Biomed Tech 2012; 57 (Suppl. 1) © 2012 by Walter de Gruyter · Berlin · Boston. DOI 10.1515/bmt-2012-4537

Complex Synchronization and Recurrence Analyses – re such Nonlinear Techniques Useful for Brain Oscillation Studies?

J. Kurths[1, 2, 3], N. Marwan[2], M. Riedl[1], S. Schinkel[1]

[1]Humboldt-Universität zu Berlin, Institute of Physics, Robert-Koch-Platz 4, D-10115 Berlin, Germany

[2], Potsdam Institute for Climate Impact Research, Telegraphenberg, P.O. Box 601203, D-14412 Potsdam, Germany

[3]King´s College, University of Aberdeen, UK

Abstract

Biological systems are typically composed of several subsystems which interact via several feedbacks. They are, therefore, typical examples of complex systems which are able to self-organization and complex structure formation even for rather weak changes of parameters or environment.

Basing on modern measurement techniques, such systems can be quantified by multivariate time series. To interpret these records and to understand basic properties of the underlying complex dynamics, it is, however, necessary to apply methods from Nonlinear Dynamics and Complex Systems Theory. Note that linear techniques, such as spectral and correlation analysis, can uncover only linear structures.

We present some modern nonlinear analysis techniques, apply them to multivariate biosignals and discuss their potentials resp. limits in comparison with well-known linear methods. We especially discuss two main approaches: i) synchronization analysis of even weakly coupled subsystems, and ii) quantification of (complex) recurrence properties.

The corresponding techniques will be applied to understand the implications of such network structures on the functional organization of the brain activities. We investigate synchronization dynamics on the cortico-cortical network of mammals and find that the network displays clustered synchronization behaviour and the dynamical clusters coincide with the topological community structures observed in the corresponding anatomical network. Next, we aim at investigating how graph theoretical approaches can help to discover systematic and task-dependent differences in high-level cognitive processes such as language perception. We will show that such an approach is feasible and that the results coincide well with the findings from neuroimaging studies.

References
Arenas, A., A. Diaz-Guilera, J. Kurths, Y. Moreno, and C. Zhou, Phys. Reports 2008, 469, 93.
Van Leeuwen, P., D. Geue, M. Thiel, D. Cysarz, S. Lange, M.C. Romano, J. Kurths, D.Grönemeyer, PNAS 2009, 106, 13661.
Marwan, N., M. Romano, M. Thiel, J. Kurths, Phys. Reports 2007, 438, 237.
Nawrath, J., M. Romano, M. Thiel, I. Kiss, J. Timmer, J. Kurths, B. Schelter, Phys. Rev. Lett. 2010, 104, 038701.
Zamora, G. Zhou, C. and Kurths, J., Frontiers Neurosc. 2011, 5, 83.
Zamora, G., E. Russo, P. Gleiser, C. Zhou, J. Kurths, Phil. Trans. A 2011, 369, 3730.
Schinkel, S., G. Zamora, O. Dimigen, W. Sommer, J. Kurths, J. Neurosc. Meth. 2011, 197, 333.

Bereitgestellt von | Bibliothek des Wissenschaftsparks Albert Einstein
Angemeldet | 193.174.18.1
Heruntergeladen am | 18.09.12 11:38