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STUDENT SEMINAR

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Tuesday, March 11, 2008
304 Whitehead Hall
4:00 p.m.

MODEL-BASED OPTIMAL INFERENCE USING A SEQUENTIAL MONTE CARLO EXPECTATION-MAXIMIZATION ALGORITHM GIVEN NOISY AND INTERMITTENT FLUORESCENCE IMAGING OF NEURAL ACTIVITY

Abstract

As recent advances in calcium sensing technologies enable us to simultaneously image many neurons, complementary analytical tools must also be developed to maximize the utility of this experimental paradigm. While the observations are fluorescence movies, the signals of interest are the spike trains and/or time-varying intracellular calcium concentrations, [Ca++]. Inferring the value of these "hidden states" is often problematic for a number of reasons: (i) observations are inherently both noisy and intermittent; (ii) the relationship between fluorescence, [Ca++], and spike trains is nonlinear; and (iii) the parameters governing the dynamics of these states are typically unknown.

We develop a sequential Monte Carlo Expectation Maximization algorithm designed to optimally infer precise spike times and [Ca++] dynamics, given the above properties. This framework confers several advantages over standard signal processing approaches. First, we can often infer the expected timing of spikes at a temporal resolution greater than that of the image frames. Second, we provide both the expected value of [Ca++] and spike trains, and their variances. Third, the parameters governing these dynamics are automatically recovered, obviating additional calibration experiments. Fourth, this framework facilitates incorporating stimulus information, potentially improving the inference fidelity. We close by discussing some possible applications for these tools.