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Data Assimilation Using Noisy Time-Averaged Measurements

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Abstract

We study the synchronization of chaotic systems when the coupling between them contains both time averages and stochastic noise. Our model dynamics—inspired by the partial differential equations which govern the atmosphere—are given by the Lorenz equations which are a system of three ordinary differential equations in the variables X, Y and Z. Our theoretical results show that coupling two copies of the Lorenz equations using a feedback control which consists of time averages of the X variable leads to exact synchronization provided the time-averaging window is known and sufficiently small. In the presence of noise the convergence is to within a factor of the variance of the noise. We also consider the case when the time-averaging window is not known and show that it is possible to tune the feedback control to recover the size of the time-averaging window. Further numerical computations show that synchronization is more accurate and occurs under much less stringent conditions than our theory requires.

Dedicated to Edriss S. Titi
on the occasion of his 60th birthday
with great respect and admiration