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Empirical Mode Decomposition based method for artefact removal in raw ICP signals

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Introduction

• Intracranial pressure (ICP) signals present macro-patterns potentially useful for diagnosis and classification of different neurological disease categories.

• ICP signals contain artefacts; e.g. very high and short physiologically impossible spikes. These reduce the accuracy of pattern recognition techniques, hindering clinical use of ICP.

• Previous methods for spikes removal assume signal stationarity. However, the ICP signal is non-linear and non-stationary (mean and variance change over time).

Methods: Empirical Mode Decomposition

1. Break down signal into sixteen components known as intrinsic mode functions (IMFs) via empirical mode decomposition (EMD) [2].

The first four IMFs (IMFs1-4) are chosen because their peaks locations align with the location of peaks in the ICP signal, highlighted with the purple boxes as examples.

2. Sum IMFs1-4 to enhance spike events, enabling a more robust artefact duration estimation. If detection is only based on IMF1 the widths of the spikes will be underestimated.

Thresholding for peak identification [1]: ICP segment considered a peak if found by IMFs and outside [−Pth1, Pth1], where:

\[ P_{th1} = \frac{\sigma}{\sqrt{2\ln(L)}} \]

\[ \sigma = \text{MAD} \]

\[ \text{MAD} = \text{Me}[\text{IMF}_{1-4}] - \text{Me}(|\text{IMF}_{1-4}|) \]

\[ L \] number of IMF samples

\[ \sigma \text{ standard deviation of the summed IMFs} \]

\[ \text{MAD} \text{ median absolute deviation} \]

Methods: peak identification

Figure 1. Raw ICP signal.

Figure 2. Examples of peaks in ICP signal and IMFS1-4.

Figure 3. Examples of peaks after summation of IMFS1-4.

Results

A new methodology based on EMD can be used for removal of unphysiological spikes in clinical ICP signals, which is essential for correct patient evaluation and diagnosis in the clinical practice.

• Calculation of detected peaks’ slew rates for spikes characterization.

• Methodology validation with visual spike identification as gold standard.

Conclusion

Ongoing research

References


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