ADAPTIVE INPUT-OUTPUT PAIRING USING ON-LINE RGA IDENTIFICATION

Khaki Sedigh, A. and Moaveni, B.

Professor of Control System,Department of Electrical and Electronics Engineering,
K. N. Toosi University of Technology Tehran Iran,
e-mail: sedigh@eetd.kntu.ac.ir

Electrical Engineering Group,Science and Research Unit, Islamic Azad University
Tehran,Iran
e-mail: b_moaveni@eetd.kntu.ac.ir

Abstract: Control structure design in the face of large plant parameter variations is an important step in the design of reconfigurable decentralized multivariable controllers. In this paper, recursive least square estimators (RLS) are used for on-line relative gain array (RGA) identification. Therefore, input-output pairing can be updated in the face of large plant parameter variations.

Keywords: Adaptive Pairing, Multivariable Control, Decentralized Control, Control Structure Design, Relative Gain Array (RGA).

1. INTRODUCTION

Large parameter variations and uncertainties can lead to different input-output pairings during plant operation. Although modelling uncertainties has been investigated in many references such as (Chen, 2002; Goodwin, 1989; Witcher, 1977), but none have considered the cases were these uncertainties can result in different input-output pairings (Bristol, 1966; Khaki Sedigh, 1985a, 2003b). In this paper, RGA is chosen as the control structure design methodology for its adaptability characteristics. It is shown that RLS identifiers can easily provide an updated version of the RGA and can therefore be employed in a reconfigurable decentralized multivariable control strategy. Simulation results are provided to show the effectiveness of the proposed methodology.

2. ANALYSIS

The plant under consideration are assumed to be represented on the discrete time set $T_T = \{0, T, 2T, ..., kT, ...\}$ where T is the sampling time, by means of an autoregressive difference equation of the form

$$y_k + A_1 y_{k-1} + ... + A_n y_{k-N} = B_1 u_{k-1} + ... + B_N u_{k-N} \quad (1)$$

where the matrices $A_i \in \Re^{m \times m}$ and $B_i \in \Re^{m \times m}$ ($i = 1,2,....., N$) are the parameter of the Nth-order model. These parameters of the ARMA model can be conveniently estimated by implementing in real time, the RLS parameter estimation algorithm (Astrom, 1995).It can easily be shown that the steady-state gain matrix of the multivariable plant can be calculate from equation (1), as fallows(Porter, 1988)

$$G(0) = (I + A_1 + ... + A_N)^{-1}(B_1 + B_2 + ... + B_N) \qquad (2)$$

where $G(s)$ is the transfer function matrix of the plant. Hence, by invoking the certainty equivalence principle, the on-line RGA of the plant is obtained by employing the estimated $\hat{A}_i$ and $\hat{B}_i$ matrices from RLS and calculating $G(0)$ from equation (2) and RGA from (Maciejowski, 1989):

$$\Gamma = G(0) \otimes G^{-T}(0) \qquad (3)$$

Hence, RGA is identified at every sampling time and the control system is notified in the case of a major change in the input-output pairing.

3. SIMULATION RESULT

Consider the following transfer function matrix

$$G(s) = \frac{(1-s)}{(1+5s)^2}\begin{bmatrix} 1 & -4.19 & -25.96 \\ 6.19 & 1 & -25.96 \\ 1 & 1 & 1 \end{bmatrix}$$

and its corresponding RGA

$$\Gamma_1 = \begin{bmatrix} 1.0009 & 5.0010 & -5.0019 \\ -5.0028 & 1.0009 & 5.0019 \\ 5.0019 & -5.0019 & 1.0000 \end{bmatrix}$$

a %25 increase in the (2,2) element of B_1 and a %25 decrease in the (2,1) element of B_2 will result in the following RGA matrix:

$$\Gamma_2 = \begin{bmatrix} 0.0777 & 0.2106 & 0.7118 \\ 0.6914 & -0.1170 & 0.4256 \\ 0.2309 & 0.9065 & -0.1374 \end{bmatrix}$$

Note that the input-output pairing proposed by Γ_1 is totally change in the case of Γ_2. Fig.1 shows the convergence of the RGA parameter and clearly indicates that a new input-output pairing ought to be adapted by the decentralized control methodology.

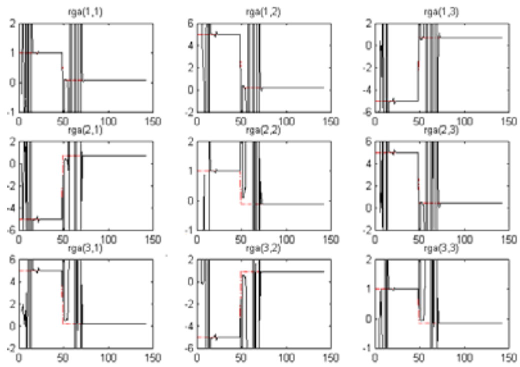

Fig. 1

4. CONCLUSION

It is shown that RLS identifiers can be employed to calculate the RGA of a multivariable plant. This would therefore provide an adaptive input-output pairing methodology in the case of large plant parameter variations or time varying processes. Hence, the multivariable decentralized control structure can undergo on-line structural modifications based on the estimated RGA observations. Finally, a simulation result is provided to show the effectiveness of the proposed methodology.

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