Models and Algorithmic Tools for Computational Processes in Cellular Biology: Recent Developments and Future Directions

(Invited Keynote Talk)

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Over the last few decades, researchers in various fields have witnessed applications of novel computing models and algorithmic paradigms in many application areas involving biological processes, quantum computing, nanotechnology, social networks and many other such disciplines. Typical characteristics of these application areas include their interdisciplinary nature going beyond previous traditional approaches that were used, and often high-risk high-gain nature of resulting collaborations. Major research challenges on a macroscopic level for such collaborations include forming appropriate interdisciplinary teams, effective communication between researchers in diverse areas, using individual expertise for overall goal of the project, and collaboration with industry if necessary. In addition, one also faces the usual challenge that lies in collaboration between theory and practice, namely sometimes theory follows application, sometimes theory precedes application, and sometimes they walk hand-in-hand. Recent and not so recent developments on analysis of models of computational processes in biology, in the context of gene and protein networks that arise in organism development and cell signalling, have given rise to many types of discrete, continuous and hybrid models, and researchers have studied the inter-relationships, powers and limitations, computational complexity and algorithmic issues as well as biological implications and validations of these models. Such investigations have given rise to fascinating interplay between many diverse research areas such as biology, control theory, discrete mathematics and computer science.

In this talk, I will discuss some successful interdisciplinary collaborative projects of mine on cell signalling processes with other researchers from control theory, cell biology and computational complexity theory [1–11]. These projects involve interesting integration of concepts from control theory (dynamical systems) and computational complexity theory (approximation algorithms and inapproximability results) with the signalling mechanisms (signal transduction networks and other models) in cellular processes in biology. I will also discuss future research problems in these topics that may be of importance to new or current researchers. No prior knowledge of dynamical systems or other models for cell signalling mechanisms will be assumed.

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