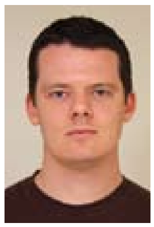
Ph.D. Dissertation Defense Seminar

General Birth-Death Processes: Probabilities, Inference, and Applications



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ABSTRACT: A birth-death process (BDP) is a continuous-time Markov chain that counts the number of particles in a system over time. Each particle can give birth to another particle or die with rates that depend on how many particles there are. BDPs are popular modeling tools in evolution, population biology, genetics, epidemiology, and ecology.

Despite the widespread interest in BDPs, no efficient method exists to evaluate the finite-time transition probabilities in a process with arbitrary birth and death rates. Statistical inference of birth and death rates also remains largely limited to continuously-observed processes. The lack of progress in developing statistical tools for dealing with data from BDPs has hindered their adoption by applied researchers, and represents a major research frontier in statistical inference for stochastic processes. In this dissertation, I seek to fill this apparent void. First, I develop mathematical theory and computational tools for computing transition probabilities for general BDPs. Second, I develop algorithms for maximum likelihood estimation of rate parameters in discretely observed processes. Third, I derive probability distributions for characteristics of certain BDPs that are fundamental in macroevolutionary studies. In each case, I give practical applications of the methodology, and show how unsolved problems can be attacked using these techniques.

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