Dr. Todd Coleman, Assistant Professor, ECE and Neuroscience, U. Illinois
http://colemant.ece.illinois.edu

"Understanding How Information is Represented and Processed in Dynamic Interacting Networks of Neural Activity", May 26th, 11am

Abstract:
"It was hypothesized decades ago by the famous neuroscientist D. O. Hebb that a fundamentally important aspect of neural computation in the brain - termed cellular assembly theory - rests upon not only on the interaction between proximal, anatomically connected neurons within a few synapses of one another, but also distal, long-range communication between neurons whose behavior are related in functionally specialized manners. Until recently, understanding the details of how this phenomena might or might not take place was impossible - due to limitations in being able to record the neural activity in many different sites in the brain. Nowadays, due to advances in neurotechnology, it is increasingly common to simultaneously record many neural signals simultaneously. In fact, an over-abundance of data has now led to the problem of data deluge: the biggest current challenge in quantitative neuroscience is to develop parsimonious, scalable toolsets that can taze out the detailed nature of the dynamical interaction between brain signal.

It is the purpose of this talk to discuss multi-scale statistical modeling techniques that explain - in an information theoretically good manner - the dynamic, causal interactions between neural signals. Equally as important, we here develop macro-scale modeling techniques that enable a way to parsimoniously describe these dynamic interactions - via provably good information-theoretic clustering algorithms, for the purpose of visualization of the most important aspects of the dynamics. The underlying idea driving this approach is that of sequential prediction and reduction in loss - a general purpose viewpoint of Granger's notion of causality that is applicable to arbitrary modalities.

We demonstrate the effectiveness of this approach on both simulated and experimental datasets as well as data sets. The latter pertain to the recordings in primary motor cortex of an awake behaving monkey preceding a movement. There, the procedure identified strong structure in the estimated causal relationships, the directionality of which is consistent with previous experimental findings of wave propagation in the simultaneously recorded local field potentials. Moreover, the estimated speed of propagation at the level of neural spike trains was 28.6 cm/s, as compared to the 30 cm/s found with local field potentials. These findings demonstrate an interesting link between the causal, directional interactions at the level of both LFPs and spike trains that is demonstrative of how information is processed preceding movements in motor cortex."

Representative Readings

C. Quinn, T. P. Coleman, N. Kiyavash, and N. G. Hatsopoulos, "Estimating the directed information to infer causal relationships in ensemble neural spike train recordings", *Journal of Computational Neuroscience*, June 2010
http://colemant.ece.illinois.edu/pubs/JCNS_QCKH_June2010FINAL.pdf

C. Quinn, N. Kiyavash, and T. P. Coleman, "Equivalence Between Minimal Generative Model Graphs and Directed Information Graphs", submitted to *IEEE International Symposium on Information Theory* , February 2011.
http://colemant.ece.illinois.edu/pubs/ISIT_QKC_Feb2011_subm.pdf

C. Quinn, T. P. Coleman and N. Kiyavash, "Causal Dependence Tree Approximations of Joint Distributions for Multiple Random Processes", submitted to*IEEE Transactions on Information Theory* , January 2011.
http://colemant.ece.illinois.edu/pubs/TransIT_QCK_Jan2011_submission.pdf