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Title: Pathwise Statistical Inference Methods for Continuous Time SDEs

Abstract:

Stochastic differential equations (SDEs) have found their way into a variety of applications including finance, statistical physics, and neuron dynamics. In these applications, there is great interest in fitting SDEs to discrete time correlated data and assessing the assumptions implicit in the assumed SDE proxy using reliable criterion appropriate for the sampling regime under consideration. This lecture will focus on statistical inference approaches that exploit various pathwise mathematical properties of SDEs. In this lecture, ``pathwise'' is meant to convey that a single discretely observed time series will be used to calibrate (and do inference on) an assumed SDE model.

The talk is divided into three parts:

(I) Illustrative examples where pathwise SDE modeling provides useful insights into complex systems will first be presented to motivate the remainder of the lectures. Several similarities between problems facing statistical physics and modern mathematical finance will be highlighted. In addition, some recent methods applicable to situations where the functional form of a parametric SDE model describing the global dynamics of the observed data is not known from \emph{a priori} considerations will be presented.

(II) Classic time series inference results and well-established mathematical properties of SDEs relevant to many statistical inference tasks (such as likelihood based inference) will the be reviewed. Topics covered will include quadratic variation and the connection of diffusive SDEs to Cauchy partial differential equation (PDE) problems.

(III) In the final portion of the lecture, it will be shown how the aforementioned mathematical properties can be exploited for estimation and carrying out goodness-of-fit tests in both the stationary and non-stationary sampling regimes. Particular attention will be paid to Hong and Li's ``omnibus'' test which utilizes accurate likelihood approximations; this test is applicable to a wide class of stochastic processes (e.g. pure jump or jump-diffusion models) and is applicable to nonstationary time series data. In addition, some recent nonparametric and semiparametric methods for estimating volatility will be surveyed and some open inference problems will be discussed.