Spectral density-based and measure-preserving ABC for partially observed diffusion processes. An illustration on Hamiltonian SDEs

Irene Tubikanec.
Johannes Kepler University Linz, Austria.

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Abstract
Approximate Bayesian computation (ABC) has become one of the major tools of likelihood-free statistical inference in complex mathematical models. Simultaneously, stochastic differential equations (SDEs) have developed to an established tool for modelling time-dependent, real-world phenomena with underlying random effects. When applying ABC to stochastic models, two major difficulties arise. First, the derivation of effective summary statistics and proper distances is particularly challenging, since simulations from the stochastic process under the same parameter configuration result in different trajectories. Second, exact simulation schemes to generate trajectories from the stochastic model are rarely available, requiring the derivation of suitable numerical methods for the synthetic data generation. To obtain summaries that are less sensitive to the intrinsic stochasticity of the model, we propose to build up the statistical method (e.g. the choice of the summary statistics) on the underlying structural properties of the model. Here, we focus on the existence of an invariant measure and we map the data to their estimated invariant density and invariant spectral density. Then, to ensure that these model properties are kept in the synthetic data generation, we adopt measure-preserving numerical splitting schemes. The derived property-based and measure-preserving ABC method is illustrated on the broad class of partially observed Hamiltonian type SDEs, both with simulated data and with real electroencephalography data. The derived summaries are particularly robust to the model simulation, and this fact, combined with the proposed reliable numerical scheme, yields accurate ABC inference. In contrast, the inference returned using standard numerical methods (Euler–Maruyama discretisation) fails. The proposed ingredients can be incorporated into any type of ABC algorithm and directly applied to all SDEs that are characterised by an invariant distribution and for which a measure-preserving numerical method can be derived.

This is joint work with Evelyn Buckwar and Massimiliano Tamborrino.

References

[1] E. Buckwar, M. Tamborrino, I. Tubikanec (2020). Spectral density-based and measure-preserving ABC for partially observed diffusion processes, Statistics and Computing, 30, 627–648. https://doi.org/10.1007/s11222-019-09909-6