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Information Science and Technology Seminar Speaker Series

Peter Loxley
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Learning Dictionary Statistics from Natural Images

Wednesday, September 12, 2012
3:00 - 4:00 PM
TA-3, Bldg. 1690, Room 102 (CNLS Conference Room)

Abstract: Understanding how the brain processes and encodes sensory information is an outstanding scientific challenge that has received a great deal of attention around the world. In visual processing, for example, the brain seems to effortlessly perform tasks that are found to be extremely difficult for current computer algorithms and architectures to perform. In this work, we are interested in how neurons (called simple cells) in the primary visual cortex manage to efficiently code data and de-correlate image pixels as a first step towards visual cognition and object recognition. Our approach is to use machine learning techniques, including sparse coding and the expectation-maximization (EM) algorithm, to learn a set of basis functions (called a dictionary) for accurately representing natural images. We assume each basis function to have the form of a 2-D Gabor wavelet, a function empirically found to provide a good fit to the receptive fields of simple cells. The dictionary statistics is then fully specified by a joint probability distribution for the learned wavelet parameters. We propose minimal models for this joint distribution, and test the performance of "sampled dictionaries". This work generalizes the uniform parameter sampling approaches used in many wavelet-based applications.

Biography: Peter Loxley received his PhD in Theoretical Physics from the University of Western Australia (one of Australia's top 8 universities). His thesis work was to understand non-homogeneous nucleation within the framework of soliton statistical mechanics. He later applied this work to quantify the stability of nano-magnets and magnetic recording devices to thermally-activated magnetization reversal.

He subsequently completed post-doctoral fellowships in the School of Physics at the University of Sydney, and in the Theoretical Division at Los Alamos National Laboratory. During this time, he applied dynamical systems techniques to investigate competitive neural dynamics in early vision; and machine learning techniques to discover how neurons in the early visual system may de-correlate image pixels as a first step towards visual cognition and object recognition. While at LANL, he has also worked on the statistical mechanics of 2-D decaying turbulence, and collaborated on a proposal entitled "Uncertainty quantification of 3-D geophysical models".

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