Joint Department of
BIOMEDICAL ENGINEERING

UNC CHAPEL HILL | NC STATE UNIVERSITY

Special Rehabilitation Engineering Seminar

Enabling Optical Methods for Next-Generation Neural Prostheses

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Dr. Giovannucci has a Ph.D. in computer science from Universitat Autònoma de Barcelona in Spain and a B.S. in electrical engineering from Politecnico di Milano in Italy. From 2008 to 2010 he was a postdoctoral fellow at Pompeu Fabra University (Barcelona), where he developed signal processing algorithms and circuit models for neuroprosthetic applications. From 2010 to 2015 he completed a postdoctoral fellowship at the Princeton Neuroscience Institute (PNI), Princeton University. At PNI, he pioneered the use of genetically encoded calcium indicators to image neurons in the cerebellum of awake learning mice, and applied them to investigate coding properties of cerebellar neurons during motor learning. Since 2015 Andrea Giovannucci is a research scientist at the Flatiron Institute, Simons Foundation, where he develops algorithms for the analysis of calcium imaging data, general-purpose neural networks and data-intensive computing projects. Dr. Giovannucci was the recipient of the First Prize for the Best Agent Service or Application in the Agent Technology Competition (IST Agentcities.net) in 2003, was shortlisted for the best Ph.D. thesis in artificial intelligence (ECCAI), and was the recipient of the prestigious Juan de La Cierva (Spain) and New Jersey Commission on Brain Injury Research (USA) fellowships. Andrea Giovannucci is the leader developer of the CaImAn open source software platform for calcium imaging analysis, currently used by hundreds of research laboratories worldwide.

ABSTRACT

Optical methods present interesting new opportunities for brain-computer interfaces (BCIs) and closed-loop experiments because of their capability to densely monitor and stimulate in-vivo large neural populations across weeks with single cell resolution. For instance, combining optical methods for recording (two-photon imaging of calcium indicators) and perturbing (optogenetics) neural ensembles opens the door to exciting closed-loop experiments, where the stimulation pattern can be determined based on the recorded activity and/or the behavioral state. However, the adoption of such tools for BCIs is currently hindered by the lack of algorithms that track neural activity in real-time. In a typical closed-loop experiment, the monitored/perturbed regions of interest (ROIs) have been preselected by analyzing offline a previous dataset from the same field of view. Monitoring the activity of a ROI, which usually corresponds to a soma, typically entails averaging the fluorescence over the corresponding ROI, resulting in a signal that is only a proxy for the actual neural activity and which can be sensitive to motion artifacts and drifts, as well as spatially overlapping sources, background/neuropil contamination, and noise. Furthermore, by preselecting the ROIs, the experimenter is unable to detect and incorporate new sources that become active later during the experiment or track changes in neuronal morphology, which prevents the execution of truly closed-loop experiments.

RERESHMENTS PROVIDED

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