Empirical mode decomposition based method for artefact removal in raw intracranial pressure signals

Martinez Tejada, Isabel; Wilhjelm, Jens E.; Juhler, Marianne; Andresen, Morten

Publication date:
2019

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Martinez Tejada, I., Wilhjelm, J. E., Juhler, M., & Andresen, M. (2019). *Empirical mode decomposition based method for artefact removal in raw intracranial pressure signals*. Poster session presented at 2019 International Symposium on Intracranial Pressure and Neuromonitoring, Leuven, Belgium.

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

Isabel Martinez-Tejada[1,2], Jens E. Wilhjelm[2], Marianne Juhler[1] and Morten Andresen[1]

[1]Department of Neurosurgery, Rigshospitalet, Blegdamsvej 9, DK-2100, Copenhagen Ø

[2]Department of Health Technology, Technical University of Denmark, Building 349, DK-2800, Kongens Lyngby

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).

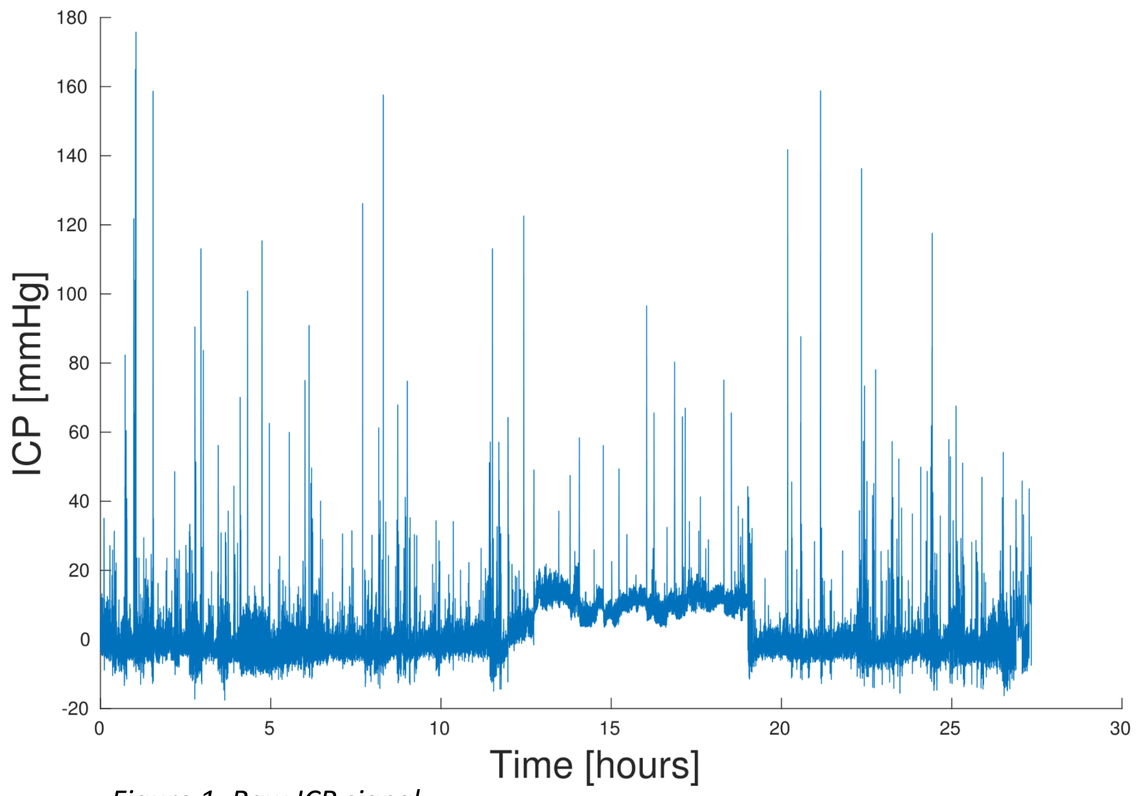

Figure 1. Raw ICP signal.

Objective

To investigate the performance of empirical mode decomposition (EMD) based techniques for spikes removal in raw ICP signals.

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 ($\text{IMFs}_{1\text{-}4}$) are chosen because their peaks locations align with the location of peaks in the ICP signal, highlighted with the purple boxes as examples.

