Identification and elimination of spiky noise features in MRS data

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Since time series in MRS can be recorded by multiple detection channels simultaneously, the cancellation of harmonic noise by using additional noise reference loops has become possible (Walsh, 2008). This opportunity has greatly extended the applicability for MRS: Recent case studies show that successful MRS measurements can be conducted with quite good quality even near housing or power lines. However, if the noise consists of randomly interfering signals with short length (some milliseconds) and high amplitudes (up to a view microVolt), e.g. in the vicinity of radio masts or electric fences, MRS measurements persist being very difficult.

If spiky noise features appear in MRS data, the remote reference technique fails, because the calculation of stable transfer functions between the MRS signal loop and the noise reference loops is not possible. A conventional method to avoid spiky noise is to define a threshold during the measurement to refuse time series with extremely high voltages. However, this method often leads to an unacceptable long measurement duration for the entire sounding. Consequently, the prefered strategy is to accept all signals and to eliminate only the corrupted parts of the time series with adequate post-processing techniques (Strehl et al., 2006).

We tested and compared three post-processing methods to eliminate finite interfering signals from an MRS dataset, which was measured at the test site Fuhrberger Feld and shows heavy distortions with spiky noise. Using common processing schemes, this data can hardly be interpreted. In our study, we focussed, first, on the possibility to automate the algorithms to identify and eliminate the spiky noise features and, second, on the capability of these algorithms to be combined with processing tools for harmonic noise cancellation (HNC).

The first method identifies and eliminates interfering signals in the time domain by searching for high voltage induction, i.e., spike-like pattern above a certain threshold. The second approach is based on the univariate wavelet transform (WT) of the measured time series. The interfering signal is identified and isolated in the wavelet domain and, after the inverse WT back into the time domain, subtracted from the original time series (Strehl et al., 2006). The third approach uses the multivariate WT and takes advantage of the multi-channel detection (Aminghafari et al., 2006).

It is shown that all procedures can easily be applied automatically, and can therefore easily be implemented on demand either as black box processes or as user controlled schemes into existing post-processing strategies. All techniques improved the signal-to-noise ratio (SNR) from 2 to about 5.5. Regarding the combination with the HNC, the univariate WT approach shows a serious shortcoming: After the application of the WT filter, the coherence of the noise pattern in the MRS signal to the remote references gets lost to some extent. Consequently, the SNR decreases from 5.5 to 3 after successive application of the univariate WT and the HNC. This shortcoming was not found for the multivariate WT. Both, the multivariate WT approach and the time domain thresholding approach could finally reach an SNR of more than 7, when combined with HNC.

References

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