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Tracking for Parameter and State Estimation in Possibly Misspecified Partially Observed Linear Ordinary Differential Equations

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Abstract

We address the problem of parameter estimation for partially observed linear Ordinary Differential Equations. Estimation from time series with standard estimators can give misleading results because estimation is often ill-posed, or the models are misspecified. The addition of a forcing function u, that represents uncertainties in the original ODE, can overcome these problems as shown in [Clairon and Brunel, 2017]. A general regularized estimation procedure is derived, that corresponds to an Optimal Control Problem (OCP) solved by the Pontryagin Maximum Principle for nonlinear ODEs. Here, we focus on the linear case and solve the OCP with a computationally fast deterministic Kalman filter which allows weakening of conditions needed for $\sqrt{n}-$consistency. A significant improvement is the avoidance of the estimation of initial conditions thanks to a profiling step. Consequently, we can deal with more elaborated penalties and also provide a profiled semiparametric estimation procedure in the case of time-varying parameters. Simulations and real data examples show that our approach is generally more accurate and more reliable than reference methods when the Fisher information matrix is badly-conditioned, with noticeable improvement in the case of model misspecification.

Keywords: Optimal Control, Profiling, Filtering, Riccati Equation, M-estimation.