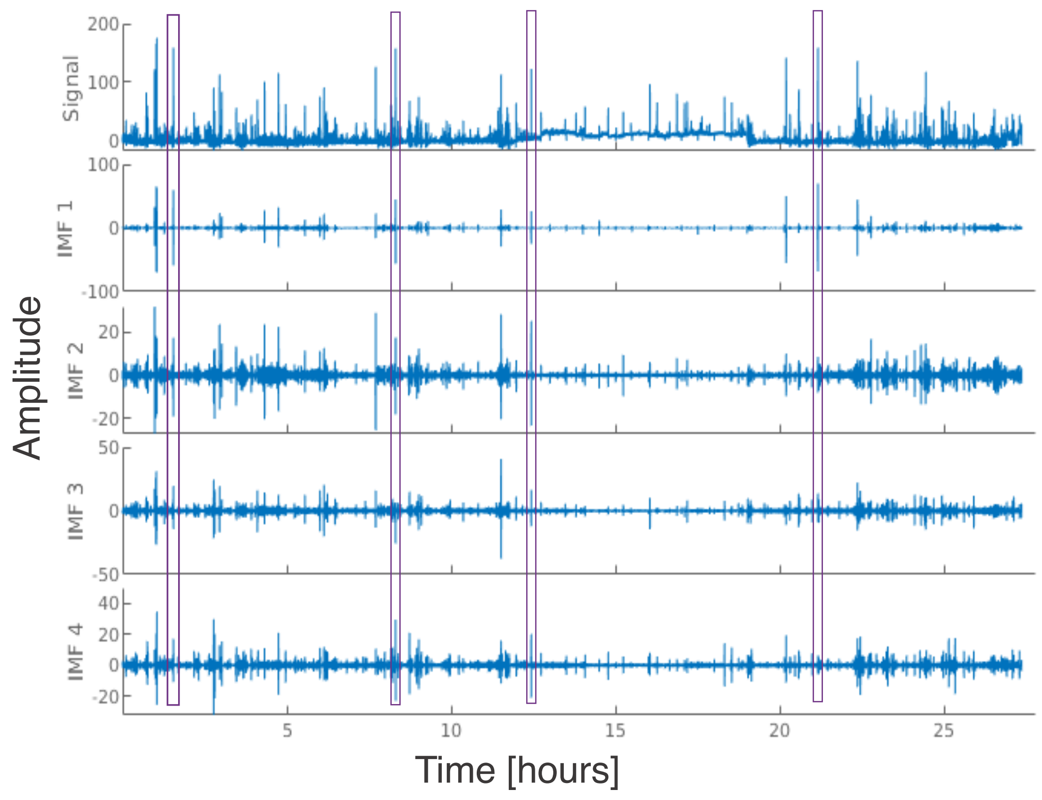

Figure 2. Examples of peaks in ICP signal and $\text{IMFS}_{1\text{-}4}$.

2. Sum $\text{IMFs}_{1\text{-}4}$ to enhance spike events, enabling a more robust artefact duration estimation.

If detection is only based on IMF_1 the widths of the spikes will be underestimated.

