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Adaptation in Stochastic Dynamic Systems—Survey and New Results IV: Seeking Minimum of API in Parameters of Data

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ABSTRACT

This paper investigates the problem of seeking minimum of API (Auxiliary Performance Index) in parameters of Data Model instead of parameters of Adaptive Filter in order to avoid the phenomenon of over parameterization. This problem was stated by Semushin in [2]. The solution to the problem can be considered as the development of API approach to parameter identification in stochastic dynamic systems.

Keywords: Linear Stochastic Systems; Parameter Estimation; Model Identification; Identification for Control; Adaptive Control MSC (2010); 93E10; 93E12; 93E35

1. Introduction

The recent papers [1,2] gave a survey of the field of adaptation in stochastic systems as it has developed over the last four decades. The author's research in this field was summarized and a novel solution for fitting an adaptive model in state space (instead of response space) was given.

In this paper, we further develop the Active Principle of Adaptation for linear time-invariant state-space stochastic MIMO filter systems included into the feedback or considered independently.

We solve the problem of seeking minimum of Auxiliary Performance Index (API) in parameters of Data Source Model (DSM) instead of parameters of Adaptive Filter (AF) in order to avoid difficulties known as Phenomenon of Over Parameterization (PhOP). The PhOP means that the number of parameters to be adjusted in AF is usually much greater than that in DSM. The solution of this problem will enable identification in the space of lower dimension and at the same time provide estimates of the given system state vector according to Original Performance Index (OPI). We verify the obtained theoretical results by two numerical simulation examples.

2. Parameterized Data Models $\mathcal{D}(\theta)$

Following the previous results of [1,2], we assume that all data models $\mathcal{D}(\theta)$ forming a set $\mathcal{D}$ are parameterized by an l-component vector θ. Each particular value of θ (which does not depend on time) specifies a $\mathcal{D}(\theta)$. Hence

$$\mathcal{D} = \left\{ \mathcal{D}(\theta) \middle| \theta \in \Theta \subset \mathsf{R}^l \right\} \tag{1}$$

where Θ is the compact subset of R^l. A given physical data model (PhDM) is described by the following equations:

$$\mathcal{D}(\theta): \begin{array}{l} x_{t+1} = \Phi(\theta) x_t + \Psi(\theta) u_t + \Gamma(\theta) w_t, t \in \mathsf{Z}_+ \\ y_t = H(\theta) x_t + v_t, t \in \mathsf{Z}_1 \end{array} \tag{2}$$

where Z_+ denotes nonnegative integers, Z_1 strictly positive integers, and Z all integers.

Every model $\mathcal{D}(\theta)$ (2) is assumed to be acting between adjacent switches as long as it is sufficient for accepting as correct the basic theoretical statement (BTS) that all processes related to the $\mathcal{D}(\theta)$ are wide-sense stationary. This statement amounts to the following assumptions. The random x_0 with $\mathsf{E}\left\{\|x_0\|\right\}^2 < \infty$ is orthogonal [3] to w_t and v_t, the zero-mean mutually orthogonal wide-sense stationary orthogonal sequences with $E\left\{w_t w_t^T\right\} = Q(\theta) \geq 0$ and $E\left\{v_t v_t^T\right\} = R(\theta) > 0$ for all $t \in \mathsf{Z}$; $\left[w^T v^T\right]^T$ is orthogonal to x_j and u_j for

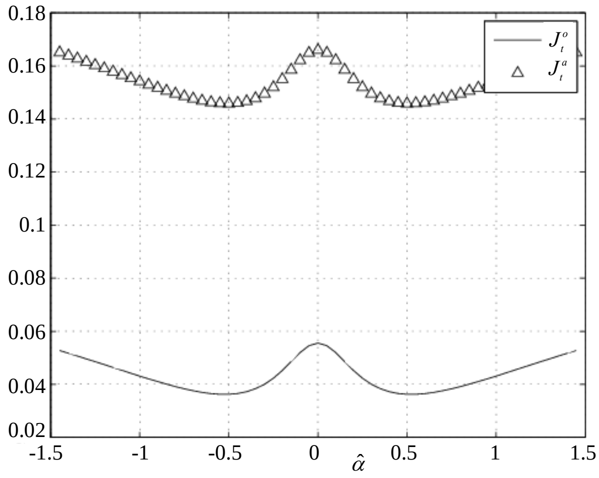

Figure 7. The values of J_t^o and J_t^a versus the estimates of parameter α (*Example E*2).

7. Conclusion

The present paper gives a comprehensive solution to the problem of seeking minimum of $J_t^a(\hat{\theta})$ in parameters $\hat{\theta}$ of Data Model $\mathcal{D}(\hat{\theta})$ or $\mathcal{D}^*(\hat{\theta})$ instead of parameters of Adaptive Filter $\mathcal{M}(\hat{\theta})$ or $\mathcal{M}^*(\hat{\theta})$. The obtained results were verified by two numerical simulation examples.

Our further research is aimed at obtaining solutions to the following issues:

- Economic feasibility, numeric stability and convergence reliability of each proposed parameter identification algorithm.
- Numerical testing of the approach and determining the scope of its appropriate use in real life problems, for example, in Health Care field [6].

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REFERENCES

[1] I. V. Semushin, "Adaptation in Stochastic Dynamic Systems—Survey and New Results I," *International Journal of Communications*, *Network and System Sciences*, Vol. 4, No. 1, 2011, pp. 17-23. http://dx.doi.org/10.4236/ijcns.2011.41002

[2] I. V. Semushin, "Adaptation in Stochastic Dynamic Systems—Survey and New Results II," *International Journal of Communications*, *Network and System Sciences*, Vol. 4, No. 4, 2011, pp. 266-285. http://dx.doi.org/10.4236/ijcns.2011.44032

[3] P. E. Caines, "Linear Stochastic Systems," John Wiley and Sons, Inc., New York, 1988.

[4] L. Ljung, "Convergence Analysis of Parametric Identification Methods," *IEEE Transactions on Automatic Control*, Vol. 23, No. 5, 1978, pp. 770-783. http://dx.doi.org/10.1109/TAC.1978.1101840

[5] E. Mosca, "Optimal, Predictive, and Adaptive Control," Prentice Hall, Inc., Englewood Cliffs, 1995.

[6] I. V. Semushin, J. V. Tsyganova and A. G. Skovikov, "Identification of a Simple Homeostasis Stochastic Model Based on Active Principle of Adaptation," *Book of Abstracts Applied Stochastic Models and Data Analysis ASMDA* 2013 *& Demographics*, Barcelona, 25-28 June 2013, p. 191.