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Independent component analysis in the automated detection of evoked potentials from multichannel recording

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Abstract

Noise reduction in multichannel evoked potential data is the aim of this work. In this work, a new method of noise reduction based on automated independent component selection is presented and applied to 68-channel EEG recording of Auditory Late Response (ALR) and the result is compared with existing method (e.g. coherent averaging). The result of comparing SNR, calculated by *Fsp*, from different methods shows that SNR is improved considerably using the new method, i.e. the mean and standard deviation of SNR across the channels in the new method is 9.43 and 5.5 respectively, whereas it was 1.38 and 1.3 using the averaging method. Moreover, SNR in the best channel, highest SNR, is 17.74 which is improved by a factor of 3.7 in comparison with the conventional averaging method that gave 4.76. The next step will be to apply the method to a new and larger dataset.

Objectives

- Noise reduction in multichannel signal recording using ***FastICA*** and automated component selection.
- Measuring SNR and compare with SNR calculated from different noise reduction methods. .

Materials and Methods

Auditory late response of a normal hearing subject was recorded using a 68 system channel with 66 channel for auditory response recording (EEG) along with two more channels for recording eye-blink and heart beats (ECG).

Stimulus and Acquisition factors:

Type	1KHz, Tone burst
Duration	70 ms
Rate	0.7 /sec
Number of sweeps	210
Sampling rate	4KHz
Filters	1-30Hz

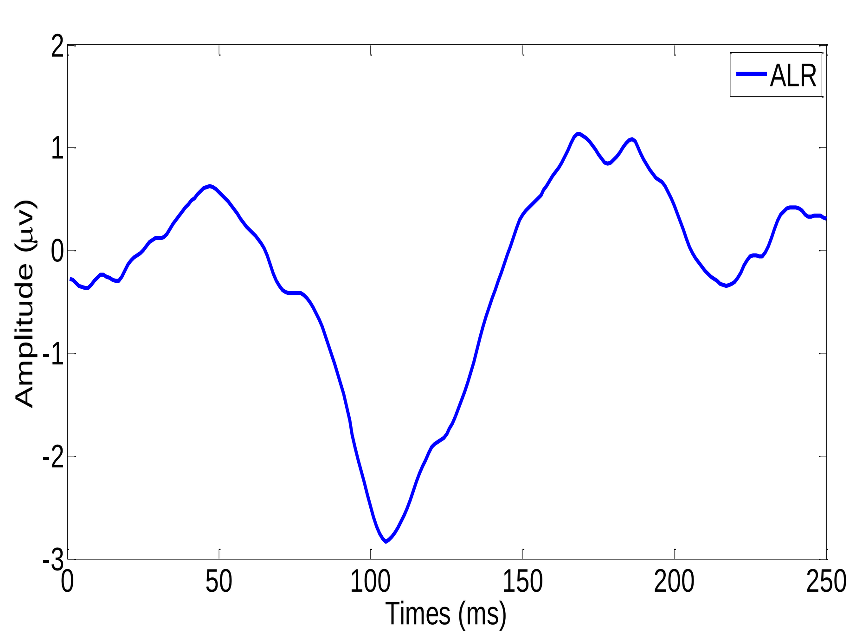

Figure1: Using stimulus parameters given in above table, the ALR waveform, extracted from vertex, would be obtained.

- **Noise reduction Using ICA:**

- ***Source separation***: Independent component analysis, using FastICA is giving ICs, mixing matrix and un-mixing.
- ***Component selection***: magnitude squared coherence (***MSC***) is used to select the "*good"* independent components, i.e. ICs whose coherence with the stimulus is statistically significant.
- ***Data reconstruction***: Using the mixing matrix obtained from FastICA and good components found from MSC data are reconstructed.
- ***Averaging*** **:** by averaging across the sweeps over the reconstructed data, the final waveform is obtained. For all 66 EEG channels.
- ***Calculating SNR***: Using Fixed single point (*Fsp)*, SNR in each channel is calculated and compared with SNR in single channel recording.

