

ACMS Applied Math Seminar

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Thursday, March 27, 2025
154 Hurley Hall
3:30 PM – 4:30 PM

Tikhonov Regularization as a Nonparametric Method for Uncertainty Quantification Under Moment Constraints

Computational models are widely used to predict the behavior of systems arising in science and engineering. They usually depend on parameters whose values must be estimated from data. Thus, to realize their predictive power, it is critical to perform parameter estimation and uncertainty quantification. In some applications, only observations about an ensemble of systems are available, where each one evolves according to the same model but for different parameter values. In these cases, one can estimate some moments of the unknown probability density for the parameters. In this talk, we show that using Tikhonov regularization to estimate the density under moment constraints can be formalized in the context of Bayesian nonparametric methods. We propose a Bayesian model for which this approach can be interpreted as a limiting maximum a posteriori (MAP) estimate for the density. We show that the infinite-dimensional optimization problem defining the MAP can be reformulated as a finite-dimensional problem which, in several cases of interest, is convex, unconstrained, and has a smooth objective function. Although the objective is defined in terms of a possibly high-dimensional integral, we are able to characterize the regularity of the integrand, enabling the use of tailored numerical schemes to approximate it. Finally, while our theoretical results characterize the form of the MAP, our numerical results illustrate the performance of our method and confirm our theoretical findings.

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Mathematics and Statistics
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