Center for Brains, Minds & Machines

Summer Course at MLB, Woods Hole: Brains, Minds and Machines

DAY	8:00 - 9:00 PM Guest Seminars	Guest Seminars (Lillie Auditorium followed by reception in Meigs Room
Tue, June 3	Jean Jacques Slotine	**Synchronization and Evolvability in Networks** Abstract: Computation, measurement, and synchronization are key issues in complex networks. Vast nonlinear networks are encountered in biology, for instance, and in neuroscience, where for most tasks the human brain grossly outperforms engineered algorithms using computational elements 7 orders of magnitude slower than their artificial counterparts. We show that nonlinear dynamic systems analysis tools yield simple but highly non-intuitive insights about such issues, and that they also suggest systematic mechanisms to build progressively more refined networks through stable accumulation of functional building blocks and motifs.
Thu, June 5	Marge Livingstone	**Functional Modules: How do we get them and what good are they?** Abstract: There are distinct regions of the brain, reproducible from one person to the next, specialized for processing the most universal forms of human expertise. What is the relationship between behavioral expertise and dedicated brain structures? Do reproducible brain structures mean only certain abilities are innate, or easily learned, or does intensive early experience influence the emergence of expertise and/or dedicated brain circuits? We found that intensive early, but not late, experience produces category-selective modules in macaque temporal lobe for stimuli never naturally encountered by monkeys, and produces more fluent processing of these stimuli than the same experience later in life. This suggests that, as in early sensory areas, experience can drive functional segregation and that this segregation may determine how that information is processed.
Sat, June 7	Stefano Fusi	**High dimensional brains** Abstract: Single-neuron activity in prefrontal cortex (PFC) is often tuned to mixtures of multiple task-related aspects. Such mixed selectivity is highly heterogeneous, seemingly disordered and difficult to interpret. Because of its prominence in PFC, it is natural to ask whether such heterogeneity plays a role in subserving the cognitive functions ascribed to this area. We addressed this question by analyzing the neural activity recorded in PFC during an object sequence memory task. We show that the recorded mixed selectivity neurons offer a significant computational advantage over specialized cells in terms of the repertoire of input-output functions that are implementable by readout neurons. The superior performance is due to the fact that the recorded mixed selectivity neurons respond to highly diverse non-linear mixtures of the task-relevant variables. This property of the responses is a signature of the high-dimensionality of the neural representations. We report that the recorded neural representations have actually the maximal dimensionality. Crucially, we also observed that this dimensionality is predictive of animal behavior. Indeed in the error trials the measured dimensionality of the neural representations collapses. Surprisingly, in these trials it was still possible to decode all task-relevant aspects, indicating that the errors are not due to a failure in coding or remembering the sensory stimuli, but instead in the way the information about the stimuli is mixed in the neuronal responses. Our findings suggest that the focus of attention should be moved from neurons that exhibit easily interpretable response tuning to the widely observed, but rarely analyzed, mixed selectivity neurons. Work done in collaboration with: M. Rigotti, O. Barak, M. Warden, X-J.Wang, N. Daw, E.K. Miller.

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Mon, June 9	Larry Jackel, North C Technologies Inc	**Neural Net Research at Bell Labs, Holmdel 1985-1995: A Personal Perspective** Abstract: The years from the mid-1980s to the mid-1990s were times of extraordinary excitement and progress in the related fields of Neural Nets and Machine Learning. At Bell Labs in Holmdel NJ, activities conducted in that decade have played a major role in shaping research directions to this day. Among the Holmdel results are the demonstration of the power Convolutional Networks, which today are considered a prime example of Deep Learning, as well as the invention of Support Vector Machines and related algorithms. In addition, hardware was developed to accelerate the algorithms being created. This talk will review, from an historical perspective, the research from that era and will discuss practical applications and benchmarking techniques that were created.
Tue, June 10	Cheston Tan	**Towards a unified account of face processing** Abstract: Faces are a class of visual stimuli with unique significance, for a variety of reasons. However, little is known about the neural mechanisms underlying holistic face processing. The main aim of this work is to further the fundamental understanding of what causes the visual processing of faces to be different from that of objects. In this computational modeling work, we show that a single factor -- "neural tuning size" -- is able to account for three key phenomena that are characteristic of face processing, namely the Composite Face Effect (CFE), Face Inversion Effect (FIE) and Whole-Part Effect (WPE). Our computational proof-of-principle provides specific neural tuning properties that correspond to the poorly-understood notion of holistic face processing, and connects these neural properties to psychophysical behavior. Overall, our work provides a unified and parsimonious theoretical account for the disparate empirical data on face-specific processing, deepening the fundamental understanding of face processing.
Wed, June 11	Alan Yuille	The Complexity of Vision