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Identification of time-varying OE models in presence of non-Gaussian noise: Application to pneumatic servo drives

Vladimir Stojanovic*,† and Novak Nedic

Department of Automatic Control, Robotics and Fluid Technique, Faculty of Mechanical and Civil Engineering, University of Kragujevac, Kraljevo, Serbia

SUMMARY

Intensive research in the field of mathematical modeling of pneumatic servo drives has shown that their mathematical models are nonlinear in which many important details cannot be included in the model. Owing the influence of the combination of heat coefficient, unknown discharge coefficient, and change of temperature, it was supposed that parameters of the pneumatic cylinder are random (stochastic parameters). On the other side, it has been well known that the nonlinear model can be approximated by a linear model with time-varying parameters. Due to the aforementioned reasons, it can be assumed that the pneumatic cylinder model is a linear stochastic model with variable parameters. In practical conditions, in measurements, there are rare, inconsistent observations with the largest part of population of observations (outliers). Therefore, synthesis of robust algorithms is of primary interest. In this paper, the robust recursive algorithm for output error models with time-varying parameters is proposed. The convergence property of the proposed robust algorithm is analyzed using the methodology of an associated ordinary differential equation system. Because *ad hoc* selection of model orders leads to overparameterization or parsimony problem, the robust Akaike's criterion is proposed to overcome these problems. By determining the least favorable probability density for a given class of probability distribution represents a base for design of the robust version of Akaike's criterion. The behavior of the proposed robust identification algorithm is considered through intensive simulations that demonstrate the superiority of the robust algorithm in relation to the linear algorithms (derived under an assumption that the stochastic disturbance has a Gaussian distribution). The good practical values of the proposed robust algorithm to identification of the pneumatic cylinder are illustrated by experimental results. Copyright © 2016 John Wiley & Sons, Ltd.

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KEY WORDS: robust identification algorithm; pneumatic servo cylinder; model order selection; robust Akaike's criterion; ε-contaminated distributions

1. INTRODUCTION

Pneumatic drives are broadly used in robotics and industrial applications because of their distinct characteristics of energy saving, cleanliness, simple structure and operation, and high efficiency and are suitable for working in a harsh environment [1, 2]. These drives have a complex structure due to time-varying dynamics, the compressibility of air, nonlinearities (friction), internal and external disturbances, and payload variations [3]. Obtaining servo drive models based on fundamental laws of physics is a difficult problem. In order to facilitate a controller design, for obtained model, the various simplifications of the model are performed. Most often, it is the linearization process around the operating point [4–7]. Also, it is known that a large number of parameters of physical systems are very difficult to determine. The unknown values of the parameters may be the result

*Correspondence to: Vladimir Stojanovic, Department of Automatic Control, Robotics and Fluid Technique, Faculty of Mechanical and Civil Engineering, University of Kragujevac, Dositejeva 19, 36000 Kraljevo, Serbia.
†E-mail: vladostojanovic@mts.rs