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Approximate Bayesian computation for stochastic hybrid systems with ergodic behaviour

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Piecewise diffusion Markov processes (PDifMPs) form a versatile class of stochastic hybrid systems that combine continuous diffusion processes with discrete event-driven dynamics, enabling flexible modelling of complex real-world hybrid phenomena. The practical utility of PDifMP models, however, depends critically on accurate estimation of their underlying parameters. In this work, we present a novel framework for parameter inference in PDifMPs based on approximate Bayesian computation (ABC). Our contributions are threefold. First, we provide detailed simulation algorithms for PDifMP sample paths. Second, we extend existing ABC summary statistics for diffusion processes to account for the hybrid nature of PDifMPs, showing particular effectiveness for ergodic systems. Third, we demonstrate our approach on several representative example PDifMPs that empirically exhibit ergodic behaviour. Our results show that the proposed ABC method reliably recovers model parameters across all examples, even in challenging scenarios where only partial information on jumps and diffusion is available or when parameters appear in state-dependent jump rate functions. These findings highlight the potential of ABC as a practical tool for inference in various complex stochastic hybrid systems.

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