Results & Conclusion

Setting a suitable threshold for P-value is not a trivial issue and the threshold should be selected carefully. A very low threshold, too few ICs, causes loss in information and a high threshold leads to a noisy reconstruction. SNR is calculated using different thresholds for P-value and the results show P-value below 0.05 (or 0.1) is a good choice for this case. Giving some EEG channels with high Fsp.

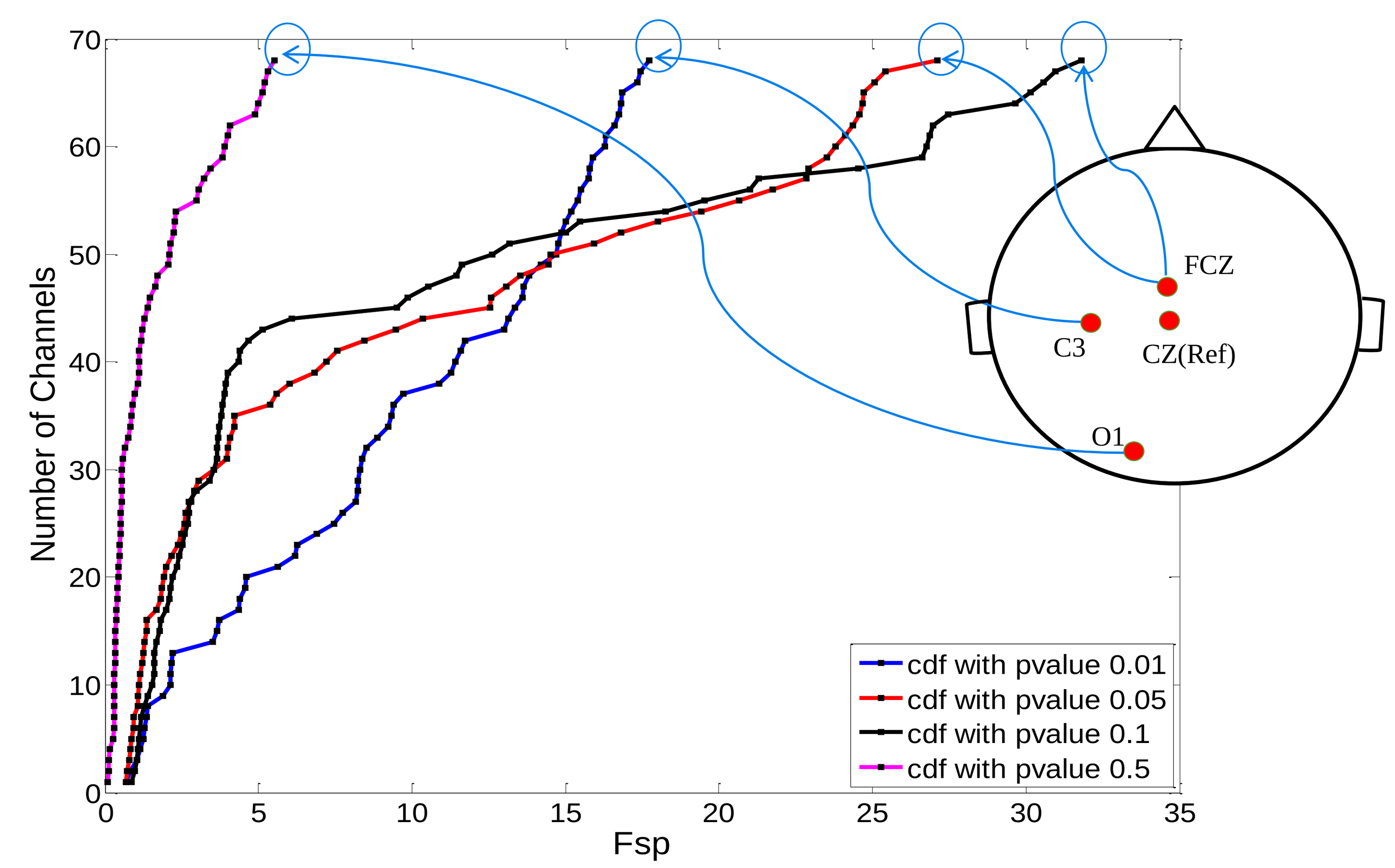

Figure 2: Cumulative distribution of Fsp. This shows number of EEG channels with Fsp less or equal to a value on abscissa, after reconstruction of signals from selected ICs. Using too many ICs for reconstruction (purple line) results in a poor SNR and selecting too few ICs causes loss in information

