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Data Assimilation in Stochastic Differential Equations: Applications to Aero-elasticity and Contaminant Tracking

A significant uncertainty exists in numerical predictions of complex systems due to (a) insufficient knowledge on the spatio-temporal variability of the system parameters and (b) lack of complete knowledge of the physics and mechanics of the associated phenomena. In modelling such natural phenomena, it is necessary to consider the random heterogeneity of the model parameters and model structural errors for realistic computer predictions. On the other hand, the widespread availability of modern sensing technology offers the possibility of utilizing measured data to calibrate such models for more accurate predictions. The problem of determining the system state from noisy measurements is called *state estimation*, or *filtering*. In some cases, the parameters characterizing the system are not fully known which one would like to estimate with less uncertainty. One can cast this system identification problem as a problem of *joint state and parameter estimation* in which we simultaneously estimate the system state and unknown parameters. In this presentation, we examine the performance of various probabilistic nonlinear filtering techniques, namely the extended Kalman filter (EKF), unscented Kalman filter (UKF), ensemble Kalman filter (EnKF), particle filter (PF), and predictor-corrector filter for the state and joint state and parameter estimation problems. A state estimation application of pollution dispersion problem in rivers described by stochastic advection-diffusion equation and an application of joint joint state and parameter estimation in aero-elasticity using wind-tunnel data will be presented.