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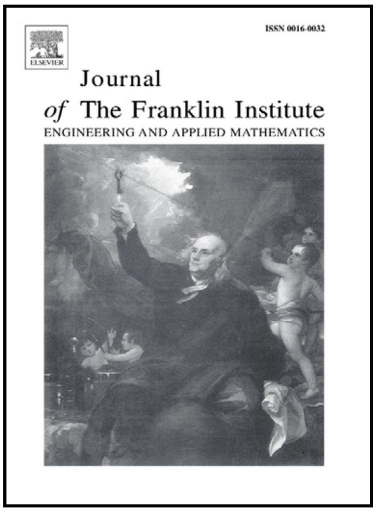

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Parameter identification of a class of nonlinear systems based on the multi-innovation identification theory☆

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Abstract

In this paper, the parameter identification problems of a class of linear-in-parameters systems are studied. Based on the multi-innovation identification theory, a multi-innovation stochastic gradient algorithm and a filtering based multi-innovation stochastic gradient algorithm are proposed. A nonlinear example is used to verify the effectiveness of the proposed algorithms and the results are compared in terms of estimation accuracy and computational efficiency. The simulation results show that the filtering based multi-innovation stochastic gradient algorithm is capable of producing highly accurate parameter estimates.

Keywords: Parameter estimation, Stochastic gradient, Multi-innovation, Data filtering, Linear in parameters model

1. Introduction

Parameter estimation and system identification techniques allow engineers to construct the mathematical models from the measured data and using some special identification techniques [1, 2] and have applications in many areas such as adaptive forecasting [3] and adaptive control [4]. For decades, many identification methods have been proposed for linear systems and nonlinear systems, e.g., the instrumental variable methods [5, 6], the bias compensation methods [7, 8, 9], the least squares algorithms [10, 11], the multi-innovation identification algorithms [12, 13] and the iterative identification methods [14, 15, 16, 17].

Compared with the least squares methods [18], the stochastic gradient method possesses an attractive characteristic of high computational efficiency but suffer a slow convergence rate. For improving the convergence rate, the multi-innovation identification theory has been proposed whose basic idea is extending the scalar innovation into an innovation vector [19]. Recently, several multi-innovation algorithms were developed. For example, Ding explored a couple of multi-innovation identification algorithms for different purposes [20], such as the multi-innovation projection algorithm and the multi-innovation forgetting gradient algorithm for tracking the time-varying parameters, and the interval-varying multi-innovation identification algorithms for non-uniform sampled systems.

The filtering technique can attenuate the noises and be used in various fields including face recognition [21, 22], fault detection [23], echo cancellation [24], image processing [25], signal processing [26, 27, 28] and parameter estimation [29]. When used in the parameter estimation, the data filtering technique is effective in improving the convergence rates and the computational efficiencies of the algorithms [30]. The decomposition technique can efficiently improve the computational efficiency, especially for the parameter estimation algorithms involving large matrix computation, i.e., the least squares algorithms with large covariance matrices [31]. In the literature, Ding and Duan presented a two-stage parameter estimation algorithms for Box-Jenkins systems [32]. Recently, Wang and Tang studied the parameter identification problems for a class of linear-in-parameters systems using the recursive least squares method [33] and the iterative methods [34]. In this paper, we focus our attention on the identification problems of a class of linear-in-parameters systems with the colored noises shown in Figure 1:

$$y(t)=\frac{\boldsymbol{\vartheta}^{\mathrm{T}}\boldsymbol{\eta}(u(t))}{A(z)}+\frac{D(z)}{C(z)}v(t), \tag{1}$$

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