DEPARTMENT OF MATHEMATICAL SCIENCES

Colloquium

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Mathematical Modeling and Systems Biology: Mechanisms, Stochastic Phenomena, and Dimension Reduction

ABSTRACT: The discipline of systems biology arose through the application of large-scale computational and analytical methods, originating in systems engineering, to quantitative biology. In the talk I will discuss examples from my own work in which mathematical modeling contributes to understand biological systems. 1. In collaboration with neurophysiologist C. Wilson, we showed that the dynamical mechanism underlying robust generation of the respiratory rhythm by central pattern generator circuits in the brainstem may be fundamentally different in the open-loop case (corresponding to classic ex vivo studies) than in the closed-loop case (i.e. in vivo) [Diekman et al, 2017]. 2. In collaboration with theoretical biophysicist B. Lindner, we have shown how to adapt phase reduction methods for biological oscillators to the case of stochastic oscillators systems, such as arise in hybrid Markov models of randomly gating ion channels in electrically active membranes in nerve cells [Thomas and Lindner, 2014, Anderson et al 2015]. 3. In a different type of dimension reduction, neuroscientist R. Galan and I are analyzing stochastic shielding approximation methods for accurately simplifying stochastic network models. By identifying optimal projections within the sample space we find reduced complexity models of neural systems with minimal error along sample paths [Schmandt and Galan 2012, Schmidt and Thomas 2014, Schmidt et al 2018]. 4. Accurate complexity reduction methods for stochastic processes have broad potential application within systems biology, for instance in understanding signal transduction pathways. With information theorist A. Eckford, I pioneered the development of exactly solvable communications channel models specific to signal transduction [Thomas and Eckford 2016].

For more details and references, see the electronic versions of this announcement.

Joint work with
C. Diekman (New Jersey Institute of Technology)
A. Eckford (York University, Toronto, Canada)
R. Galan (Case Western Reserve University)
B. Lindner (Humboldt University, Berlin, Germany)
D. Schmidt (University of Nevada, Reno)
C. Wilson (Loma Linda University)

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