Computing the quasipotential for nongradient SDEs

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Abstract

The quasipotential is a crucial function for quantifying transitions between attractors of dynamical systems evolving according to nongradient SDEs with small white noise. It can be viewed as an analogue of the potential function for gradient SDEs in which the invariant density is given by the Gibbs density, the transition rates given by the Kramer's/Langer's formula, and the maximum likelihood transition paths go directly uphill or downhill. Likewise, the quasipotential allows us to approximate the invariant probability measure and find transition rates and maximum likelihood transition paths for nongradient SDEs. Unfortunately, it cannot be found analytically except for special cases. We develop Dijkstra-like numerical methods for computing the quasipotential in whole regions for 2D and 3D SDEs. We test them on a number of examples with point attractors and limit cycles and demonstrate their efficiency and accuracy. We apply them to genetic switch models and to Lorenz'63 with added small white noise for a parameter range embracing the case where the strange attractor and the asymptotically stable equilibria coexist.

Keywords: quasipotential, maximum likelihood transition path, Dijkstra, like, Lorenz'63

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