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0.1 Reconstruction and prediction of Continuous Dynamical System

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Since early 1980s when the pioneering works by Packard et al was published, there have been a great deal of research works devoted to global vector field reconstruction. Particular attention is paid to chaotic dynamical systems. Global vector field reconstruction is still a big challenge of growing interest in the field of nonlinear dynamics. In particular, universal and robust methods for reconstruction and prediction of continuous dynamical systems are yet to be developed.

In this paper, we developed a new and universal method to reconstruct and, at the same time, predict continuous dynamic systems, i.e. measured-based, mixed embedding, time-integrating method. Our method uses a set of natural orthogonal polynomials which are uniquely determined by the measure, probability density function in high dimensional space of the system. Based on the set of natural orthogonal polynomials, the ordinary differential equations (ODEs)-like integrator is extracted from the evolutions of the singular or multiple time series of the system with the generalized mixed embedding technique. This integrator can be used to not only reconstruct the dynamics but predict the future evolution of the system.

The numerical experiments for Lorenz system show that our method is robust in reconstructing and forecasting continuous systems. Our method is suitable for any kind of dynamical systems (discrete or continuous), singular or multiple variable measurements. The reconstructed system holds all the dynamical properties of the original system; its global invariants are almost the same as the original. Additionally, we apply it

to a high dimensional system known as ZC-model for El Niño-Southern Oscillation. The results indicate our model can faithfully reproduce the entire time-space evolution of all the fields of the ZC model to a significant accuracy.