Shadowing-based data assimilation method for partially observed models

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Data assimilation is broadly used in atmosphere and ocean science to correct error in the state estimation by incorporating information from measurements into the mathematical model. The widely-used variational data assimilation method has a drawback of a drastic increase of the number of local minima of the corresponding cost function as the number of measurements increases. The shadowing approach to data assimilation, which was pioneered by K. Judd and L. Smith in Physica D (2001), aims at estimating the whole trajectory at once. It has no drawback of several local minima. However, it is computationally expensive, requires measurements of the whole trajectory, and has an infinite subspace of solutions.

We propose to decrease the computational cost by projecting the shadowing approach to the unstable subspace that typically has much lower dimension than the phase space. Furthermore, we propose a novel shadowing-based data assimilation method that lifts up the requirement of a fully-observed state. We prove convergence of the method and demonstrate in numerical experiments with Lorenz models that the developed data assimilation method substantially outperforms the variational data assimilation method.

References:

[1] https://doi.org/10.1137/18M1223897

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