Dept. of Electrical & Computer Engineering

Colloquium

Optimal Noise Filtering in the Chemotactic Response of E. coli

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Abstract: One of the many similar features between biological and engineered systems is the need to make decisions based on imperfect information about the environment. The signaling pathway that mediates chemotaxis – the process by which cells migrate towards chemical cues – in *Escherichia coli* serves as an ideal vehicle for studying how biology copes with this form of uncertainty because the system is relatively simple and the biochemical entities are well understood. Moreover, there are many similarities in the signaling system with those found in more complex systems such as the mammalian inflammatory and developmental processes. We investigate the filtering properties of the *E. coli* signal transduction network. Through simulation, we first show that the cutoff frequency has a dramatic effect on the chemotactic efficiency of the cell. Then, using a mathematical model to describe the signal, noise, and system, we formulate and solve an optimal filtering problem to determine the cutoff frequency that bests separates the low-frequency signal from the high-frequency noise. There is good agreement between the theory, simulations, and published experimental data. Our theory and simulations offer several important predictions regarding the effect of certain biochemical components and environmental conditions on the ability of cells to chemotax. This work furnishes a simple quantitative framework for interpreting many of the key notions about bacterial chemotaxis from a system-theoretic viewpoint, and, more generally, it highlights the constraints on biological systems imposed by noise.

Biography: B. Andrews is a PhD student in Electrical and Computer Engineering at Johns Hopkins University. He received his B.S. and M.S. degrees from The Ohio State University in 2004. His background is in systems and control theory, and his research has focused on the integration of control and biology. Example topics include the use of foraging theory from behavioral ecology for cooperative control of multi-agent systems and, more recently, the study of the biochemical mechanisms governing chemotaxis in cellular organisms such as the bacteria *E. coli* and the amoeba *D. discoideum* from a systems-theoretic viewpoint. He has authored several papers in both engineering and biology journals.