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Fast removal of ocular artifacts from electro-encephalogram signals using spatial constraint independent component analysis based recursive least squares in brain-computer interface

Key words: Ocular artifacts, Electroencephalogram (EEG), Electrooculogram (EOG), Brain-computer interface (BCI), Spatial constraint independent component analysis based recursive least squares (SCICA-RLS)

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Introduction

- An adaptive filter based on reference signals from an electrooculogram (EOG) can reduce ocular interference, but collecting EOG signals during a long-term EEG recording is inconvenient and uncomfortable.
- To remove ocular artifacts from EEG in brain-computer interfaces (BCIs), a method named spatial constraint independent component analysis based recursive least squares (SCICA-RLS) is proposed.
- The proposed method avoids the need for parallel EOG recordings. In addition, it has the ability of fast computation.

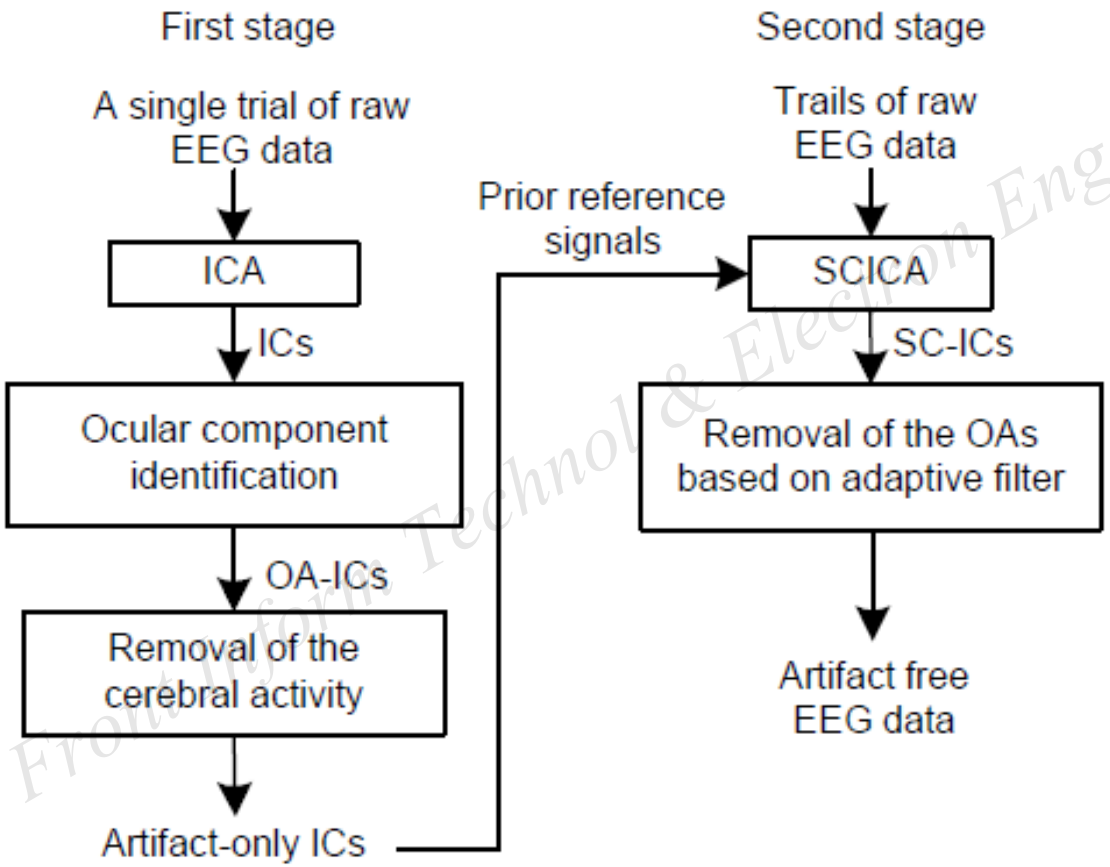


Fig. 1 Simple flowchart of the proposed method

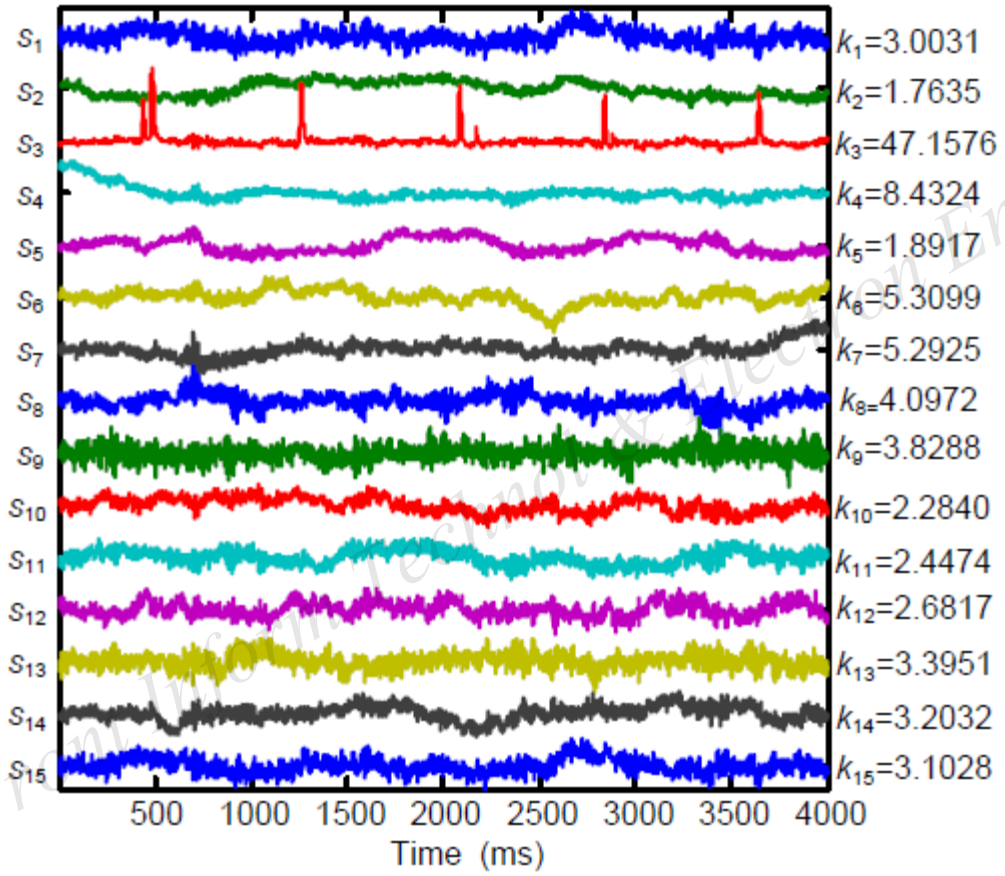
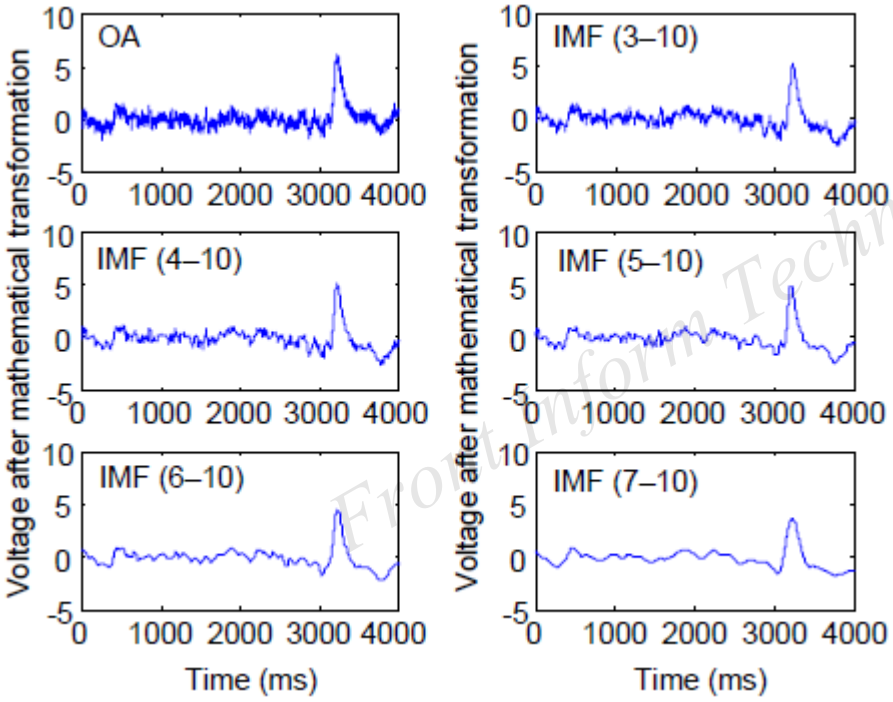
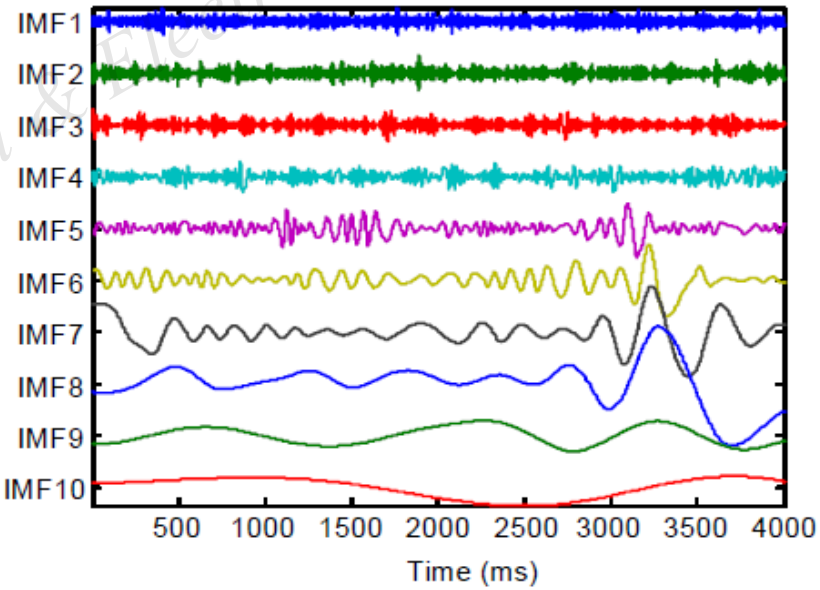


