工学系研究科専攻間横断型教育プログラム
「機械システム・イノベーション」

GMSI

最先端融合科学イノベーション
教育研究コンソーシアム

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Multi-scale modeling of cells: cellular fate from probability landscape of stochastic networks and large scale cell migration and proliferation in wound healing

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Abstract:
Cells possessing the same genome can exhibit diverse properties. Networks of interacting molecules under stochastic control of small copy-number events can dictate how cells acquire different phenotypes.
Cells with different properties grow, divide, and interact with each other and with the Extra-Cellular Matrix (ECM) through mechanical forces and signal transduction, resulting in the formation of complex patterns that are important for processes such as tissue development and wound healing. We describe recent progress towards understanding and modeling these phenomena. We first discuss an optimal state enumeration algorithm and the ACME (accurate chemical master equation) method for solving the discrete chemical master equation (dCME) underlying stochastic networks. We discuss how exact time-evolving probabilistic landscapes can be computed without Gillespie simulation or Fokker-Planck/Langevin approximations, how a priori error bound for the steady state can be constructed without trial simulations. We also show how to characterize multi-stability, epigenetic states, first-passage time of rare events, and the robustness of decision networks from computed probability landscape. We then discuss recent development of discrete cell models and the dynamic cellular finite element method (dyCelFEM) that can be used to study thousands of interacting cells in migration. With full account of changes in cellular shapes, topology, and mechanics, and with key signaling networks embedded in individual cells, we can study the full range of cell motion, from motilities of individual cells to collective cell migrations. We discuss our recent findings on effects of micro-patterned geometry on cell elongation and migration. We also described results on examining the effects of biochemical and mechanical cues in regulating cell migration and proliferation, and in controlling tissue patterning in re-epithelialization of skin wound healing.
(Please visit bioacme.org and gila.bioe.uic.edu/liang/liang_pub.html for further information).

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