GCC Theoretical & Computational Neuroscience 15th Annual Conference

January 26, 2018

BioScience Research Collaborative

6500 Main St.

Conference Organizers:
Fabrizio Gabbiani, Baylor College of Medicine;
Krešimir Josić, University of Houston;
Xaq Pitkow, Rice University and Baylor College of Medicine;
Harel Shouval, UT Health Science Center

Gulf Coast Consortia

QUANTITATIVE BIOMEDICAL SCIENCES

Conference Sponsor:

The **Gulf Coast Consortia (GCC)** is a dynamic, multi-institution collaboration of basic and translational scientists, researchers, clinicians and students in the quantitative biomedical sciences who participate in joint training programs, utilize shared facilities and equipment, and exchange scientific knowledge. Working together, GCC member institutions provide a cutting edge collaborative training environment and research infrastructure, beyond the capability of any single institution.

GCC training programs provide opportunities for a new generation of scientists. Current programs for predoctoral and/or postdoctoral trainees focus on

- **Biomedical Informatics and Data Science** (NIH/NLM)
- **Computational Cancer Biology** (also summer program for undergrads) (CPRIT)
- **Interdisciplinary Pharmacology** (NIH/NIGMS)
- **Molecular Biophysics** (NIH/NIGMS)
- **Neuroengineering** (NSF)

GCC research consortia and clusters catalyze cross-institutional interactions to provide support for collaborative research; acquire funding for research centers and shared research facilities and equipment; and sponsor workshops, symposia and conferences that promote collaboration. New consortia form when faculty come together around a common interest, establish a working vision and engage a broad faculty community. Their shared vision may be developed into newly forming clusters with potential to grow into a consortium.

Consortia

- **Chemical Genomics**
- **Magnetic Resonance**
- **Regenerative Medicine**
- **Theoretical and Computational Neuroscience**
- **Translational Pain Research**

Clusters

- **Alcohol and Addiction Research**
- **Antimicrobial Resistance**
- **Nano-X**
- **Neuroengineering**

More than 450 faculty are engaged in GCC programs. Current GCC members are Baylor College of Medicine, Rice University, University of Houston, The University of Texas Health Science Center at Houston, The University of Texas Medical Branch at Galveston, The University of Texas MD Anderson Cancer Center, and the Institute of Biosciences and Technology of Texas A&M Health Science Center.

The GCC supports the research efforts of our biomedical community by providing research conferences and symposia throughout the year and Research Mentor Training workshops for postdocs and faculty and Rigor & Reproducibility workshops for all levels of researchers. More information may be found on our website.

www.gulfcoastconsortia.org

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QUANTITATIVE BIOMEDICAL SCIENCES

15TH ANNUAL GCC CONFERENCE ON THEORETICAL AND COMPUTATIONAL NEUROSCIENCE

Agenda

Friday, January 26, 2018
BioScience Research Collaborative, 6500 Main St, First Floor Auditorium

10:00	Poster Set-up and Light Breakfast
10:30	Welcome
10:40 - 11:20	**Robert Rosenbaum**, **PhD**, Assistant Professor, Applied and Computational Mathematics and Statistics, University of Notre Dame *A Reservoir Computing Model of Motor Learning with Parallel Cortical and Basal Ganglia Pathways*
11:20 - 11:40	**Kaushik Lakshminarasimhan**, Predoctoral Student, Neuroscience, Baylor College of Medicine *Task Representation in the Macaque Posterior Parietal Cortex during Virtual Navigation*
11:40 - 12:20	Poster Session and Poster Judging
12:20 - 12:55	Lunch and Posters
1:00 - 1:50	**Cristina Savin, PhD**, Assistant Professor, Neural Science and Data Science, New York University *Spike-based Probabilistic Computation*
1:50 - 2:10	**Etienne Ackermann**, Predoctoral Student, Electrical & Computer Engineering, Rice University *O Replay, Replay! Wherefore Art Thou Replay?*
2:10 - 2:30	**Hongxia Wang, PhD**, Postdoctoral Fellow, Neuroscience, Baylor College of Medicine *Feed Forward Inhibition Conveys Time-varying Stimulus Information in a Collision Detection Circuit*
2:30 - 2:55	Coffee/Networking Break
2:55 - 3:55	Group Discussion
3:55 - 4:45	**Keynote/Keck Seminar Speaker:** **Stuart Geman, PhD,** Professor, Applied Mathematics, Brown University *Universal Binding*
4:45 - 5:00	Poster Awards and Closing Remarks
5:00	Reception

