Going NUTS in an optical trap: precise Bayesian estimation of trap parameters by Hamiltonian Monte Carlo

Suvojit, Ayan, Ronojoy etc

(Dated:)

Abstract

Bayesian inference provides a principled way of estimating the parameters of a stochastic process that is observed at discrete points in time. The overdamped motion of a bead confined in an optical trap is usually modelled as an Ornstein-Uhlenbeck process and is discretely observed in experiment. Here we present a fast and accurate Bayesian method for determining the parameters of this process, the trap potential and the particle friction coefficient, by using Hamiltonian Monte Carlo with a no-U turn sampler (NUTS). Our method is several orders of magnitude faster than the current state of the art and requires much less data than conventional equipartition or power-spectrum based methods. We implement our method in the open source Stan probabilistic programming language allowing it to be easily extended to more complex experimental situations like beads in multiple optical traps, underdamped bead motion, and retarded hydrodynamic interactions.