Fig. 2 Fifteen ICs separated by ICA and their kurtosis values

Synthesized artifact signal by selecting different numbers of IMFs



10 IMFs decomposed by EMD from an OA of real EEG data



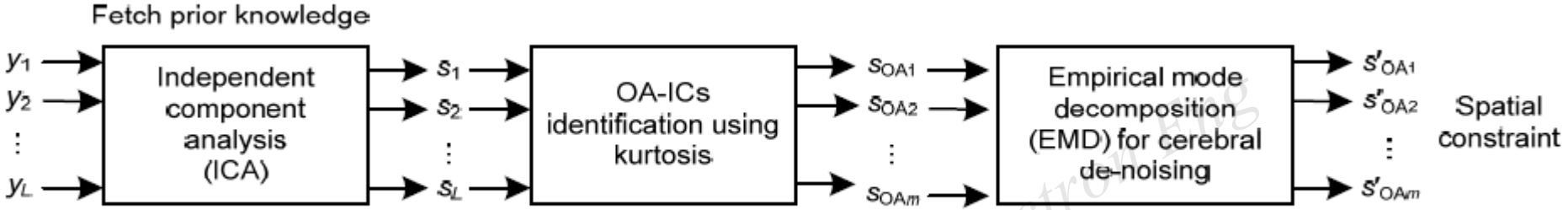


Fig. 4 Block diagram of the first stage

