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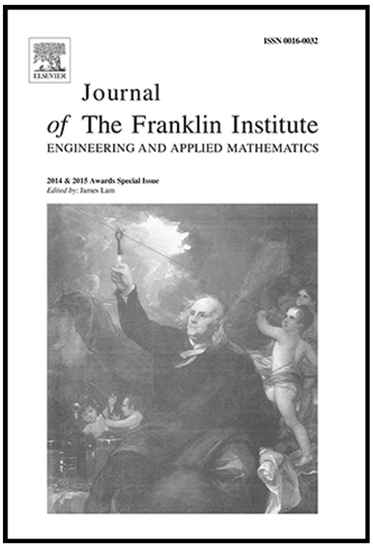

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Feng Ding, Yanjiao Wang, Jiyang Dai, Qishen Li, Qijia Chen

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A recursive least squares parameter estimation algorithm for output nonlinear autoregressive systems using the input–output data filtering

Feng Ding[a,b,d,*], Yanjiao Wang[a], Jiyang Dai[c], Qishen Li[c], Qijia Chen[a]

[a] *School of Internet of Things Engineering, Jiangnan University, Wuxi 214122, PR China*
[b] *College of Automation and Electronic Engineering, Qingdao University of Science and Technology, Qingdao 266042, PR China.*
[c] *School of Information Engineering, Nanchang Hangkong University, Nanchang 330063, PR China*
[d] *Department of Mathematics, Faculty of Science, King Abdulaziz University, Jeddah 21589, Saudi Arabia*

Abstract

In the revised paper, we have highlighted the changes made in blue.
Nonlinear systems exist widely in industrial processes. This paper studies the parameter estimation methods of establishing the mathematical models for a class of output nonlinear systems, whose output is nonlinear about the past outputs and linear about the inputs. We use an estimated noise transfer function to filter the input-output data and obtain two identification models, one containing the parameters of the system model, and the other containing the parameters of the noise model. Based on the data filtering technique, a data filtering based recursive least squares algorithm is proposed. The simulation results show that the proposed algorithm can generate more accurate parameter estimates than the recursive generalized least squares algorithm.

Keywords: Mathematical modeling, Nonlinear system, Least squares, Parameter estimation

1. Introduction

Parameter identification and establishing the models of dynamical systems are the basis of control system analysis [1, 2, 3] and controller design [4, 5]. Linear system identification methods have been well developed [6, 7], e.g., the generalized projection algorithm [8] for time-varying systems and the auxiliary model based recursive least squares algorithm for linear-in-parameter systems [9]. Nonlinear system identification has received much research attention [10]. Xu et al studied the parameter estimation and controller design for dynamic systems from the step responses based on the Newton iteration [11] and the Newton iteration algorithm to the parameter estimation for dynamical systems [12] and presented a damping iterative parameter identification method for dynamical systems based on the sine signal measurement [13]. Raja and Chaudhary studied a two-stage fractional least mean square identification algorithm for parameter estimation of CARMA systems [14]. Li discussed parameter estimation for Hammerstein CARARMA systems based on the Newton iteration [15]. Xie et al. studied the finite impulse response model identification of multirate processes with random delays using the expectation maxumum algorithm [16].

Hammerstein models [17, 18], Wiener models and their combination [19] are the most common model structures in the literature of nonlinear systems. Wang and Ding presented an interval-varying generalized extended stochastic gradient (GESG) algorithm and an interval-varying recursive generalized extended least squares (RGELS) algorithm for Hammerstein-Wiener systems [20] and a filtering based GESG algorithm and a filtering based RGELS algorithm for Hammerstein-Wiener systems with ARMA noise [21]. Wang and Zhang used the Taylor expansion and investigated an improved least squares algorithm for identifying the parameters of multivariable Hammerstein output-error moving average systems [22]. Wang et al. discussed the recasted models based hierarchical extended stochastic gradient method for MIMO nonlinear systems [23].

Information filtering has wide applications in many areas [24, 25], e.g., signal processing [26, 27], particle filtering [28] and state estimation [29]. Some filtering based methods have been used in different fields during the past decade [30, 31], e.g., signal processing [32] and parameter identification [33]. A filtering based iterative algorithm [34], a filtering based auxiliary model hierarchical gradient algorithm [35] and a filtering based auxiliary model hierarchical least squares algorithm [36] have been proposed for multivariable systems. A decomposition based least squares iterative identification algorithm has been proposed for multivariate pseudo-linear ARMA systems using the data filtering [37]. About the decomposition based identification, Xu et al. proposed the parameter estimation algorithms for dynamical response signals based on the multi-innovation theory and the

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*Corresponding author at: School of Internet of Things Engineering, Jiangnan University, Wuxi 214122, PR China
Email address: fding@jiangnan.edu.cn (Feng Ding)