Organizing Committee:
Fabrizio Gabbiani, Professor, Neuroscience, Baylor College of Medicine
Krešimir Josić, Professor, Mathematics, University of Houston
Xaq Pitkow, Assistant Professor, Neuroscience, Baylor College of Medicine / Electrical & Computer Engineering, Rice University
Harel Shouval, Professor, Neurobiology & Anatomy, UT Health Science Center at Houston

Speaker Abstracts
(in order of appearance)

Robert Rosenbaum, PhD
Assistant Professor, Applied and Computational Mathematics and Statistics
University of Notre Dame
A Reservoir Computing Model of Motor Learning with Parallel Cortical and Basal Ganglia Pathways

About Dr. Rosenbaum: Dr. Rosenbaum received his PhD in Mathematics at the University of Houston in 2011 where he studied the transfer and propagation of correlated neuronal activity with Krešimir Josić. From 2011-2014, he was a postdoctoral associate at the University of Pittsburgh in the department of Mathematics. In 2014, he became an assistant professor in the department of Applied and Computational Mathematics and Statistics at Notre Dame University and a member of the Neural Dynamics and Computing Group. Dr. Rosenbaum uses computational and mathematical methods to study how coherent function emerges from the interplay between structure and dynamics in the brain.
https://www3.nd.edu/~rrosenb1/

Abstract: Reservoir computing is a biologically inspired class of learning algorithms in which the intrinsic dynamics of a recurrent neural network are mined to produce target time series. Most existing reservoir computing algorithms rely on fully supervised learning rules, which require access to an exact copy of the target response, greatly reducing the utility of the system. Reinforcement learning rules have been developed for reservoir computing, but we find that they fail to converge on complex motor tasks. Current theories of biological motor learning pose that early learning is controlled by dopamine modulated plasticity in the basal ganglia that trains parallel cortical pathways through unsupervised plasticity as a motor task becomes well-learned. We developed a novel learning algorithm for reservoir computing that models the interaction between reinforcement and unsupervised learning observed in experiments. This algorithm converges on simulated motor tasks on which previous reservoir computing algorithms fail, and reproduces experimental findings that relate Parkinson's disease and its treatments to motor learning. Hence, incorporating biological theories of motor learning improves the effectiveness and biological relevance of reservoir computing models.

Kaushik Lakshminarasimhan
Predoctoral Student, Neuroscience
Baylor College of Medicine
Task Representation in the Macaque Posterior Parietal Cortex during Virtual Navigation

Abstract: Much of what we know about how the brain computes comes from highly controlled tasks that use stimuli with stationary statistics and a limited set of actions (usually two). Such tasks may be inadequate to fully reveal the rich structure of neural representations and computations that mediate fluid behaviour. To understand dynamic neural processing underlying natural behaviour, we trained macaque monkeys on a continuous-time foraging task in which they used a joystick to steer freely and catch targets in a two-dimensional virtual environment devoid of landmarks. In order to solve the task, monkeys had to dynamically update their position estimates by integrating optic flow generated by self-motion. We implanted multi-electrode arrays to sample the activity of a large number of neurons in the posterior parietal cortex (PPC). Fitting a generalized additive model to the neural activity revealed that a majority of neurons encoded multiple task-relevant variables ranging from the monkeys' instantaneous linear and angular velocity to more abstract, integrated variables such as distance and direction of heading. We then inferred the structure of neural interactions by extending our model to include coupling between neurons. We found that there was sparse but indiscriminate flow of information between neurons encoding different task variables, and that the coupled model provided a better account of neural responses. To understand how task variables are represented at the population level, we used canonical correlation analysis and found that the dimensionality of task-relevant neural subspace was as high as possible.

Similar analyses on uncoupled and coupled model populations showed that coupling between neurons was responsible for broadening the task representation. These results demonstrate that recurrent connections in the primate PPC facilitate processing and integration of sensory inputs in dynamic environments.

