Distinguishing between pre- and post-incision under general anaesthesia by spectral and recurrence analysis of EEG data

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Nowadays, surgical operations are impossible to imagine without general anaesthesia, which involves loss of consciousness, immobility, amnesia and analgesia. Understanding mechanisms underlying each of these effects guarantees well-controlled medical treatment.
Our work focuses on analgesia effect of general anaesthesia, more specifically, on patients reaction on nociception stimuli. The study was conducted on dataset consisting of 230 EEG signals: pre- and post-incisional recordings for 115 patients, who received desflurane and propofol [1].
Initial analysis was performed by power spectral analysis, which is a widespread approach in signal processing. Power spectral information was described by fitting the background activity and measuring power contained in delta and alpha bands according to power of background activity. The fact that power spectrum of background activity decays as frequency increasing is well known and thoroughly studied [2]. Here, traditional $1/f^\alpha$ behaviour of the decay was replaced by a Lorentzian model to describe the power spectrum of background activity.
Due to observed non-stationary nature of EEG signals spectral analysis does not suffice to reveal significant changes between two states. A further improvement was done by expanding spectra with time information. To obtain time-frequency representations of the signals conventional spectrograms were used as well as a spectrogram reassignment technique [3]. The latter allows to ameliorate readability of a spectrogram by reassigning energy contained in spectrogram to more precise positions.
Subsequently, obtained spectrograms were used in recurrence analysis [4] and its quantification by complexity measure. Recurrence analysis allows to describe and visualise dynamics of a system and discover structural patterns contained in the data.

Structure of each recurrence plot is characterised by Lempel–Ziv complexity measure [5].

Acknowledgements

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References

1. James W. Sleigh, Leslie, K. & Voss, L. The effect of skin incision on the electroencephalogram during general anesthesia maintained with propofol or desflurane. Journal of clinical monitoring and computing 24, 307–18 (2010), 10.1007/s10877-010-9251-3

2. Bédard, C. & Destexhe, A. Macroscopic Models of Local Field Potentials and the Apparent 1/f Noise in Brain Activity. Biophysical Journal 96, 2589–2603 (2009), 10.1016/j.bpj.2008.12.3951

3. Auger, F. et al. Time-Frequency Reassignment and Synchrosqueezing: An Overview. IEEE Signal Processing Magazine 30, 32–41 (2013), 10.1109/MSP.2013.2265316

4. Marwan, N., Carmenromano, M., Thiel, M. & Kurths, J. Recurrence plots for the analysis of complex systems. Physics Reports 438, 237–329 (2007), 10.1016/j.physrep.2006.11.001

5. Zhang, X.-S., Roy, R. J. & Jensen, E. W. EEG complexity as a measure of depth of anesthesia for patients. Biomedical Engineering, IEEE Transactions on 48, 1424–1433 (2001), 10.1109/10.966601

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