Formal Methods in Cell Biology

Jasmin Fisher

Microsoft Research, Cambridge, United Kingdom

Abstract

Biological systems are extremely complex reactive systems. They operate as highly concurrent programs with millions of entities running in parallel and communicating with each other under various environmental conditions. Understanding how living systems operate in such harmony and precision, and how this harmony is being disrupted in diseased states, are key questions in biological and medical research. Due to their enormous complexity, the comprehension and analysis of living systems is a major challenge. Over the last decade various efforts to tackle this problem concentrate on a new approach called Executable Biology focused on the construction and analysis of executable models describing biological phenomena. Over the years, these efforts have demonstrated successfully how the use of formal methods can be beneficial for gaining new biological insights and even directing new experimental avenues. In this tutorial, I will survey some of the major efforts in this direction, using formal verification, synthesis and the design of new tools to reason about information processing during cells decision-making, organisms development, and molecular mechanisms underlying various human cancers.

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