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Parameter Estimation with Ignorance

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Parameter estimation in nonlinear models is a common task, and one for which there is no general solution at present. In the case of linear models, the distribution of forecast errors provides a reliable guide to parameter estimation, but in nonlinear models the facts that (1) predictability may vary with location in state space, and that (2) the distribution of forecast errors is expected not to be Normal, suggests that parameter estimates based on least squares methods may be systematically biased. Parameter estimation for nonlinear systems based on variations in the accuracy of probability forecasts is considered. Empirical results for several chaotic systems (the Logistic Map, the Henon Map and the 12-D Lorenz96 flow) are presented at various noise levels and sampling rates. Selecting parameter values by minimizing Ignorance, a proper local skill score for continuous probability forecasts as a function of the parameter values is easier to implement in practice than alternative nonlinear methods based on the geometry of attractors, the ability of the model to shadow the observations or model synchronization. As expected, it is more effective when the forecast error distributions are non-Gaussian. The goal of parameter estimation is not defined uniquely when the model class is imperfect. In short, the desired parameter values can be expected to be a function of the application for which they are determined. Parameter estimation in this imperfect model scenario is also discussed. Initial experiments suggest that our approach is also useful for identifying “best” parameter in an imperfect model as long as the notion of “best” is well defined. The information deficit, defined as the difference between the Empirical Ignorance and Implied Ignorance can be used to identify remaining forecast system inadequacy, in both perfect and imperfect model scenario.