

Automatic detection - different types of detection algorithms, validation and adaptation

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Abstract

High Frequency Oscillations (HFOs 30-600 Hz) are electrophysiological signatures of both physiological and pathological activity. They typically appear during slow wave sleep (Staba et al., 2002) or may occur in epileptogenic regions at the time - or independently - of interictal spikes (Jacobs et al., 2008) or at the onset of seizures (Bartolomei et al., 2008). As a matter of fact, the terminology "HFO" covers a variety of activities that may have specific spectral characteristics (Worrell et al., 2004), spatial extent (Zijlmans et al., 2011) and clinical value (Jiruska et al., 2010). In this context, the proper detection and identification of HFOs is crucial. However the automatic detection of HFOs is recognized as a difficult problem, due to: i) poor signal-to-noise ratio, ii) contamination of signals by transient broadband events like spikes or artifacts, iii) pitfalls in applying classical filtering techniques (Benar et al., 2010), and iv) wide diversity of oscillations occurring from the gamma (>30 Hz) up to the fast ripple (<600 Hz) frequency band. During this teaching workshop, some basic principles of signal detection and characterization will be presented. Then a number of algorithms that implement these principles for HFO detection and classification will be described. Advantages and limitations of proposed approaches will be discussed along with their performance in the context of interictal (Biro et al., 2013; Blanco et al., 2010; Staba et al., 2002) and ictal ((Bartolomei et al., 2008), (David et al., 2011), (Gnatkovsky et al., 2011)) activity.

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References

- Bartolomei F, Chauvel P, Wendling F. Epileptogenicity of brain structures in human temporal lobe epilepsy: a quantified study from intracerebral EEG. *Brain : a journal of neurology*, 2008; 131: 1818-30.
- Benar CG, Chauviere L, Bartolomei F, Wendling F. Pitfalls of high-pass filtering for detecting epileptic oscillations: a technical note on "false" ripples. *Clinical neurophysiology : official journal of the International Federation of Clinical Neurophysiology*, 2010; 121: 301-10.
- Biro G, Kachenoura A, Albera L, Benar C, Wendling F. Automatic detection of fast ripples. *Journal of neuroscience methods*, 2013; 213: 236-49.
- Blanco JA, Stead M, Krieger A, Viventi J, Marsh WR, Lee KH, Worrell GA, Litt B. Unsupervised classification of high-frequency oscillations in human neocortical epilepsy and control patients. *Journal of neurophysiology*, 2010; 104: 2900-12.
- David O, Blauwblomme T, Job AS, Chabardes S, Hoffmann D, Minotti L, Kahane P. Imaging the seizure onset zone with stereo-electroencephalography. *Brain : a journal of neurology*, 2011; 134: 2898-911.
- Gnatkovsky V, Francione S, Cardinale F, Mai R, Tassi L, Lo Russo G, de Curtis M. Identification of reproducible ictal patterns based on quantified frequency analysis of intracranial EEG signals. *Epilepsia*, 2011; 52: 477-88.
- Jacobs J, LeVan P, Chander R, Hall J, Dubeau F, Gotman J. Interictal high-frequency oscillations (80-500 Hz) are an indicator of seizure onset areas independent of spikes in the human epileptic brain. *Epilepsia*, 2008; 49: 1893-907.
- Jiruska P, Finnerty GT, Powell AD, Lofti N, Cmejla R, Jefferys JG. Epileptic high-frequency network activity in a model of non-lesional temporal lobe epilepsy. *Brain : a journal of neurology*, 2010; 133: 1380-90.
- Staba RJ, Wilson CL, Bragin A, Fried I, Engel J, Jr. Quantitative analysis of high-frequency oscillations (80-500 Hz) recorded in human epileptic hippocampus and entorhinal cortex. *Journal of neurophysiology*, 2002; 88: 1743-52.
- Worrell GA, Parish L, Cranstoun SD, Jonas R, Baltuch G, Litt B. High-frequency oscillations and seizure generation in neocortical epilepsy. *Brain*, 2004; 127: 1496-506.
- Zijlmans M, Jacobs J, Kahn YU, Zelmann R, Dubeau F, Gotman J. Ictal and interictal high frequency oscillations in patients with focal epilepsy. *Clin Neurophysiol*, 2011; 122: 664-71.