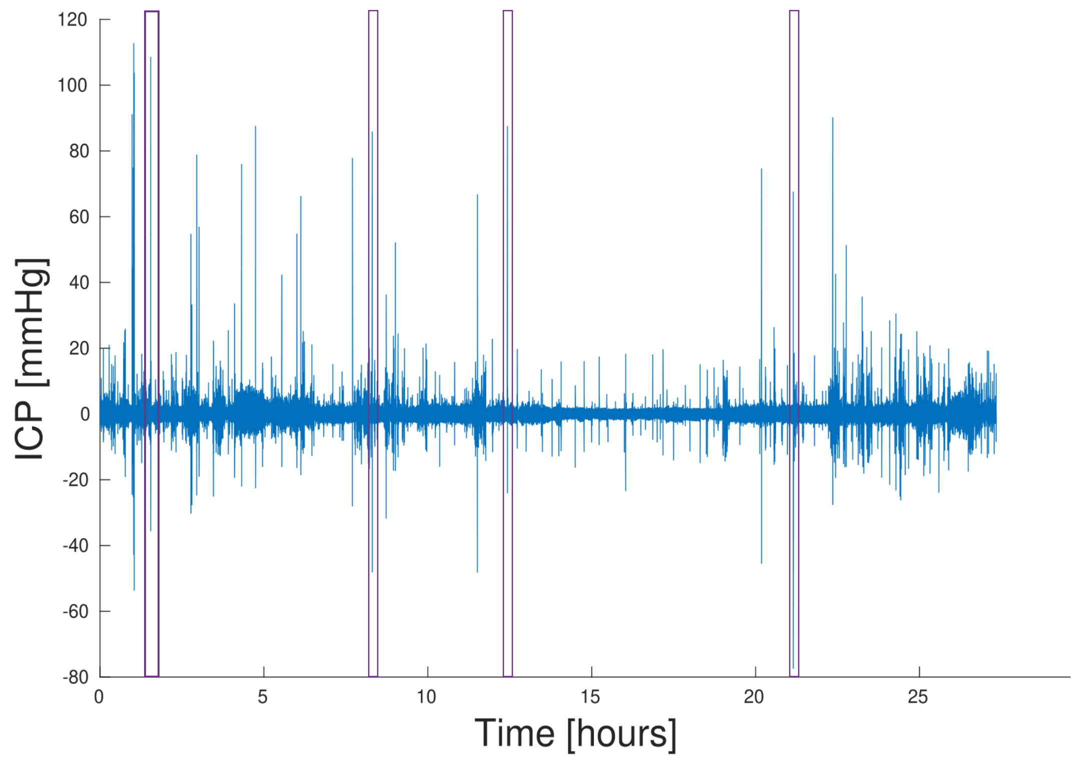

Figure 3. Examples of peaks after summation of $\text{IMFs}_{1\text{-}4}$.

Methods: peak identification

Thresholding for peak identification [1]: ICP segment considered a peak if found by IMFs *and* outside $[-P_{th}, P_{th}]$, where:

$$P_{th} = \hat{\sigma}\sqrt{2\log(L)} \qquad \hat{\sigma} = \frac{\text{MAD}}{0.6745}$$

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

$\hat{\sigma}$: standard deviation of the summed IMFs
L : number of IMF samples
Me: median
MAD: median absolute deviation

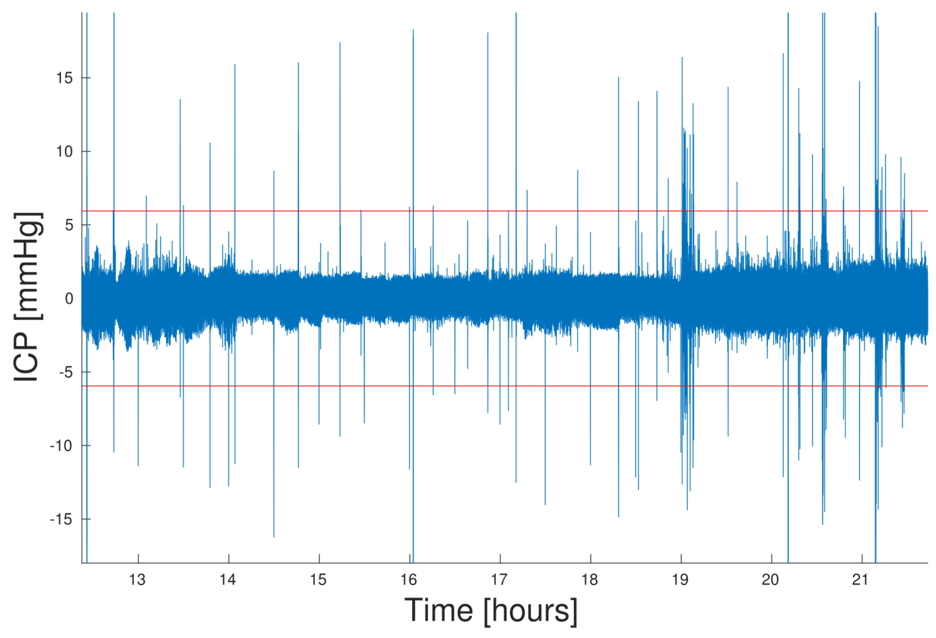

Figure 4. ICP signal with lower and upper thresholds marked in red.