Comparison of calculated Fsp in different methods of noise reduction shows that the MSC method has a better performance than other alternatives such as conventional averaging and ICs selection by kurtosis. Moreover, reconstructing data using only one IC, the IC with highest Fsp, leads to have a same signal in all the channels and one value for Fsp. This implies loss in information.

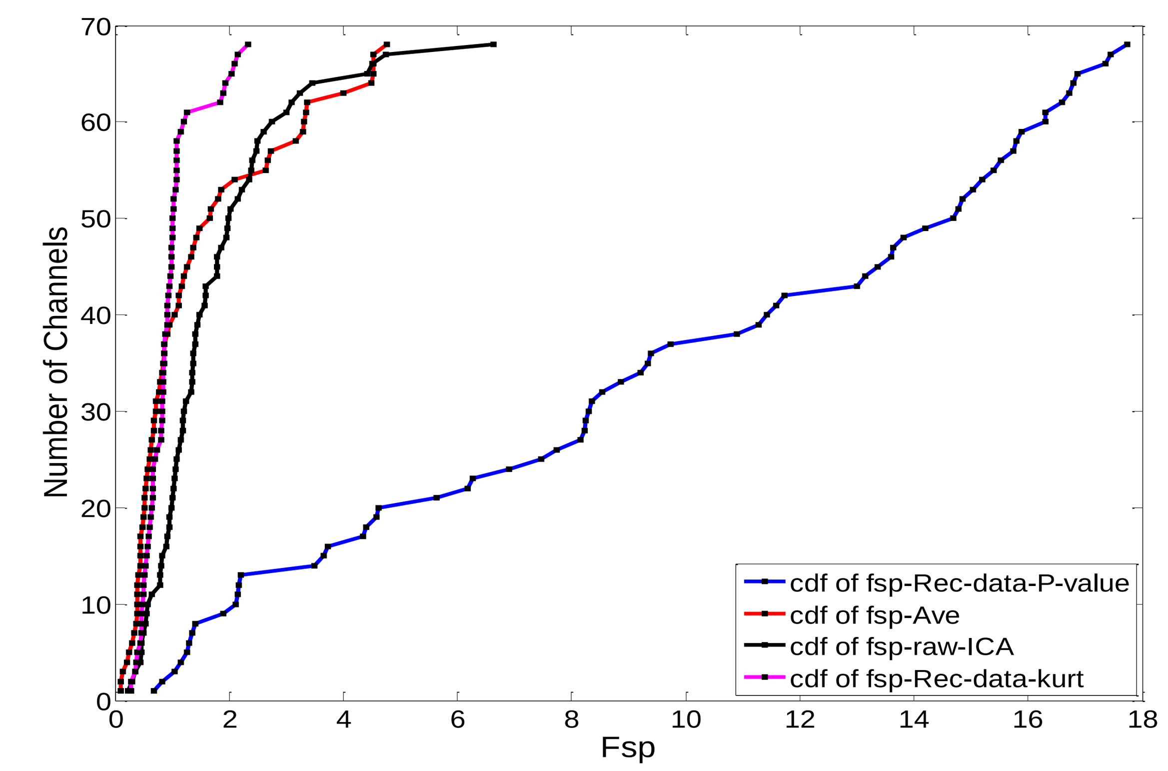

Figure 3: SNR in different channels using different methods for noise reduction. The purple line shows data reconstruction using Kurtosis for IC selection. Red line is for conventional averaging, black line is averaging ICs across the sweeps and blue line is the MSC method (P-value=0.01). Performance of MSC is considerably better in SNR improvement

