Help

Overview

EP_den gives different options for denoising the data using the wavelet transform. This tutorial shows you how to do automatic and manual ERP-denosing using the EP_den graphic user interface and the batch files. In passing, we will briefly mention some of our results using wavelets in ERPs, so that they can be (at least partially) reproduced using this software and the data examples.

Getting started

First start by adding the directory EP_den_Auto with subfolders in your matlab path (using the matlab File/Set Path menu). Load the program by typing EP_den in matlab. Set the parameters:

Sr: sampling frequency (in Hz).
Stim: time of stimulus onset (in samples).
Samples: number of samples per trial.
Scales: number of scales in which the signal should be decomposed (max: 10)

Load the data S4_O2T.asc, which contains 33 trial ERPs, using the **load** button. In the upper panel the average ERP will appear. There are 3 evoked responses: the P100 (a positive peak at about 100ms), the N200 (the negative deflection following it) and the P300 (the largest positive peak at about 400ms). The lower panel discloses the wavelet decomposition of the average ERP. For more details on the data and experimental setup see [1]. The coefficients show the correlation of the average ERP with the wavelet function (biorthogonal B-spline) at different scales and times. Clicking in "**Bands**" we see the reconstructed signal for each scale (which is calculated using the inverse wavelet transform).

The original data can be decomposed in up to 10 detail levels (D1 – D10) and a last approximation (Apr). The frequency limits of each scale are approx. calculated dividing by 2 the sampling rate. In the case of 512 Hz, these are (with a 5 scales decomposition):
D1: 128 – 256 Hz; D2: 64 – 128 Hz; D3: 32 – 64 Hz; D4: 16 – 32 Hz; D5: 8 – 16 Hz; A5: 0 – 8 Hz. Note that D2, D3, D4, D5, A5 approx. correspond to the EEG frequency bands: Gamma, Beta, Alpha, Theta and Delta, respectively.

Let us now see how the decomposition works by changing the number of scales. By setting "Scales" to 1, the average ERP is decomposed in only one detail level (D1) with the high frequencies (~ 64-128 Hz) and one approximation level (A1) with the low frequency activity (~ 0 – 64 Hz). If we set "Scales" to 2, we then subdivide A1 into D2 and A2. Analogously, by setting "Scales" to 3 we subdivide A2 into D3 and A3 and so on. See how the signal gets decomposed up to "Scale" 5 and check also how the coefficients look like.

Wavelet denoising

Automatic denoising:

The automatic denoising gives two options:

- **Neigh:** Gives wavelet denosing based on the neighbouring coefficients technique [2].

- **NZT:** Gives wavelet denosing based on the neighbouring coefficients and Zerotrees technique [3].

Clicking each button gives you the denoised data in read.

Manual denoising:

- Select **Coefficients** from the **Make Plots** panel
- Select **select-scale and coefficients** button
- Click on the coefficients panel and drag the mouse to make a square box around the coefficients of interest
- Select **Add** (**remove**) button to add (remove) the selected coefficients

The denoised average and single-trials will be reconstructed by the new set of denoised coefficients automatically. Make sure you start with the automatic denosing and then do the manual modification. Later you can just remove all the denoised coefficients selected by automatic denoising and do the manual denoising.

Load-den-coeff

This menu gives you the possibility to denoise the data using a set of predefined wavelet coefficients. This can be useful for denoising data from different subjects but with the same set of coefficients. The user can automatically denoise the data from one subject; save the denoised file and then denoise the rest of the data using the same set of coefficients.

- Select **Load-den-coeff**
- Open the den_coeff file in the save directory

Make plots

This menu plots either the wavelet coefficients; the reconstructed signal for each scale (band); the single-trial traces (in gray the original trials and in red the denoised trials) or a contour plot of the original, denoised and latency-corrected trials (trials are in the y-axis). In all cases, the upper plot always shows the original average ERP (in gray) and the average denoised signal (in red) and the latency-corrected average (in blue). In the case of single-trial or contour plots, the number of trials to be plotted can be selected with the bottom numbers.

Find Peaks
This menu gives the possibility to find the maximum (minimum) potential of the average and the single-trials in a given time range defined by **t_min** and **t_max,** and plot the latency-corrected average based on the maximum (minimum) peak of the average signal. This menu can be used for further single-trial analysis.

- Set **t_min**
- Set **t_max**
- Select **Positive (negative)** radio button to find the most positive (negative) potentials in the time range of **t_min** to **t_max**
- Select **latency-corrected average** to plot the latency-corrected average data

Note that after selecting the **Positive** (**Negative**) radio button, the left bottom panel automatically switches to show the single-trials and the given time range will be shown by a blue rectangle across the single-trials. Furthermore the most positive (negative) potentials in the given time range will be shown by asterisks.

Batch files

You can find the batch files for the automatic denosing algorithms in the folder with the same name. Here the main file is the EP_den_Auto and the rest are the functions calling from the EP_den_Auto. You should first set the parameters, the plot-type ('coeff', 'bands', 'single' or 'contour') and the denosing technique ('Neigh' or 'NZT'). The input should be a 1 column ASCII file in which trials should be concatenated one after the other without blanks. You should set the 'path', 'filename', 'save_path' and 'save_filename'. The program load the input with the 'filename' from the 'path' and save the denoised results with the'save_filename_den' in the 'save_path'.

- Open **EP_den_Auto.m**
- Set **handles.par.sr**
- Set **handles.par.stim**
- Set **handles.par. samples**
- Set **handles.par.scales**
- Set **handles.par.plot_type**
  - ✓ 'coeff'
  - ✓ 'bands'
  - ✓ 'single'
  - ✓ 'contour'
- Set **handles.par.den_type**
  - ✓ ' do_den'
  - ✓ 'load_den_coeff'
- Set **handles.par.auto_den_type**
  - ✓ 'Neigh'
  - ✓ 'NZT'
- Set **filename**
- Set **save_filename**
- Set **save_path**
- Run the program

References

[1] **Automatic denoising of single-trial evoked potentials.**
M. Ahmadi, R. Quian Quiroga
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[2] **Incorporating information on neighboring coefficients into wavelet estimation.**
T.T. Cai, B.W. Silverman
Sankhya Ser B, 2001; 63:127-148

[3] **Embedded image coding using Zerotrees of wavelet coefficients.**
J.M. Shapiro
Signal Processing, IEEE Transactions on, 1993; 41: 3445-3462