Cristina Savin, PhD
Assistant Professor, Neural Science and Data Science
New York University
Spike-based Probabilistic Computation

About Dr. Savin: Dr. Savin received her PhD in Computational Neuroscience at the Frankfurt Institute for Advanced Studies in the lab of Jochen Triesch. As a postdoc, she worked with Mate Lengyel in the Computational and Biological Learning Lab at Cambridge University, then briefly with Sophie Deneve in the Group for Neural Theory at the École Normale Supérieure in Paris. In 2013, she became a fellow at the Institute for Science and Technology, Austria, based in the lab of Gasper Tkacik. In 2017, Dr. Savin joined the Center for Neural Science and the Center for Data Science (CDS) at NYU as an Assistant Professor. Her research focuses on learning and memory at the level of neural circuits in the brain. She uses a combination of theoretical modelling, computer simulations and data analysis to study how different plasticity mechanisms subserve these functions.
http://pub.ist.ac.at/~csavin/

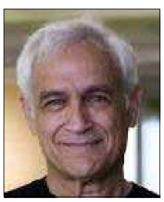
Abstract: In many situations humans and animals seem to use information about uncertainty to guide behaviour. Such computation has been successfully conceptualised as probabilistic inference, with Bayesian methods accounting for a range of behavioural observations, from sensory perception to motor action. Despite much progress, the neural underpinnings of Bayesian computation remain controversial (Fiser et al, 2010; Pouget et al, 2013). The talk will centre on the question of how populations of spiking neurons could encode and compute using probability distributions. I will describe a novel coding scheme for representing uncertainty in spiking neural circuits (Savin & Deneve, 2014). The model provides a conceptual bridge between currently competing models for representing probabilities (probabilistic population codes and sampling), while exploiting the computational advantages of both. Furthermore, the account for a range of experimental observation on single cell and pairs of cells spiking and their modulation by uncertainty. Lastly, the model exposes some of the challenges associated with interpreting neural activity in relation to behavioral uncertainty and points to novel population-level tools for the experimental validation of probabilistic representations.

Etienne Ackermann
Predoctoral Student, Electrical & Computer Engineering
Rice University
O Replay, Replay! Wherefore Art Thou Replay?

Abstract: The place cell activity of hippocampal pyramidal cells during exploration has been described as the cognitive map substrate of spatial memory. Replay–time-compressed reactivation of place cell sequences–is observed during hippocampal sharp-wave ripple-associated population burst events and is critical for consolidation and recall-guided behaviors. To present, population burst event (PBE) activity has been analyzed as a phenomenon subordinate to the place code. Here, we use machine learning of a hidden Markov model to study PBEs observed during exploration of linear mazes. We demonstrate that estimated models are consistent with temporal replay sequences and that the learned latent states correspond to a spatial map of the environment. Moreover, we demonstrate the identification of hippocampal replay without recourse to the place code, using only congruence with the PBE model. Finally, we demonstrate that a PBE-based model can also capture the structure of activity in open fields which lack obvious sequential templates. These results suggest that downstream regions can potentially rely on population burst activity to form a substrate for memory. Additionally, by forming models in the absence of data on spatial behavior, we lay the groundwork for studies of non-spatial memory.

Hongxia Wang, PhD
Postdoctoral Fellow, Neuroscience
Baylor College of Medicine
Feed Forward Inhibition Conveys Time-varying Stimulus Information in a Collision Detection Circuit

Abstract: Feed-forward inhibition is ubiquitous as a motif in the organization of neuronal circuits. During sensory information processing, it is traditionally thought to sharpen the responses and temporal tuning of feed forward excitation onto principal neurons. As it often exhibits complex time-varying activation properties, feed forward inhibition could also convey information used by single neurons to implement dendritic computations on sensory stimulus variables. We investigated this possibility in a collision detecting neuron of the locust optic lobe that receives both feed forward excitation and inhibition. We identified a small population of neurons mediating feed forward inhibition, with wide visual receptive fields and whose responses depend both on the size and speed of moving stimuli. By studying responses to simulated objects approaching on a collision course, we determined that they jointly encode the angular size of expansion of the stimulus. Feed forward excitation on the other hand encodes a function of the angular velocity of expansion and the targeted collision detecting neuron combines these two variables non-linearly in its firing output. Thus, feed forward inhibition plays an active role in shaping the detailed firing rate time course of this collision detecting neuron, a feature critical to the appropriate execution of escape behaviors. These results suggest that feed forward inhibition could similarly convey time-varying stimulus information in other neuronal circuits.



Stuart Geman, PhD
Professor, Applied Mathematics
Brown University
Universal Binding

Dr. Geman received his PhD in Applied Mathematics from MIT in 1977 where he studied differential equations with random coefficients, advised by Herman Chernoff. He joined the division of Applied Mathematics at Brown University in 1997 and was named James Manning Professor in 1997. His research interests include the statistical analysis of neurophysiological data, neural representation and neural modeling, and compositional vision. Dr. Geman has been a recipient of many awards and in 2011 was elected to the National Academy of Sciences.
http://www.dam.brown.edu/people/geman/