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**Title:** Subsampling-extrapolation bandwidth selection in bivariate kernel density estimation

**Abstract:**
This talk focuses on bivariate kernel density estimation that bridges the gap between univariate and multivariate applications. We propose a subsampling-extrapolation bandwidth matrix selector that improves the reliability of the conventional cross-validation method. The proposed procedure combines a U-statistic expression of the mean integrated squared error and asymptotic theory, and can be used in both cases of diagonal bandwidth matrix and unconstrained bandwidth matrix. In the subsampling stage, one takes advantage of the reduced variability of estimating the bandwidth matrix at a subsample size $m (m < n)$; in the extrapolation stage, a simple linear extrapolation is used to remove the incurred bias. Simulation studies reveal that the proposed method reduces the variability of the cross-validation method by about 50% and achieves an expected integrated squared error that is up to 30% smaller than that of the benchmark. It shows comparable or improved performance compared to other competitors across six distributions in terms of the expected integrated squared error. We prove that the components of the selected bivariate bandwidth matrix follow an asymptotic multivariate normal distribution, and also discuss the relative rate of convergence of the proposed bandwidth selector.