The Measurement and Analysis of Cortical Networks

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ABSTRACT

Technological advances over the past five years have led to an unprecedented level of volume and detail in the acquisition of neuroscientific data relating to the mammalian brain. However, this creates significant challenges in the processing and interpretation of the data. We will adopt a network-centric approach to tackle this, as it matches the physical structure of the brain.

We present methods to extract functional brain networks from spatio-temporal time series that describe neural activity, such as in functional magnetic resonance imaging (fMRI). These networks capture intrinsic brain dynamics. We describe computational methods to extract topological regularities in such networks, including motifs and cycles.

We analyze the relationship between the structure of the network, as represented by its motifs, and its function. For instance, example hub neurons in the hippocampus promote synchrony and shortest loops act as pacemakers of neural activity. We demonstrate the relevance of the network analysis techniques in understanding specific brain-related disorders such as schizophrenia and autism. For instance, the disruption of cortical networks involved in synchronization may be a contributor to autism and schizophrenic patients which have been shown to have higher connectivity within the default mode network.

ABOUT THE KEYNOTE SPEAKER

Dr. A. Ravishankar Rao is a Research staff member at the Computational Biology Center within the IBM T.J. Watson Research Center, Yorktown Heights, New York. His research interests include image processing, computer vision and computational neuroscience. He is currently working on the analysis of brain images and mathematical modeling of neural circuits with the goal of understanding computation in the brain. He is an Associate Editor of the journals Neural Networks, Pattern Recognition and Machine Vision and Applications. He received his B.Tech degree in electrical engineering from the Indian Institute of Technology, and a Ph.D. in computer engineering from the University of Michigan, Ann Arbor. His research has resulted in twenty-three patents and over fifty publications. He has published a book entitled “A Taxonomy for Texture Description and Identification,” and co-edited the books, “High throughput Image Reconstruction and Analysis”, and “The Relevance of the Time Domain to Neural Network Models”. He is the founding chair of the New York Chapter of the IEEE Computational Intelligence Society. He is an IEEE Fellow, and a Master Inventor at IBM.