My doctoral research work focuses on the algorithmic discovery, formal verification and automated analysis of probabilistic models using high-performance computing techniques. Probabilistic computational models are increasingly used to study the behavior of both natural and man-made systems. While the structure of such models is often available from the literature, unknown quantitative features of the system are usually incorporated into the model as numerical parameters. The efficient discovery of these parameter values in stochastic models against expert-provided specifications remains a challenge for the formal methods community.

This dissertation discusses two new algorithmic techniques for synthesizing parameters of probabilistic models. The first technique finds parameters by reducing the parameter synthesis problem to a repeated probabilistic model checking problem, and using sequential hypothesis testing, and simulated annealing to efficiently solve it. We applied this technique to analyze a model of the glucose-insulin metabolism. An important research question was: what are the model states, if any, in which the patient exhibits behaviors that indicate a diabetic or prediabetic condition? We successfully answered this question by synthesizing values of three parameters (viz, pancreatic responsivity to glucose rate of change, pancreatic response to glucose, and the delay between glucose signal and insulin secretion) that ensure that the glucose-insulin subsystem spends at least 20 minutes in a diabetic scenario, where the glucose concentration remains within a specified range -- conditions that confirm the capability of the model to represent diabetic behavior.

The second technique discovers parameters using a combination of a stochastic optimization meta-heuristic and Bayesian model checking. We applied this algorithm to solve a drug-discovery problem by synthesizing the amount and schedule of doses (i.e. the parameters) of bacterial lipopolysaccharide in a clinical agent-based model of the dynamics of acute inflammation in order to guarantee a set of desired clinical outcomes with high probability.

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The public is welcome to attend.