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Saal Auditorium Room.202, Alon High-Tech Building 37

Seminar Series Supported by Jeffrey and Holly Ullman

Brain Information & Coding Day Seminar

January 15, 2015 **Register by:** http://www.cs.bgu.ac.il/~frankel/Brain-Information/registration.html

09:30 Coffee & Tagging

09:45 Opening Remarks and Greeting:
Shlomi Dolev, Ben-Gurion University

10:00 Movement Generation and Perception: Models, Behavior and Neural Representations
Prof. Tamar Flash, Weizmann Institute of Science

Abstract: In my talk I will provide an overview of our studies of different aspects of human trajectory formation and of principles that are common to both motion production and perception. I will present recent advancements in our studies, based on the idea, that motion planning involves the mixture of several geometries including Equi-affine, Full Affine and Euclidean geometries and that motor timing and durations arise from the combination of such geometries. This theory was recently generalized to deal with motor compositionality—the idea that complex movements are constructed from elementary building blocks. In particular we combined the geometrical approach with optimization models – which led to new movement segmentation and extraction algorithms. Another recent direction I will discuss is the study of motor variability. Given the similarity between the kinematic laws of motion underlying motion perception and production I will also present findings from EEG and fMRI studies aimed at examining brain activity patterns reflecting motor invariants and preferred brain responses to kinematic features of abstract and biological motion stimuli.

10:40 Neural Dynamics of Perceptual Detection Under Temporal Uncertainty
Dr. Omri Barak, Technion Institute of Technology

Abstract: Under uncertainty, the brain uses previous knowledge to transform sensory inputs into the percepts on which decisions are based. When the uncertainty lies in the timing of sensory evidence, however, the mechanism underlying the use of previously acquired temporal information remains unknown. We study this issue in monkeys performing a detection task with variable stimulation times. We use the neural correlates of false alarms to infer the subject's response criterion and find that it modulates over the course of a trial. Analysis of premotor cortex activity shows that this modulation is represented by the dynamics of population responses. A trained recurrent network model reproduces the experimental findings, and demonstrates a novel neural mechanism to benefit from temporal expectations in perceptual detection. Previous knowledge about the probability of stimulation over time can be intrinsically encoded in the neural population dynamics, allowing a flexible control of the response criterion over time.

11:20 Holographic "Brain" Memory
Ariel Hanemann, Ben-Gurion University

Abstract: The fascinating question of the relation of information and coding theory to the memories stored in the brain is our research scope. We speculate there is a certain code used to represent memories, rather than unique code for different memories. The cortex uniform structure supports our speculation. In fact, we can compute the information capacity that neural networks can store. Recently we suggested holographic coding that can fit Pribram's holographic memory theory based on randomization and the Walsh-Hadamard transform. Using the holographic coding metaphor, the memory should be retrieved by a reference beam as in a hologram. Our general Idea is that the memories in the brain are stored together holographically and there is a "directory" part that is in charge of retrieving specific memories. This part acts like the reference beam in a hologram. We explore the possibility that the brain learns its directory (possibly in the temporal lobe), during memory consolidation. This directory is a neural network that is used for sending signals to the cortex to recall memories. The network learns to distinguish between objects during saving, in order to signal the correct recall. We suggest simple framework and implementation for the directory's learning process.
Joint work with Daniel Berend, Shlomi Dolev, Sergey Frenkel and Rami Puzis

12:00 Lunch

13:00 Information Flow in Perception-Action Cycles - a Key to the Understanding of Brains and Cognition
Prof. Naftali Tishby, Hebrew University of Jerusalem

Abstract: Arguably, the key function of the brain and in fact all living organism, is to selectively process sensory information for valuable behavior. I will review the highlights of a new theoretical framework for quantifying and understanding this statement on the basis of information theory combined with control and dynamical systems. In particular, I will show how the predictive information of the environment governs our ability to learn and acquire the statistical regularities needed for valuable decisions, actions and planning. I will discuss several coding theorems that relate sensory/perceptual capacity to decision efficiency, and show how they can be combined with dynamical control systems and reinforcement learning. I will then show some applications of this theoretical framework to the analysis of neuroscience and cognitive experiments, as well as its possible implications on the semantic structure of natural languages.

13:40 "Elastic Rods" in the Brain for Completion of Visual Information
Prof. Ohad Ben-Shahar, Ben-Gurion University

Abstract: Visual curve completion, an early visual process that completes the occluded parts between observed boundary fragments (a.k.a. inducers), is a major problem in perceptual organization and a critical step toward higher level visual tasks in both biological and machine vision. Most computational contributions to solving this problem suggest desired perceptual properties that the completed contour should satisfy in the image plane, and then seek the mathematical curves that provide them. Alternatively, few studies have suggested to frame the problem not in the image plane but rather in the unit tangent bundle, the space that abstracts the primary visual cortex, where curve completion allegedly occurs. Combining both schools, here we propose and develop a biologically plausible theory of "elastica in the visual cortex" that provides not only perceptually superior completion results but also a rigorous computational prediction that inducer curvatures greatly affects the shape of the completed curve, as indeed indicated by human perception.

14:20 Coffee Break

14:35 Understanding the Capacity of Information Retrieval From Long-Term Memory
Prof. Misha Tsodyks, Weizmann Institute of Science

Abstract: Human memory stores vast amounts of information. Yet retrieving this information is challenging when specific cues are lacking. Classical experiments on free recall of lists of randomly assembled words indicate non-trivial scaling laws for the number of recalled words for lists of increasing length. The fundamental factors that control retrieval capacity are not clear. Here we propose a simple associative model of retrieval where each recalled item triggers the recall of the next item based on the similarity between their long-term neuronal representations. The model predicts retrieval capacity laws that are compatible with the psychological literature. The model also predicts that different items stored in memory have different probability to be recalled depending on the size of their representation. An analysis of the large data on free recall collected in the lab of Prof. Kahana (UPenn) provided a highly specific pattern of statistical dependencies predicted by the model. The analysis also shows how subjects can overcome fundamental limits on information recall by utilizing the temporal order of words in presented lists.

15:15 In Search for the Neural Code: Neural Coding of Sensory Information and Planned Motor Command
Prof. Maoz Shamir, Ben-Gurion University

Abstract: What is the neural code? How is information from one brain region communicated to another? How can theoretical research assist us to unravel this mystery? In my talk I will describe the basic principles that emerge from empirical findings on the neuronal representation of external stimuli and planned motor commands. I will explain the theoretical methodology and the theoretical approaches for addressing this problem. Specifically, I will illustrate these ideas using the example of fast coding of external stimuli using neuronal response latency. Time permitting, I will elaborate on the effects of neuronal noise correlations on the accuracy of the code and highlight neuronal heterogeneity and response variability as possible primary sources of information in the central nervous system. Finally, I will point out future directions in the field of neuronal coding.

15:55 End of Brain Information & Coding Day Seminar