School of Computer Science
MS Thesis
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ENSEMBLE METHODS FOR DATE ASSIMILATION – A SURVEY

ABSTRACT

As a result of the lack of the knowledge with regard to the statistical properties of the dynamic models and operational observations, as well as the computational burden related to the high dimensionality of the realistic data assimilation problems especially those complex nonlinear filtering problems, the ensemble Kalman filter scheme has been paid much more attention in recent years and has becomes one of the most popular methods. This thesis work aims to study several typical ensemble based methods that are presented so far. The approaches investigated in this study include Ensemble Adjustment Kalman Filter (EAKF), Ensemble Transform Kalman Filter (ETKF), Local Ensemble Kalman Filter (LEnKF), a version of Ensemble Square Root Kalman Filter (EnSRKF) with the similar idea as LEnKF but without localization, Four-dimensional Ensemble Kalman Filter (4DEnKF), Deterministic Ensemble Kalman Filter (DEnKF), the Hybrid ETKF-3DVAR scheme and a data assimilation method with multiple models. For each method, the theory aspects and detailed implementations have been summarized. All of the methods examined in this thesis do not use perturbed observations, which avoids one source of sampling error.

Although these ensemble methods are straightforward to implement and the sampling error can be reduced by adopting relatively more ensemble members, increasing the number of ensemble members to a large number will increase the computational cost. Compared to these methods, a newly presented data assimilation scheme which is called the generalized Polynomial Chaos based Ensemble Kalman Filter (gPC-based EnKF) is more efficient and accurate. The specifics about this approach are investigated in detail and two popular implementations associated with this method are also provided in the thesis, which are called Stochastic Galerkin (SG) based Ensemble Kalman Filter and Stochastic Collocation (SC) based Ensemble Kalman Filter. The efficiency and accuracy of the gPC-based Ensemble Kalman Filter are achieved by the following two key ingredients: first, solving the dynamic equations of the stochastic state vector through the gPC methodology; second, creating an arbitrary large number of samples of the gPC approximations for the stochastic solution without any additional computational. Two examples about the SG based Ensemble Kalman Filter are discussed and give a better understanding of the new presented scheme. As an efficient data assimilation approach, the continuous and deeper study on the gPC-based Ensemble Kalman Filter approach will be conducted in the future and in practical application fields.

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