International Journal of Innovative Computing, Information and Control
Volume **1**, Number **3**, September **2005**

ICIC International ©2005 ISSN 1349-4198
pp. **527–545**

SYSTEM IDENTIFICATION AND ORDER DETERMINATION USING CANONICAL-FORMS

Mitsuru Matsubara, Yusuke Usui and Sueo Sugimoto

Department of Electrical and Electronic Engineering
Ritsumeikan University
Noji-Higashi, Kusatsu City, Shiga 525-8577, Japan
sugimoto@se.ritsumei.ac.jp

Received November 2004; revised April 2005

Abstract. *In this paper, we present identification algorithms for parametric canonical-formed Multiple-Input Multiple-Output (MIMO) state-space models and also for determining the order of models, based on maximum-likelihood and Akaike's Information Criterion (AIC). To obtain maximum-likelihood estimate of model parameters, we apply Expectation-Maximization (EM) algorithms which are iterative methods such that the choice of the initial estimates is most important. The initial estimates of parameters in canonical-formed state-space models are obtained by MOESP [2] or N4SID [3] methods where the similarity transformation plays a key role.*

Keywords: System identification, MIMO system, Order determination, Subspace-methods, Canonical-form, Expectation-Maximization (EM) algorithm, Akaike's Information Criterion (AIC)

1. **Introduction.** Recently, the methods of Subspace-based State-Space System Identification (4SID) have been suggested as an alternative to traditional system identification techniques [1]. The 4SID methods are attractive since they can estimate state-space models directly from input-output data, without requiring canonical parameterizations and non-linear optimizations. In addition, subspace methods are often implemented using robust numerical tools such as the QR-factorization and the Singular Value Decomposition (SVD), which make them useful and efficient from a numerical point of view. However it is considered that subspace-methods have some problems, the first problem is that it is necessary to guarantee the stability of the model, the second one is that the explicit criterion which determines the system order is required, and the third problem is to actualize more precise estimation of parameters. The first two problems are attributed to the facts that the system parameters of MIMO state-space model are not unique and the statistical properties of the system parameters estimated by subspace-methods are not clear. Therefore the above analysis motivates us to develop an algorithm in this paper, which obtains Maximum-Likelihood (ML) estimates for canonical and unique parametric state-space model, and determines the system order with the use of AIC. We employ an EM algorithm which is initialized by subspace-methods, e.g. MOESP, N4SID, and