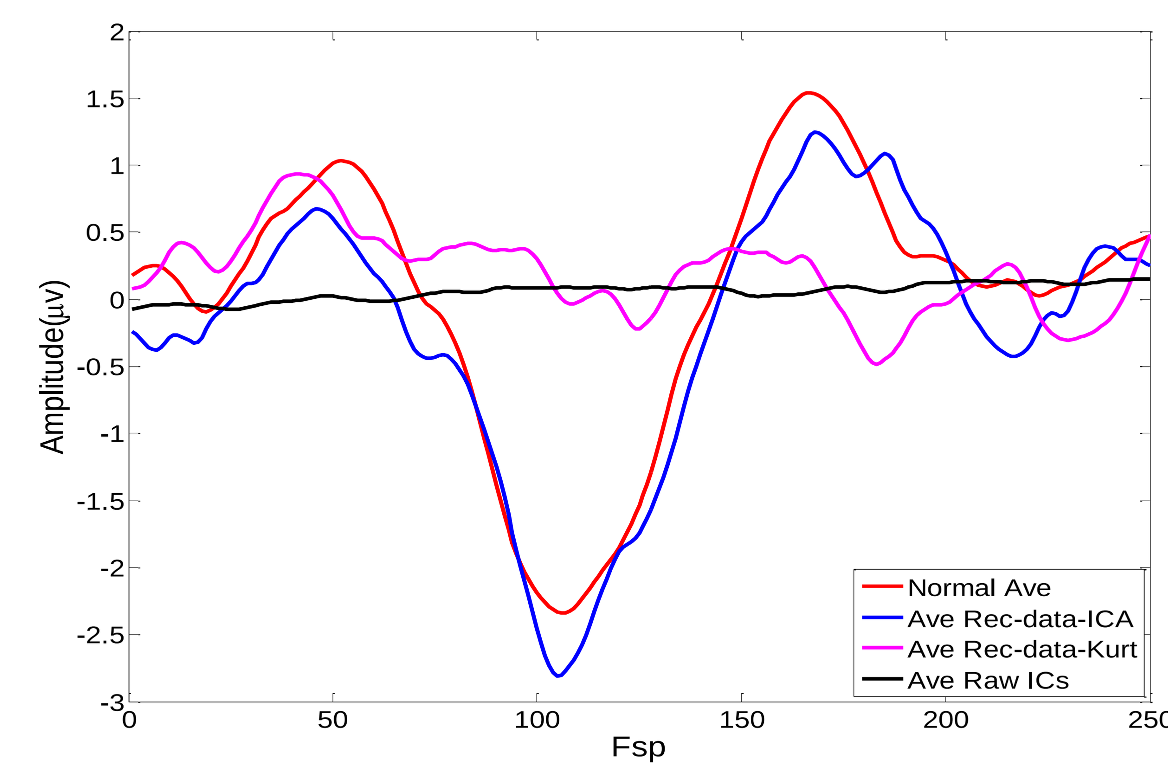

Figure 4: ALR waveform obtained from different methods in channel one (i.e. cortex).

By reconstructing data using the new method (i.e. 0.01 as threshold of the P-value) SNR is improved considerably. the mean and standard deviation of SNR across the channels for the new method is found to be 9.43 and 5.5 respectively, whereas it was 1.38 and 1.3 using the averaging method. Moreover, SNR in the best channel is found 17.74 which is an improvement by a factor of 3.7 in comparison with averaging method that gave 4.76.

References

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