Varying-coefficient stochastic diffusion processes with deep learning

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Abstract

Varying-coefficient stochastic diffusion processes provide a flexible way to capture time-varying dynamics in time series. These models allow both the drift and diffusion terms in the stochastic differential equation to evolve over time, reflecting changing market conditions. In this dissertation, we explore different methodologies for modeling time series: nonparametric estimation of varying-coefficient SDE, deep learning for multivariate time series, and high-dimensional regression with LASSO. For the univariate case, we estimate time-varying drift and diffusion functions using local regression. We establish the asymptotic properties of the model estimators under regularity conditions. To extend the analysis to multivariate settings, we use a regressionbased structure to model relationships among interdependent financial variables and make prediction. Deep learning neural networks are applied to capture nonlinear dependencies and temporal dynamics across multiple series. As the number of variables increases, the high dimensionality poses challenges for estimation and interpretation. To address this, we incorporate LASSO regularization for variable selection and dimensionality reduction. We investigate the selection consistency of LASSO in high-dimensional time series regression when predictors may include both stationary and nonstationary components.

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