Systematic Statistical Approach for Artifact Rejection of High-Density EEG Recorded during Walking

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THIS paper describes a systematic statistical approach for artifact rejection of high-density electroencephalography (EEG) recorded during walking for independent component analysis (ICA). EEG recorded during locomotion is inherently noisier than static seated tasks because of mechanical artifacts associated with walking dynamics [1]. While automated unsupervised methods have been developed for seated tasks [2], this paper focuses on developing an artifact rejection methodology to be used for EEG recorded during locomotion. Our working hypothesis is that noisier channels have a greater likelihood of being identified as being noisy using multiple automatic channel rejection methods compared to less noisy channels.

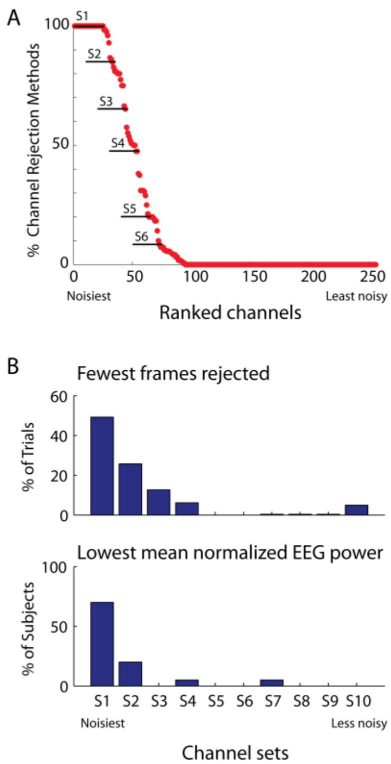

Fig. 1. A) Ranked channels from one subject and sets of excluded channels, S1-S6. **B)** Comparison of sets of excluded channels.

For EEG recorded during walking, we use automatic channel rejection methods that use a combination of standard deviation (SD), kurtosis (K), and correlation (C) [1], but have not systematically analyzed the results of various combinations. We systematically applied 4 standard deviation, 4 kurtosis, and 5 correlation thresholds in every possible order for a total of 480 different channel rejection methods or trials. We analyzed high-density EEG data from 20 subjects who performed three locomotor tasks for 20 minutes each. For each subject, we chose standard deviation thresholds that corresponded to rejecting 5, 10, 20, and 30 channels based on standard deviations calculated for all 256 scalp electrodes. The kurtosis thresholds were 2, 3, 4, and 5 and the correlation thresholds were 0.0001, 0.00025, 0.0005, 0.001, and 0.005. We ranked channels based on the percentage of trials a channel was identified as being noisy (Fig. 1A).

To evaluate the effectiveness of our noise rankings, we created ten channel sets using a window that excluded N number of channels, where N was the number channels identified as being noisy for 100% of the methods. The channel set S1 excluded only the channels identified as being noisy for 100% of the methods. We shifted the window of channels to exclude by increments of 10 channels along the ranked channels (Fig. 1A). For each channel set, we identified the percentage of frames, i.e. periods of time, of EEG with substantial artifact. For each frame and channel, we computed the z-transformed power using the median and interquartile range, rather than the mean and standard deviation. We then averaged across all channels to obtain the mean normalized power for each frame. We identified noisy frames as having mean normalized powers greater than an interquartile threshold. We used a range of interquartile thresholds from 0.6 to 3.0, in increments of 0.2.

Channel sets that excluded more of the noisy channels (S1 & S2) tended to reject the fewest percentage of frames and had lower mean normalized EEG powers (Fig. 1B). Channel set S1 that excluded the noisiest channels rejected the fewest frames ~50% of the time and also had the lowest average normalized powers for 70% of the subjects. These results support our systematic statistical approach for artifact rejection of high-density EEG recorded during locomotor tasks.

REFERENCES

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