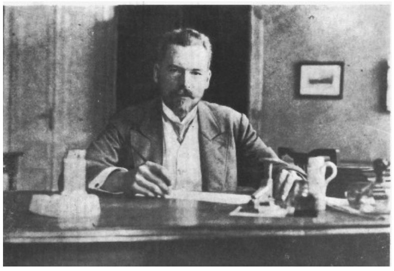

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Controlling Uncertainty of Empirical First-Passage Times in the Small-Sample Regime

Monday, 25 September 2023 15:05 (25 minutes)

First-passage phenomena are ubiquitous in nature and at the heart of e.g., reaction kinetics, gene regulation, the foraging behavior of animals, and stock option dynamics. Whereas theoretical studies focus on predicting statistics of the first-passage time for a given process, practical applications typically aim at inferring kinetic rates, i.e. inverse mean first-passage times, from experimental or simulation data. The inference of such empirical first-passage times is however challenging because usually, only a small number of realizations are available, giving rise to high uncertainties and non-Gaussian errors.

We present general bounds on the probability that the empirical first-passage time inferred from a sample of n independent realizations deviates from the true mean first-passage time by more than any given amount in either direction. We construct non-asymptotic confidence intervals that hold in the elusive small-sample regime and thus fill the gap between asymptotic methods and the Bayesian approach that is known to be sensitive to prior belief and tends to underestimate uncertainty in the small-sample setting. Our results allow for model-free error control and reliable error estimation in kinetic inference, and are thus important for the analysis of experimental and simulation data in the presence of limited sampling.

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