Signal-To-Noise Management, SNM

This is a brief description of the Signal-To-Noise Management Project performed at the Institute of Electrical and Biomedical Engineering (UMIT Tirol, Hall in Tirol, PI: Gerald Fischer). The project aims to promote usability of software for the analysis of evoked potentials by signal-to-noise management.

Evoked potentials are an established diagnostic modality in the field of neurophysiology. Such evoked responses are specific electric patterns recorded from a specific part of the nervous system (e.g., the brain or a peripheral nerve) following presentation of a stimulus (an electric pulse, a light flash, or a pure tone). However, evoked potentials are relatively small in amplitude and superimposed by much larger potential (spontaneous physiological activity and electrical interference, Figure 1). Standard technology requires repetition and averaging of many stimuli (some hundreds or thousands) rendering investigations time consuming and challenging for patients and the medical team.

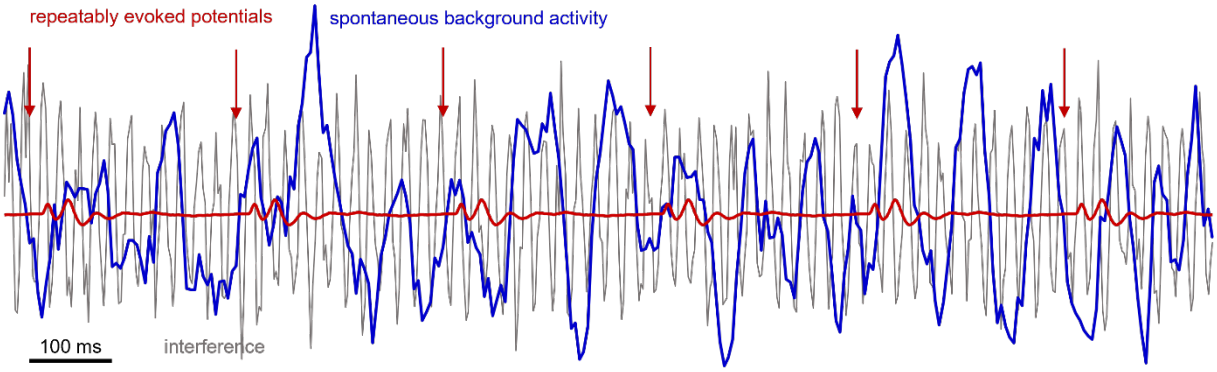

Figure 1: Challenge of evoked potential recordings: Evoked responses (red) of relatively small amplitude are repeatably evoked by a series of stimuli (arrows). These diagnostic target signals are superimposed by physiological background activity (blue; e.g., spontaneous EEGs) and electrical interference (gray; e.g., power line interference and amplifier noise) of much higher amplitude.

Working hypothesis: state of the art amplifier technology (sigma-delta-converters) allows for full digital signal processing and, thus, for the development of tailored suppressing techniques for all individual sources of interference and background activity. This allows for the development of real time signal processing methods providing shortening of investigation time at increased robustness to distortion events (e.g., motion artifacts) in routine experimental conditions. We hypothesize that improvements in clinical usability will promote extended diagnostic use of evoked potentials in movement disorders and inherited neurodegeneration.

Concept of Signal-to-Noise management: Figure 2 provides an overview on the real-time SNM-method under development. The evoked target signal is superimposed by background activity and a plurality of interference sources.

- In a first step Sigma-Delta analog to digital conversion allows for high suppression of stochastic noise (quantification errors and thermal noise) while maintain full signal bandwidth for the following processing steps.
- Smart trail averaging assures high suppression of power line interference and isolated distortion events in addition to standard comb-filtering.
- Target band filtering allows for suppression of background and interference components which are distinctly separated from the target in the frequency domain. Notably, filters are designed such that diagnostic key information (morphology and latency) is persevered.

- The extracted evoked signals are displayed in real-time with estimates of signal quality (signal-to-noise ratio, confidence intervals for latency and peak-to-peak amplitude). This allows the physician to terminate investigation upon obtaining a sufficient quality for a particular diagnostic purpose.

