PHYSIOCRATE: A SIGNALPLANT TOOLBOX FOR RESPIRATORY, BLOOD PRESSURE AND EMG SIGNAL ANALYSIS

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Abstract: The paper presented here describes the SignalPlant library for analysis of physiological signals. This library contains plugins for analysis of continuous blood pressure (BP), respiratory signals (RESP) and electromyographic signals (EMG). Its principal advantages are real-time previews of results, ease of use and a multi-thread approach. The library is available free and open-source under an MIT license as part of the SignalPlant project at https://signalplant.codeplex.com.

Keywords: SignalPlant, plugin, signal analysis, blood pressure, respiration, EMG

1 INTRODUCTION

SignalPlant [1] is a free software platform for signal analysis. Although SignalPlant is a powerful tool for signal inspection, processing and analysis, it lacks specific plugins for analysis of blood pressure (BP), respiration (RESP) and electromyographic signals (EMG). For this reason, we have developed three plugins with a user-friendly and interactive graphic user interface (GUI) allowing real-time results previewing. This is a major advantage over existing solutions such as RASCHlab [2] in which iterative parameter setting may be a time-consuming process. Here, we present the library with three new plugins extending SignalPlant to include new functionality.

2 RESPIRATION SIGNAL ANALYSIS PLUGIN

Respiratory signals may be obtained from several measuring devices such as inductance plethysmography or nasal thermistor or by deriving a respirational wave from an accelerometer placed on the chest. The respiration plugin presented here (Fig. 1) allows processing of all the mentioned signal types. It evaluates the following parameters from a RESP signal – amplitude, respiratory frequency, ventilation, and expiration and inspiration duration. It can be used in two modes. The first mode retrieves results from the whole signal, excluding artificial areas. The second mode allows analysis of selected parts of a signal, using labels as starting points and a fixed window duration (defined by the user in Fig. 1-B). RESP signal maxima and minima are localized automatically by an algorithm that finds local extremes in a floating window. This process is split into multiple threads for improved time efficiency. Signal distortion may be eliminated with a low-pass finite-impulse-response filter (FIR, Fig. 1-B). Moreover, it is also possible to manually change the positions of respiration maxima and minima in SignalPlant if the user is not satisfied with their automatic detection. The user can inspect the analyzed signal, the list of individual inspirations and expirations and the overall statistical results (switchable in Fig. 1-C) in real time as the plugin immediately recomputes the results whenever the user changes any setting. This is a major improvement over existing solutions such as [2] or [3].

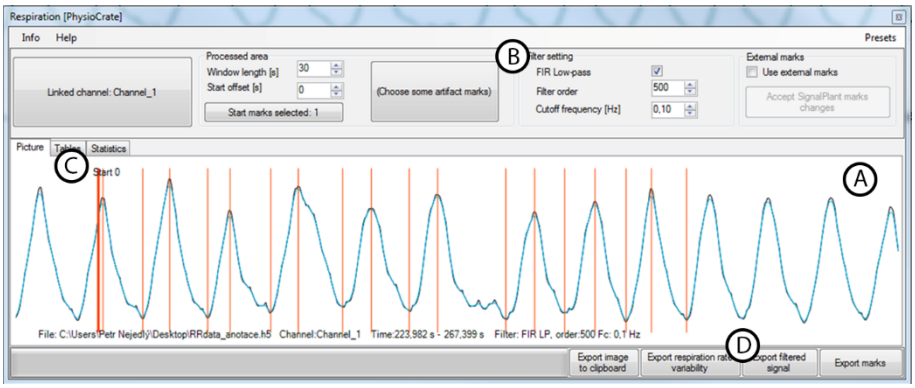

Figure 1 – Respiration analysis plugin window showing preview of detected inhalations and exhalations from a respiratory record in a 30-second window started by the Start-0 mark. A – review area. The original signal is the black line, the filtered signal (FIR low-pass at 0.1 Hz, 500th order) is the blue line; minima and maxima are represented as orange vertical lines. B – parameter settings panel. C – page switch. D – export buttons.