Results

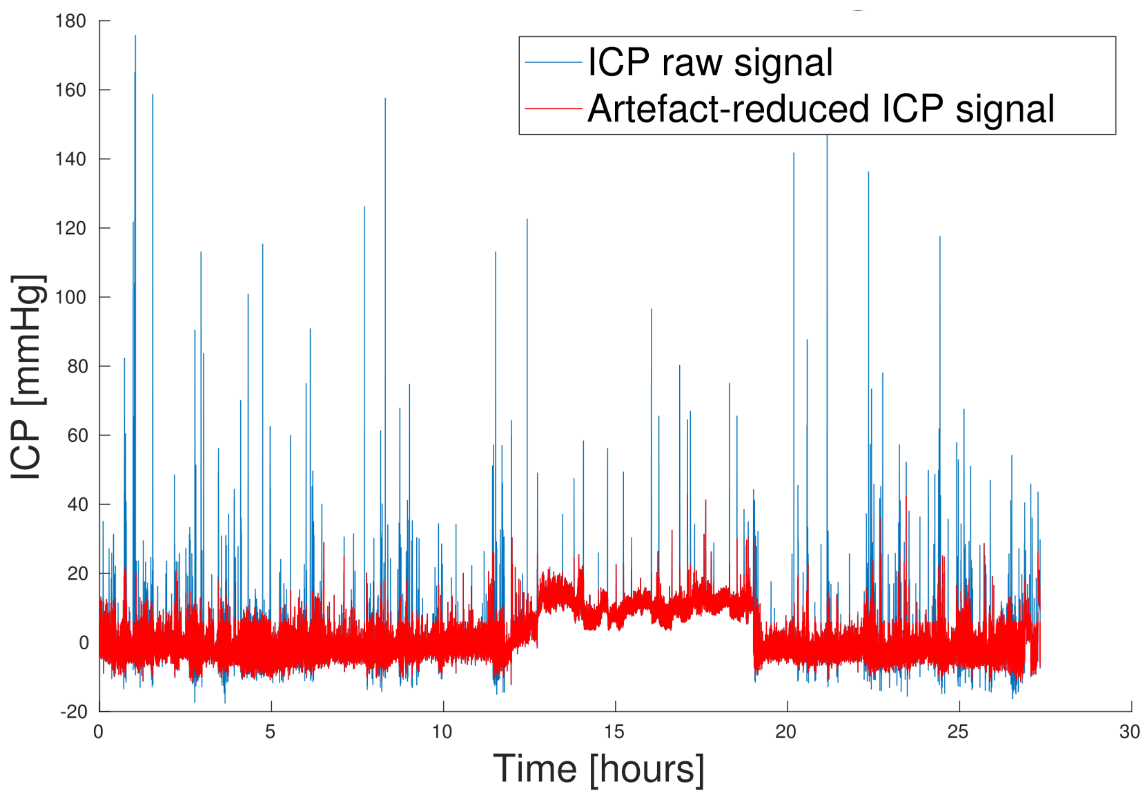

Figure 5. Artefact-reduced ICP signal.

Conclusion

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.

Ongoing research

- Calculation of detected peaks' slew rates for spikes characterization.
- Methodology validation with visual spike identification as gold standard.

References

[1] Boudraa, A. O., Cexus, J. C., & Saidi, Z. (2005). EMD-Based Signal Noise Reduction. Proceedings of World Academy of Science, Engineering and Technology, 2, 93–96.

[2] Feng, M., Loy, L. Y., Zhang, F., & Guan, C. (2011). Artifact removal for intracranial pressure monitoring signals: A robust solution with signal decomposition. Proceedings of the Annual International Conference of the Ieee Engineering in Medicine and Biology Society, Embs, 2011, 6090182, 797–801.

Acknowledgements

The authors are thankful for contributions from the Novo Nordisk Foundation Tandem Programme.

imate@dtu.dk jwil@dtu.dk marianne.juhler@regionh.dk andresen@gmail.com