

Probabilistic Model Checking for Biology

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Probabilistic model checking is an automated method for verifying the correctness and performance of probabilistic models. Property specifications are expressed in a probabilistic extension of temporal logic, and the probabilistic model checker can compute the probability of a given event, the probability of its occurrence within a given time interval, or expected cost or reward.

The lectures will focus on the application of probabilistic model checking to biological systems, as implemented in the probabilistic model checker PRISM. The models that arise in this case are typically *continuous-time Markov chains* and the logic is CSL, *Continuous Stochastic Logic*.

The lectures will begin with an introduction to Markov chains, the logic CSL and the corresponding model checking algorithms. Then an overview will be given of how molecular signalling networks are modelled in PRISM, and what can be learnt from applying probabilistic model checking on concrete examples of signalling networks, for example FGF and MAPK. Then we will consider DNA computation, and specifically the DSD formalism (DNA Strand Displacement), and demonstrate how design errors can be detected in DNA gate design using probabilistic model checking, analogously to model checking for digital circuits.

The course will also introduce PRISM [4,6], a state-of-the-art probabilistic model checker, and illustrate several case studies that have been modelled and analysed in PRISM, such as Bluetooth device discovery, Zeroconf link-local addressing and probabilistic contract signing.

References

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