MULTIESTIMATION SCHEME FOR ADAPTIVE CONTROL OF THREE TANK SYSTEM

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Abstract: This paper deals with a one possibility of improvement of a self-tuning controller reliability and performance. A simple estimation scheme is replaced by so-called a multiestimation scheme and the self-tuning controller is then synthesized from this scheme. A higher level switching structure between various estimation schemes is used to supervise the reparametrization of the self-tuning controller in real time. The basic usefulness of the proposed scheme is to improve the accuracy of estimated parameters of the controlled system and then better transient response is obtained.

Keywords: Self-tuning control, Recursive estimation, ARX models, ARMAX models, Recursive identification algorithms, Multiestimation scheme.

1. INTRODUCTION

A self-tuning controller is based on recursive estimation of parameters of the controlled plant. These parameters are then used in controller synthesis. Unknown disturbances, non-modeled dynamics and abrupt changes in parameters of controlled system can cause a simple recursive identification scheme leads to inadequate estimations. The controller based on these estimated parameters can give poor performance.

In order to deal with this problem several suggestion were proposed and can be found in literature. In some of these approaches the modification of an existing recursive identification algorithms is proposed in order to improve theirs behavior (Hill, and Ydstie, 2004) or off-line version of identification algorithm can be used in identification part of self-tuning controller, due to the fact that off-line version produced more accurate parameter estimates than its recursive counterparts (Jiang and Zhang, 2004). Another possibility deals with using so-called multiple models approach (Naredra and Balakrishnan, 1994; Naredra and Balakrishnan, 1997). The models are established for different operating conditions. Each of them has corresponding linear controller. A supervisor then determines form process data which model best represents the process at a particular time, and then switches in its associated controller.

In this paper the similar approach to multiple models is used and is based on work presented in (Ibeas, *et al.*, 2002). A simple estimation scheme in identification part of self-tuning controller is replaced by so-called a multiestimation scheme and the self-tuning controller is than synthesized from this scheme. The scheme contains the supervisor which chooses the active controller and determined the switching time between controllers. The basic usefulness of the proposed scheme is to improve the transient response.

The paper is organized as follows: in Section 2 the basic linear model structures are described, Section 3 summarize several well-known recursive identification procedures and forgetting factors, Section 4 gives the experimental results, finally Section 5 concludes paper.

2. MODEL STRUCTURE

The basic step in identification procedure is the choice of suitable type of the model. The structure of the model should sufficiently describe the dynamics of given plant and purposes for which model is build.

All linear models can be derived from general linear model (Ljung, 1987) by its simplification. In this work, the three basic linear models are taken into consideration. These are ARX (*AutoRegressive with eXogenous input)*, ARMAX (*AutoRegressive Moving Average with eXogenous input)*, OE (*Output Error)* models.

These models are used in identification part of proposed multiestimation scheme for description of the dynamics of given plant.

3. RECURSIVE PARAMETER ESTIMATION

Recursive identification algorithm is an integral part of STC and play important role in tracking time-variant parameters. The recursive parameter estimation algorithms are based on the data analysis of the input and output signals from the process to be identified. Many recursive identification algorithms were proposed (Ljung, 1987, Söderström and Stoica, 1989; Wellstead and Zarrop, 1991). In this part several well-known recursive algorithms are briefly summarized.

3.1 RLS

Recursive least square method (RLS) can be used for parameter estimate of ARX model. Standard RLS algorithm assumes that the parameters of the model process are constant. In many cases, however, the estimator will be required to track changes in a set of parameters. To cope with tracking the time-variant parameters some adjustment mechanism must be introduced in the basic equations. Several implementations have been proposed (Kulhavý, 1987; Ljung, 1987; Söderström and Stoica 1989; Kulhavý and Zarrop 1993; Corriou, 2004; Wellstead and Zarrop 1991). In this work, adaptive directional forgetting is taken into consideration.

3.2 RPLR

Recursive pseudolinear regression method (RPLR) is used for parameter estimations of ARMAX and OE model. Formally it takes the same form as RLS (Ljung, 1987; Söderström and Stoica 1989; Nelles, 2001). However, the regression and parameter vectors are different

3.3 RIV

It can be shown that if the process does not meet the noise assumption made by the ARX model, the parameters are estimated biased and nonconsistent. This problem can be avoided using instrumental variable method (Söderström and Stoica, 1989). In this work two types of instrument are taken into consideration. These are model independent instrument (RIV1) and model dependent instrument (RIV2) (Branica, *et al.*, 2002).

3.4 RPEM

The recursive prediction error method (RPEM) allows the online identification of all linear model structure. Since all model structure except ARX are nonlinearly parameterized, no exact recursive algorithm can exist; rather some approximations must be made (Moore and Boel 1986; Moore and Weiss 1979; Söderström and Stoica 1989).

4. PARALLEL MULTIESTIMATION SCHEME

Recursive estimation parameter algorithms play an important role in tracking time variant parameters of the process dynamic model and are fundamental part of self-tuning controller. If the estimation algorithm starts running with estimated vector far away from real plant parameter vector, than the transient will have large deviations from desired output resulting in a bad performance. A parallel multiestimation scheme has chosen in order to improve the transient response of the adaptive system. The architecture of multiestimation scheme is depicted in Fig 1.

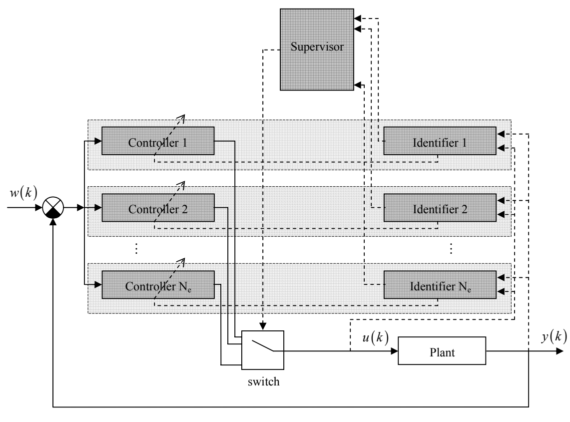

Fig. 1. Multiestimation scheme

The scheme consists of N_e pairs of identification algorithm-adaptive controller. All N_e estimation algorithms are performed at each sampling time t_k (running in parallel) (i.e. at each sampling time t_k every algorithm gives estimated plant parameter vector $\hat{\boldsymbol{\Theta}}_i(k)$ and estimated plant output $\hat{y}_i(k)$,