Detection of Eye Blinks from EEG using Hidden Markov Models

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Eye blinks are one of the major sources of physiological noise during electroencephalography (EEG) recordings [1]. There are two aspects in detecting eye blinks, automatic removal of eye blink artifacts and assessing the quality of the EEG record (in terms of its degradation due to eye blinks) for experiments such as brain computer interfaces (BCIs).

In this paper, hidden Markov models (HMMs) are used to detect eye blinks from fronto-polar electrodes (Fp1 and Fp2) of EEG recordings. One of the advantages of the current method is there is no need to have extra electroocculogram (EOG) channels for detection.

EEG signals were recorded with a 64-channel Biosemi Active 2 system. Seven subjects participated in experiments. Subjects were asked to move their right or left index finger depending on the arrow they saw on the screen approximately 1 meter away from them. Three-minute epochs were used for analysis from each subject.

First, EEG data were referenced to the Cz electrode. Then the data were downsampled from 2048 Hz to 256 Hz. Savitzky-Golay smoothing (SGS) was applied to the downsampled data (Figure A) for removal of low frequency trends. SGS is a local polynomial regression method, which preserves discriptive features of the data such as relative maxima and minima [2]. After SGS, smoothed data were substracted from the unsmoothed EEG data (Figure B). A left-to-right circular HMM model was trained using the forward-backward procedure [3]. Data were modeled with Gaussian mixtures. The HMM contains a background state corresponding to the time points in which no eye blinks occurs, together with 39 states corresponding to various phases of the eye blink [4]. The background state transitions to eye blinks with probability *p* and stays at itself with probability 1-*p* (Figure D). Transitions from state 2 to 40 occur with probability one. Detected eye blinks are superimposed on the data and indicated with red color (Figure C).

Table 1. Results

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**T**
TP	29	126	63	79	55	108	24	484
TN	0	2	3	3	2	3	1	14
FP	0	2	38	8	7	0	3	58

Results and Conclusion

Results in Table-1 show that 484 eye blinks out of 498 could be detected correctly (97.2 %). However there are 58 false alarms (FP). Especially 3 out of 7 subjects' false alarms are significantly high. One solution to this problem may be adjusting the order parameter in SGS. Person specific parameters might give better FP performance.

References

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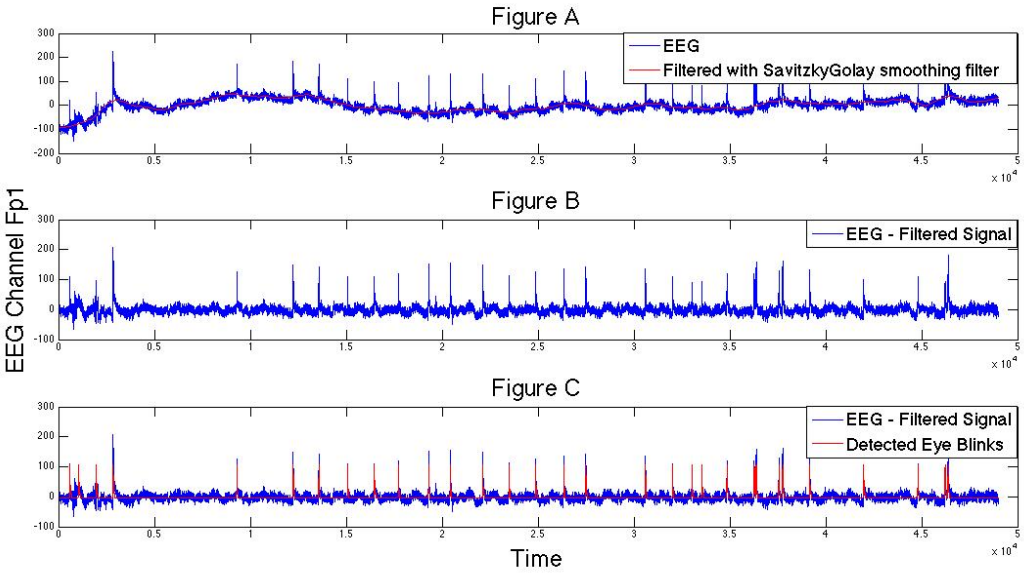

Figure D