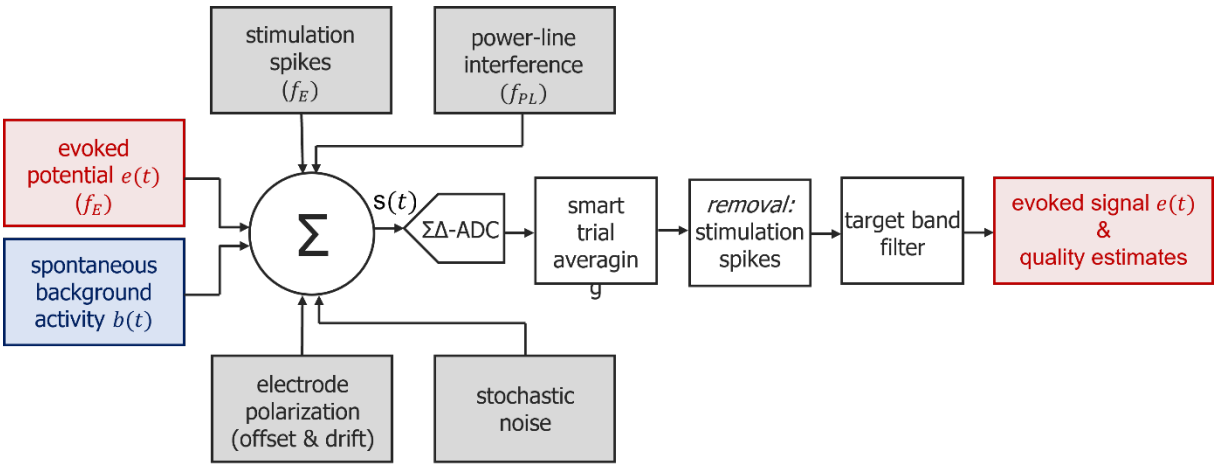

Figure 2: Concept of SNM (see text)

Figure 3 shows high quality signals obtained for stimulation of the right median nerve.

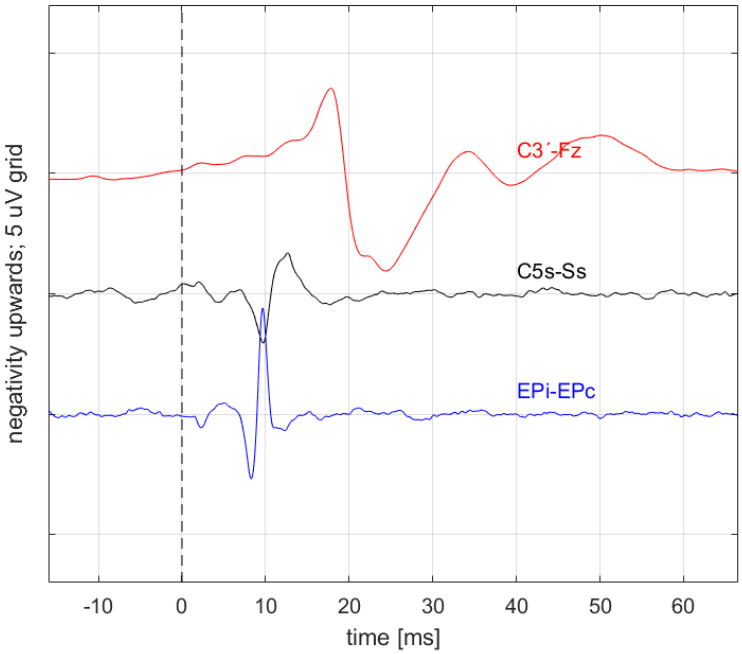

Figure3: Evoked responses following right median nerve stimulation (750 stimuli) extracted by SNM in a normal volunteer. The bottom trace depicts the peripheral sensory compound action potential recorded at the Erb-point (N10 latency 9.7 ms). The middle trace depicts a cervical recording (N13 latency 12.7 ms). The top trace depicts the cortical response (N20 latency 17.8 ms).