysis of EMG signals for feedback and training applications.

Huber *et al.*, J Str Cond Res, 24(6):1527-36, 2010.
Kugler *et al.*, Proc. of the 17th ESB, 2010.
Kugler *et al.*, Proc. of the 8th IACSS, 67-70, 2011.
Nigg *et al.*, Wiley, 2007.
Stirling *et al.*, J Elec Kin, 21(4):566-71, 2011.
von Tscharner, J Elec Kin, 10(6):433-45, 2000.