DEVELOPMENT OF A REAL-TIME AUTOMATIC ELECTROPHYSIOLOGICAL NOISE REDUCTION ALGORITHM BASED ON DISCRETE SPECTRUM ANALYSIS

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INTRODUCTION

Electrophysiological signals, such as electromyogram (EMG), electrocardiogram (ECG) and electroencephalogram (EEG) constituted a critical part of the physiological database in the rapidly developing field of medical-related artificial intelligence (A.I). Big data from gigabits to terabits is accumulated by daily-wearable devices and routinely sent to cloud server for post-processing. Thus, it provides us the possibility to implement machine learning or even deep learning to help us identify biomarkers. However, the most important factor to affect the accuracy of the model is not the complexity of algorithm or the network's architecture. The factor to affect the accuracy is the quality of preprocessing, which primally related to the data cleaning.

Conventional artifact-removal methods are either limited to their scope of application (specified to ECG or EEG artifact only) or have the hazards to filter out too much information (like ICA approach) [1]. Furthermore, the time-domain based machine learning algorithms are usually time-consuming, less accurate in extreme high-dimensional data and trigger the curse of dimensionality. Implementing the frequency-domain based algorithms can reduce the dimensionality but requires feature engineering to extract or construct useful features from the loads of information.

Thus, to optimize the preprocessing procedure, we proposed a real-time automatic noise-reduction algorithm to balance the processing accuracy and feasibility**.**

METHOD

Firstly, Hilbert filter is applied to filter out background noise (usually 50HZ and 60HZ). Based on the non-stationary feature of SEEG data, we choose Morlet wavelet [2] rather than normal Fourier transform to implement time-frequency analysis to visually inspect the time range of noise in each time clip. Secondly, a dynamic threshold method is applied to quantify information on the time-frequency spectrum to identify the location of noise in time sequence. By comparing the computed artifact markers with the ground-truth labelled noise, a binary classification is performed to quantify the algorithm precision.

RESULTS AND DISCUSSION

For the artifact removal, we choose a one second window as the detection unit. If noise is detected at time point 10.6 seconds, then the time range of (10,11) will be marked as 1 (like the blue rectangle) and those ground truth labels (red rectangles) will be transformed in the same way. Figure 2 displays the process of how to transfer it into a binary classification problem. The performance varies in different channel and patients. We choose F1-score as the benchmark to objectively measure he accuracy of the algorithm. The Table 1 and 2 show the result of two different channels.

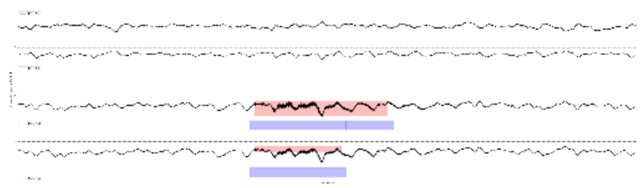

Figure 1. The red rectangles are ground-truth labels and blue rectangles are predicted values.

POL A13	True artifacts	True normal signal
Predicted artifacts	111	1
Predicted normal signal	43	3539

Table 1. The result in channel POL A13. The precision is 99.2%, recall is 72.1% and the F1 score is 0.835

POL A15	True artifacts	True normal signal
Predicted artifacts	382	6
Predicted normal signal	41	3171

Table 2. The result in channel POL A15. The precision is 98.6%, the recall is 90.3% and the F1 score is 0.942.

SIGNIFICANCE

This automatic noise detection algorithm can be used in electrophysiological signal preprocessing with precision and arithmetic processing speed. Successful application of this algorithm in big data processing can greatly shorten the data review time and improve computing efficiency in the post-processing.

REFERENCES

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