Hybrid Modeling for Forecasting Population Dymanics

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Abstract

We present a novel hybrid approach for forecasting dynamical systems and demonstrate our methodology on population data from cannibalistic flour beetles. In our proposed method, a portion of a mechanistic model's equations are used to predict a subset of the variables while a model-free prediction method is used to predict the remaining. The direct benefit of this is a reduction in complexity of the required parameter estimation problem which leads to an overall increase in prediction accuracy of future population behavior. Utilizing a Bayesian parameter estimation framework, we implemented uncertainty quantification analysis and found that the increase in prediction accuracy, afforded by our hybrid approach, is associated with lower levels of parameter correlations and Fisher Information Matrix rank deficiency. Though demonstrated on beetle population dynamics, our approach can be generalized to forecasting any ecological system in which multivariate time series data are available.

Keywords: dynamical systems, prediction, parameter estimation, population dynamics, uncertainty quantification.