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Pilot Study on Using Fractional Order Calculus-Based Filtering for the Purpose of EEG Signals Analysis

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Introduction: Analysis of Electroencephalography (EEG) signals has recently awaken increased interest of numerous researchers all around the world - caused by the rapid development of BCI-related research areas. The EEG signals are applied in most of the BCI systems as they provide necessary information in regards of brain's activity. In this paper pilot study on implementation of filtering based on fractional order calculus (Bi-Fractional Filters - BFF) for the purpose of EEG signals' classification was in short presented.

Material, Methods and Results: The application of EEG signals in BCI, especially from cost effective sensors is a difficult task, as it relies on real time analysis and interpretation of low quality data and its interpretation depends on the applied method of signal processing [1]. The concept of using of fractional calculus in technical application has become popular in recent years, however the theory was developed already in the 19^{th} century. One of rapidly developing area is implementation of fractional filters for bio-signals processing, as it allows great flexibility in filter shaping [3]. In this paper fractional filtering process was carried out with the Laguerre impulse response approximation implementation [4]. The Fig. 1 illustrates: (a) time series of the analysed 'mu'-waves recorded from the right hemisphere of the brain (C3) using the gaming (not medical) headset Emotiv, so the obtained data is not really 'raw'; (b) is this signal's spectrum. One can observe damping of 28 dB/dec, which is not possible while using traditional filters; (c) Comparison (another, sample time-interval) of using a basic band-pass (8 and 12 Hz) filter and a fractional - BFF filter (with the given parameters:α=0.7, b=11.1688, c=124.7412).

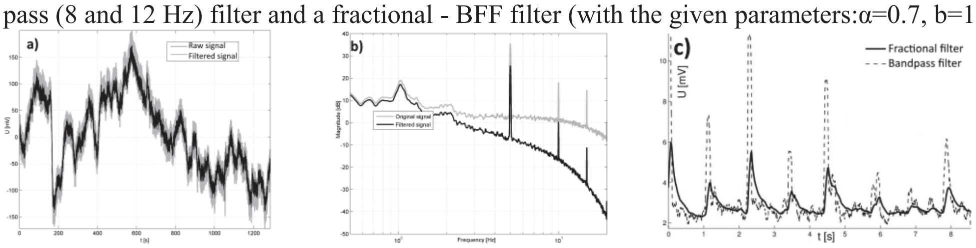

Fig. 1. a) time series (sample 1); b) spectral analysis (sample 1); c) fractional and band-pass filtering (sample 2).

Discussion: The research is currently of initial study stage and the idea of using BFF filtering is being tested. The results are promissing and show wide range of filter design possibilities. Implementation of such filtering in fractional form is numerically impossible – so the approximation has to be taken into account due to occurence of numerical errors. The high order of approximation enables more accurate filters' response, but it may provide less numerical stability.

Significance: The implementation of BFF Filtering is not very popular yet, but the authors assume that it will become widely used in the near future due to its efficiency and wider potential in development of frequency filters' characteristics. The proposed method also offers more flexible adjustment of the frequency characteristics [5]. The previous applied methods were in more detail presented in: [1,2].

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