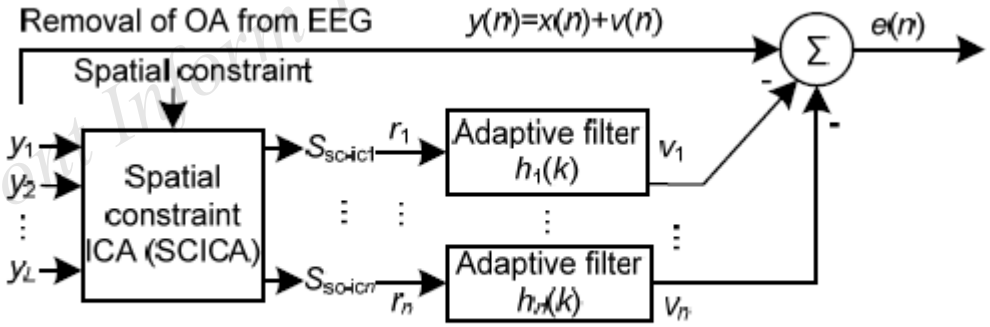
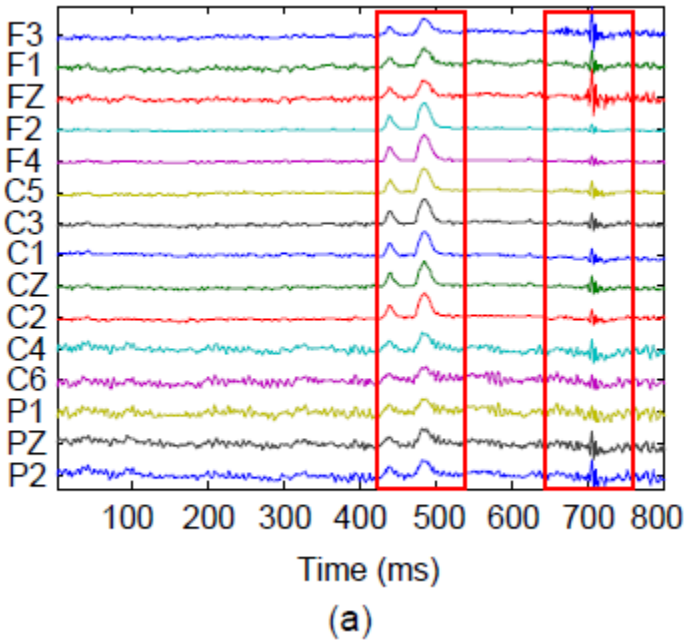
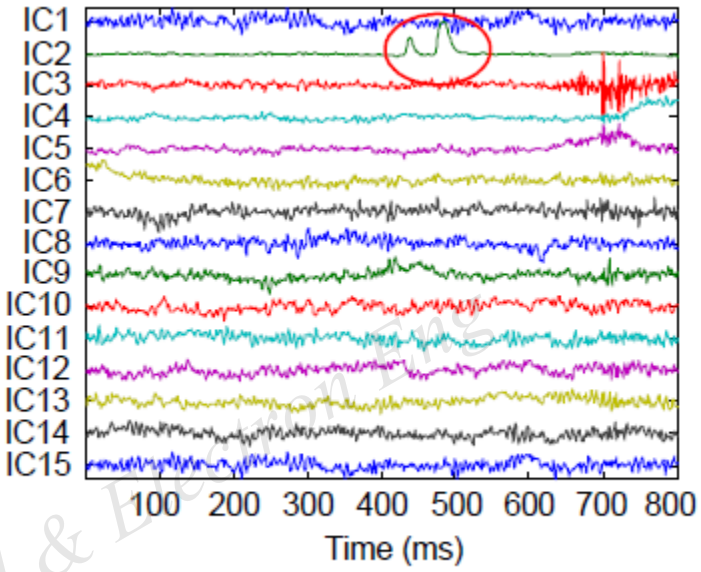


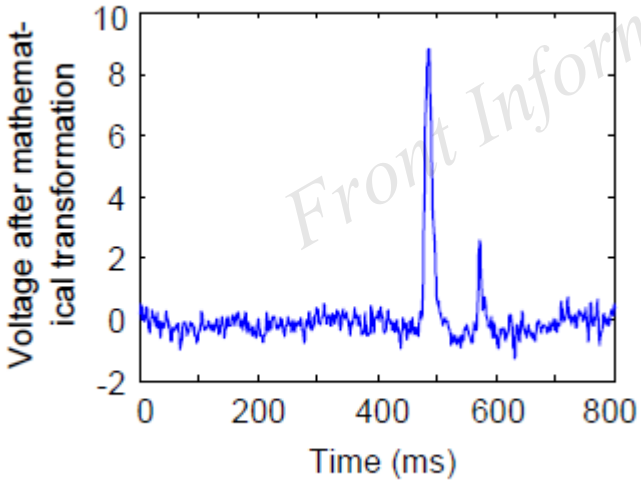
Fig. 5 Block diagram of the second stage



(a)



(b)

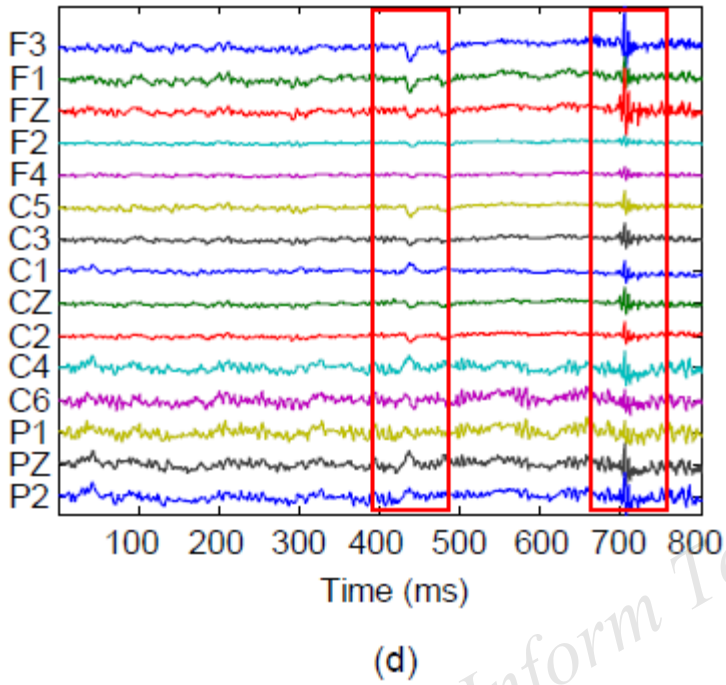


(c)

