Neuroscience 2015

Presentation Abstract

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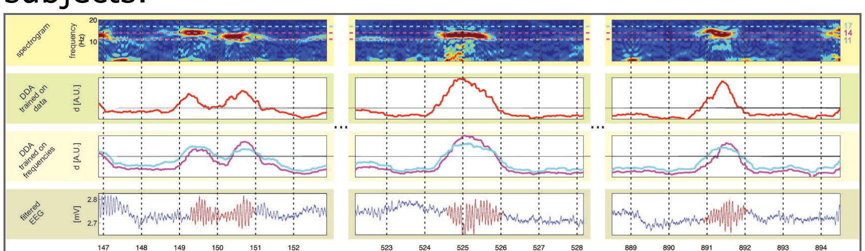
| Program#/Poster#: | 815.14/Z16 |
| Presentation Title: | Nonlinear dynamical sleep spindle detection using delay differential analysis |
| Location: | Hall A |
| Presentation time: | Wednesday, Oct 21, 2015, 1:00 PM - 5:00 PM |
| Presenter at Poster: | Wed, Oct. 21, 2015, 2:00 PM - 3:00 PM |
| Topic: | ++E.08.e Sleep: Systems |
| Authors: | ***A. L. SAMPSON**[1,2], C. LAINSCSEK[1,2], S. S. CASH[3,4], E. HALGREN[2], T. J. SEJNOWSKI[1,2];<br>[1]Salk Inst. For Biol. Studies, La Jolla, CA; [2]UCSD, La Jolla, CA; [3]Massachusetts Gen. Hosp., Boston, MA; [4]Harvard Med. Sch., Boston, MA |
| Abstract: | Since nonlinear data analysis works upon the dynamical structure of the data, it allows for classification in near real time of raw data. Here, we use delay differential analysis (DDA), which is a time domain classification framework based on embedding theory. An embedding reveals the nonlinear invariant properties of an unknown dynamical system (here the brain) from a single time series (here electrocephalogram (EEG) data). The |

embedding in DDA serves as a low-dimensional nonlinear functional basis onto which the data are mapped. Since the basis is built on the dynamical structure of the data, preprocessing of the data is not necessary, and the low dimensionality removes the risk of overfitting. A model that was trained on a single EEG channel from one subject can be applied to a wide range of data from different subjects, channels, and recording systems. Given these desirable properties, DDA is ideally suited to the problem of sleep spindle detection. Sleep spindles are 11-17 Hz oscillations recorded in the EEG during stage 2 sleep. As sleep spindles are thought to arise from the activity of thalamocortical circuitry, they have become a subject of study for their potential roles in memory consolidation and other cognitive functions. In light of their potential importance, a method for reliably identifying spindles in real time is needed. DDA analyses were applied to intracranial recordings from patients with intractable epilepsy and compared to traditional wavelet methods. As a bridge between these two methods, an additional DDA classifier was built on simulated data (noise-diluted harmonics) to detect frequency bands. One single set of DDA parameters can be used for 15 tested recordings. The mean area under the receiver operating characteristic curve is 0.75. DDA is a powerful method for improving the sensitivity of EEG analyses to transitory time series features that does not rely on any post-hoc adjustment of outputs or tailoring to individual subjects.



The figure shows the abovementioned spindle detection algorithm results. The lowest row in the plot shows the data with the spindles marked by a human expert. In the next row, the DDA frequency band detector outputs are shown (in blue for a 11-17 Hz band and in magenta for a 11-14 Hz band). In the next row, the DDA output (trained on one channel from a different subject) is shown. We also show the spectrograms for reference.

Lainscsek, C. Sejnowski, T.J. Delay Differential Analysis of Time Series, Neural Computation, 27, 594-614, 2015

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| Disclosures: | **A.L. Sampson:** None. **C. Lainscsek:** None. **S.S. Cash:** None. **E. Halgren:** None. **T.J. Sejnowski:** None. |
| Keyword (s): | SLEEP |

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