REAL-TIME DETECTION OF SUPPRESSION IN EEG

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INTRODUCTION

In clinical settings, timely and robust detection of suppression in EEG signals is very important. In particular, the presence of burst-suppression pattern in EEG indicates deep general anesthesia or underlying severe neuropathology such as stroke and ischemia. With the advent of neurological monitoring for anesthetic management, anesthesiologists consider the presence of suppression as an ominous sign when not related to a high dosage of anesthetic drugs.

The automatic detection of suppression in EEG waveform is typically carried out based on a method inherited from visual observation, where suppression is defined as a period longer than 0.5 s with peak-to-peak amplitude less than 5 μV pp [1][1]. However, being based on peak-to-peak measurements, this method is particularly sensitive to noise and can fail to detect suppression in certain conditions.

In this study, we investigate the changes in the first derivative of EEG signals during suppression periods to develop an algorithm for automatic detection of suppression in real time. We also provide preliminary results where we compare the performance of our novel method to the visual annotations by an expert technologist. We further provide a comparison with the traditional peak-to-peak method for reference.

METHODS

(a) EEG recordings

Retrospective analysis was done on EEG signals acquired from 5 patients undergoing cardiovascular surgeries. The EEG signal was obtained using bilateral EasyPrep™ electrodes connected to the NeuroSENSE™ monitor at a sampling frequency of 900 S/s.

The suppression periods in the EEG signal were manually annotated. The EEG data, with the two channels combined together, consisted of a total of 5.19 hrs of annotated suppression periods.

(b) First derivative of EEG

The first time-derivative of EEG signal has shown some promise as an easily measurable proxy order parameter for the cerebral cortex [2]. The time-varying EEG signals reflect the fluctuations in the soma potential, and the first derivative of these fluctuations has been shown to be strongly linked to the mean soma potential.

A burst-suppression pattern in EEG may be generated due to activation of large and small number of neurons in an alternating fashion. Hence, it is expected to be accompanied by waxing and waning of the mean soma potential.

Fig. 1 presents a sample EEG segment exhibiting burst suppression pattern (1a) along with its first time-derivative (1b). One interesting thing to note is that the detection of suppression periods from the first derivative of EEG signal looks similar to the problem of silence detection in speech signals, or the detection of muscle inactivity in EMG signals.

For the time-varying EEG signal $s(t)$, we postulate that the median absolute value of the first derivative, i.e., $\mathrm{median}(|ds/dt|)$, should be a good candidate for suppression detection. This is because it gives a robust measure of the rate of change of EEG while reducing the importance of outliers such as ECG artifacts, etc.

(c) Suppression Detection

All the data processing was done using Matlab® v.7.4.0. The EEG was first preprocessed using the NeuroSENSE algorithm v.2.1.1.2 (notch filter at 50/60 Hz, high-pass filter at 0.5 Hz, decimation to 128 S/s) [3]. Suppression periods were then detected from the EEG data using both the traditional method based on peak-to-peak amplitude, and the new proposed method based on the first time-derivative of the EEG signal. **Fig. 1** shows the classification of a sample EEG segment into burst and suppression by visual detection (1c) and automatic detection using both the algorithms (1d, 1e).

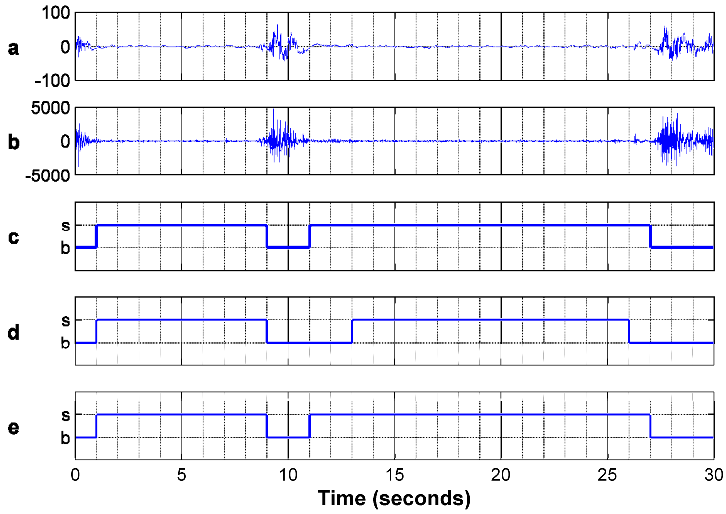

Fig. 1: (a) Sample EEG segment; (b) First derivative; (c) Visual detection; (d) Automatic detection using traditional method; (e) Automatic detection using new method [s: suppression; b: burst]

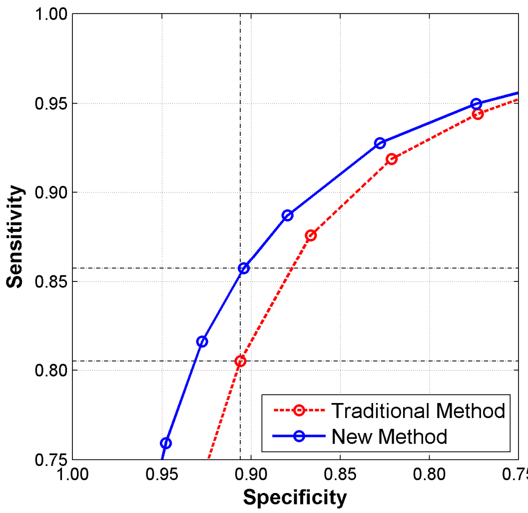

Fig. 2: ROC curve for suppression detection for the traditional and new method

RESULTS

The ROC curves for the detection of suppression periods in EEG signal using both the traditional and new method are shown in **Fig. 2**. It is apparent that the new method performs better than the traditional method in the detection of suppression. Using the traditional method with a detection threshold of 5 µV pp, the specificity and sensitivity are 90.60% and 80.52% respectively. For the same specificity, our proposed method gives an increased sensitivity of 85.73%.

CONCLUSIONS & DISCUSSION

This paper proposes a new method for the automatic detection of suppression in EEG signals based on its first-time derivative. The preliminary results obtained with this method were compared with the visual annotations by an expert technologist and the traditional peak-to-peak method. The new method appears to perform better than the traditional method in these clinical cases.

A more challenging dataset containing near-suppression patterns, for which the traditional peak-to-peak method may perform poorly, is currently being investigated.

REFERENCES

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