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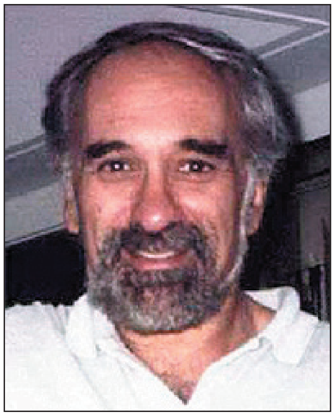
THE INSTITUTE FOR SYSTEMS RESEARCH



Eduardo Sontag

Department of Mathematics

BioMaPS Institute for Quantitative Biology, Computer Science and Electrical and Computer Engineering

Rutgers University

Tuesday, May 2, 5:00 p.m.

Control Systems Theory and a Qualitative/Quantitative Approach to Systems Biology

Biology is in need of powerful tools to help understand, organize, quantify, and conceptualize the properties of protein, gene, and metabolic networks. Critical issues include the analysis of information processing, signaling, robustness, feedback, and dynamical properties of such networks. To a large extent, these constitute the focus of control systems theory, a sophisticated and deeply-developed field of mathematics and theoretical engineering. Systems theory allows one to constrain and predict internal structure from input/output experiments, quantify sensitivities, analyze the effects of feedback loops, and verify the controllability and observability of components and the identifiability of parameters.

In this talk I will argue that in spite of its immense success in engineering, the "off the shelf" application of known control theory is not always appropriate. Detailed models are hard to come by; it is virtually impossible to experimentally validate the form of the nonlinearities used in reaction terms and even when such forms are known, to accurately estimate coefficients (parameters). New tools must be developed to bridge the "data-rich/data-poor" dichotomy that exists in systems biology. I illustrate this point by describing a new approach to analyzing certain highly nonlinear dynamical systems which blends qualitative and graph-theoretic network knowledge of the type often obtained from biological experiments with a small amount of "quantitative" data such as is obtained from steady-state step responses. This novel approach originally emerged from studying possible multi-stability or oscillations in feedback loops in cell signal transduction, but it also is of more general applicability. The mathematical techniques rely heavily on the theory of monotone systems with inputs and outputs.

Biography

Eduardo Sontag received his Ph.D. in Mathematics at the University of Florida in 1976, studying with Rudolf Kalman. Since 1977, he has been at Rutgers, where he is professor of mathematics, and on the faculties of the BioMaPS Institute for Quantitative Biology and the departments of Computer Science and Electrical and Computer Engineering. Sontag's research interests are in control and dynamical systems theory as well as systems molecular biology.

His awards include SIAM's Reid Prize (2001), IEEE's Bode Prize (2002), and Rutgers' Board of Trustees Award for Excellence in Research (2002) and Teacher/Scholar Award (2005). Sontag was an Invited Speaker at the 1994 International Congress of Mathematicians, and is a IEEE Fellow. He has written more than 350 papers, and is an ISI "Highly Cited Author."

He is on the editorial boards of *IEEE Proceedings on Systems Biology; SIAM Review; Synthetic and Systems Biology; International Journal of Biological Sciences; Journal of Computer and Systems Sciences;* and *Neural Computing Surveys* (Board of Advisors). He is also a former Board member of *IEEE Transactions in Automatic Control; Systems and Control Letters; Dynamics and Control; Neurocomputing; Neural Networks; Control-Theory and Advanced Technology,* and *Control, Optimization and the Calculus of Variations*. In addition, he is a co-founder and co-managing editor of the Springer journal *MCSS (Mathematics of Control, Signals, and Systems).*

Lecture

Tuesday, May 2, 5:00 p.m. (reception in the lobby at 4:30 p.m.)
1115 Computer Science Instructional Center (CSIC)

Roundtable discussion

Wednesday, May 3, 10:00 a.m.
2168 A.V. Williams Building

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