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Nonparametric drift estimation for the stochastic heat equation from local measurements

Abstract:

It is well-known that parameters in the drift of a stochastic *ordinary* differential equation, observed continuously on a time interval $[0, T]$, are generally only identifiable, if either $T \to \infty$, the driving noise becomes small or if a sequence of independent samples is observed. For stochastic *partial* differential equations, on the other hand, the situation is quite different. For instance, in case of the stochastic heat equation

$$dX(t,x) = \vartheta \Delta X(t,x)dt + dW(t,x), \quad x \in \Omega \subset R^d, \tag{1}$$

where Δ is the Laplace operator and $\vartheta > 0$ is an unknown parameter, [1] have shown that consistent estimation of ϑ is also possible in finite time $T < \infty$, if $\langle X(t,\cdot), e_k \rangle$ is observed continuously on $[0, T]$ for $k = 1, \ldots, N$ as $N \to \infty$, where the e_k are the eigenfunctions of Δ.
Based on an MLE-inspired estimator, we study this estimation problem with respect to a single *local measurement* $\langle X(t,\cdot), K_{h,x_0} \rangle$, where $x_0 \in \Omega$ and $K_{h,x_0}(x) = h^{-d/2} K(h^{-1}(x - x_0))$ for a smooth kernel K with compact support, as long as $h \to 0$. This easily extends to the more difficult nonparametric estimation problem, when ϑ is space-dependent. Indeed, we can show that $\vartheta(x_0)$ is identifiable using only local information. Central

limit theorems are discussed, along with the question of efficiency.

References

[1] M. Huebner and B.L. Rozovskii. On asymptotic properties of maximum likelihood estimators for parabolic stochastic PDE's. *Probability theory and related fields*, **103**, 1995, 143-163.

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