3 CONTINUOUS BLOOD PRESSURE ANALYSIS PLUGIN

This plugin is designed for the analysis of signals obtained from invasive and non-invasive blood pressure measurements. The input signal is filtered with a filter (FIR low-pass at 10 Hz, 50th order), after which local extremes are found. These extremes must satisfy the condition that they are greater than the 90th percentile or lower than the 10th percentile in comparison with surrounding values to be accepted as systoles and diastoles. This plugin may produce heart-rate, systolic and diastolic curves as well as systolic/diastolic marks for each beat. The user interface is extremely similar to the GUI in the RESP analysis plugin.

4 ELECTROMYOGRAM ANALYSIS PLUGIN

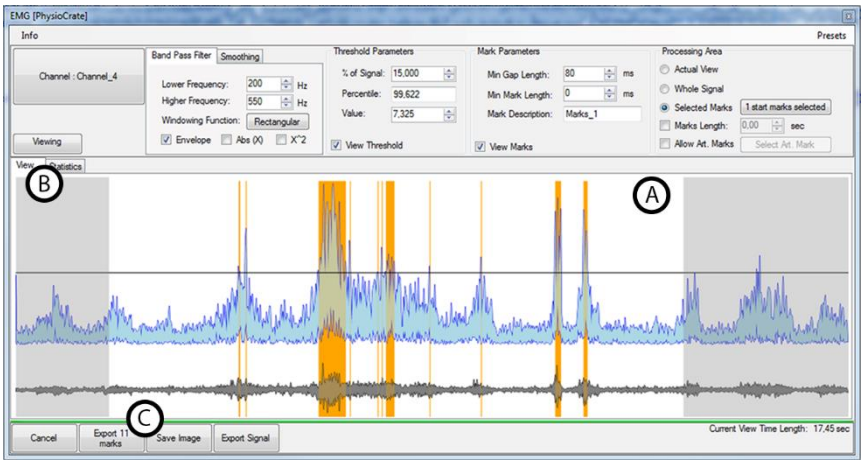

Figure 2 – EMG analysis plugin window showing a preview of an EMG record of the m. corrugator supercilii activity. A – preview area. Detected areas with higher activity in the specified frequency range are marked by the orange color. The original signal (dark gray) is at the bottom. The blue signal is the resultant envelope of EMG analysis. B – parameter settings panel. C – export buttons.

The presented plugin is designed for the detection of areas in which an amplitude envelope in a given frequency range exceeds the selected threshold, as is the case in the detection of muscle activity in EMG records. The measured signal is displayed in a plugin window (Fig. 2) and the user defines the properties (Fig. 2-B) of the pre-processing chain. The signal is transformed into amplitude envelopes

using the Hilbert transform (selectable frequency range, windowing function and squaring). Consequently, it is possible to apply smoothing (selectable window size and type). These processes are split into multiple threads to speed up the computational process. The threshold value can be set in three modes. Firstly, directly as a value, secondly, as a percentage of the signal maximum, and thirdly as a user-defined percentile of the signal. Areas with an amplitude higher than the threshold value are highlighted (Fig. 2-A – orange areas) so as to be easily identified by the user. To ease the plugin manipulation, the user is given an opportunity to make his own preset for most used controls.

5 RESULTS AND CONCLUSION

Systole detection from Blood pressure plugin was validated using 18 records from MIT-BIH Polysomnographic Database [4]. We compared annotated position of R wave with detected starts of systoles. Average sensitivity was 99.33% and positive predictive value was 99.39%. Respiration plugins was validated using 42 records from CapnoBase[5][6] database. Average sensitivity was 93.27% and positive predictive value 92.80%.

We have developed interactive plugins that are going to be used in neuropsychological research for the analysis of respiration, continuous blood pressure and EMG signals. Their principal advantages over existing solutions are real-time interaction with the user, multi-thread approach and 64-bit architecture. Furthermore, presented plugins allows user to save analysis parameters that can be re-used later. Plugins allow working with file formats supported by SignalPlant (as EDF, BIN, SCOPEWIN, MAT *etc*.) and they are accompanied with help file in PDF. Plugins are available free under an MIT license in the form of source code as well as compiled DLL and can be downloaded from https://signalplant.codeplex.com/ as part of SignalPlant software.

ACKNOWLEDGEMENT

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