First passage events in biological systems with non-exponential inter-event times

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Abstract-

It is often possible to model the dynamics of biological systems as a series of discrete transitions between a finite set of observable states (or compartments). When the residence times in each state, or inter-event times more generally, are exponentially distributed, then one can write a set of ordinary differential equations, which accurately describe the evolution of mean quantities. Non-exponential inter-event times can also be experimentally observed, but are more difficult to analyse mathematically. In this paper, we focus on the computation of first passage events and their probabilities in biological systems with non-exponential inter-event times. We show, with three case studies from Molecular Immunology, Virology and Epidemiology, that significant errors are introduced when drawing conclusions based on the assumption that inter-event times are exponentially distributed. Our approach allows these errors to be avoided with the use of phase-type distributions that approximate arbitrarily distributed inter-event times.

Index Terms- Applied mathematics; Computational biology and bioinformatics

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