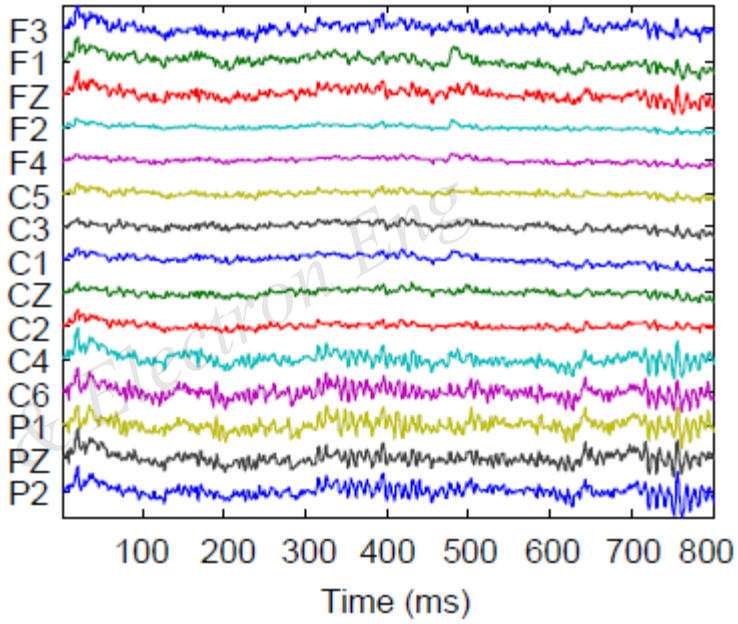
(a) Raw EEG data

(b) Fifteen ICs seperated by ICA

(c) SC-IC separated by SCICA



(d)



(e)

(d) Result of standard ICA method (not all the artifacts were removed)

(e) Result of the SCICA-RLS method (almost all the artifacts were removed)

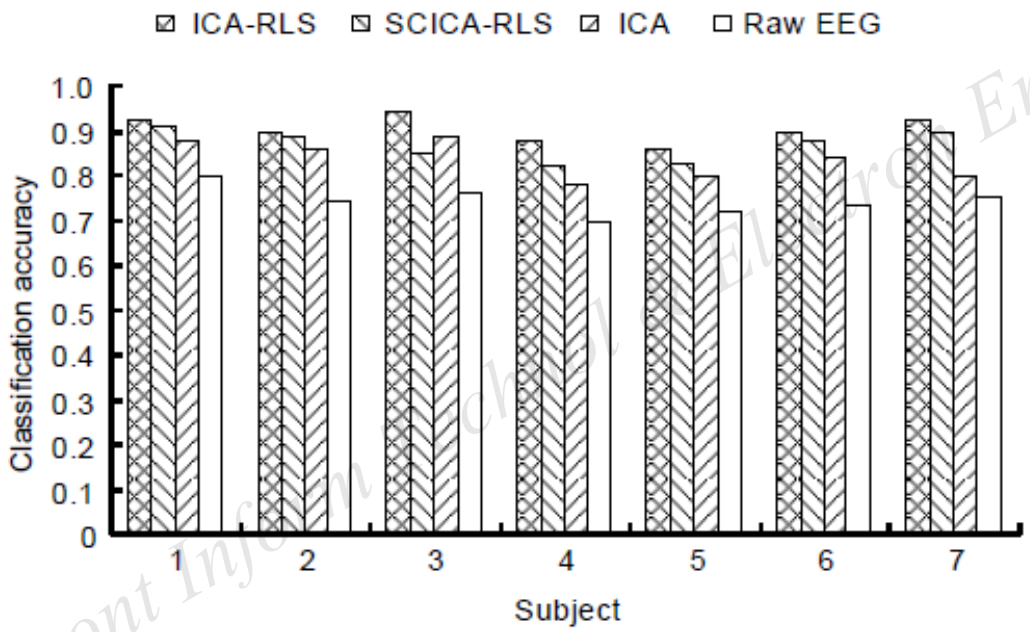


Fig. 8 Comparison of classification accuracies for different methods and subjects

Conclusions

- A new method, SCICA-RLS, for automatically removing ocular artifacts in EEG data is presented.
- The method eliminates the embarrassment of collecting EOG data during a long-term EEG recording.
- The proposed method can remove artifacts clearly and achieve high classification accuracy.
- Meanwhile, the proposed method is much faster than the ICA and ICA-RLS methods, which can provide a foundation for online and practical applications.