

SELF TUNING CONTROLLER BASED ON ROBUST ESTIMATION AND ADAPTIVE SAMPLING

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Abstract: In this paper we supposed that real industrial processes can be modeled by low-pass filter. For model of the process we used the Butterworth filter. In such case algorithm for parameters estimation is very simple and only is need estimate two parameters: gain and cut-off frequency of the filter. Further supposed that disturbance is stochastic. In engineering practice assumption about exactly known distribution of disturbances is never fulfilled owing present of outliers in observations. In that case we use Huber's min-max approach for construction robust recursive algorithm. Algorithm includes: filtering of data; data normalization; variable forgetting factor which maintains the trace of covariance matrix; scaling of the regressor vector. Using pole placement methodology we get self-tuning controller. Very important characteristics of the controller, from the application point of view, are anti-reset windup possibility and adaptive sampling.

Keywords: Self-tuning regulator, Butterworth filter, robustness, pole placement, adaptive sampling

INTRODUCTION

The real industrial processes are generally nonlinear time-varying, have variable time delays and other nonminimum phase effects. Moreover they are often interactive and are perturbed by changes of operating conditions. All of these factors make control of the process to be very difficult task. In such situation classical three-term regulator tuned according different rules (McMillan, 1983) can give unacceptable behaviour of dosed loop. One possibility is using adaptive controller. Essential ingredient of such controller is model of the process and we assume that the local behavior of the process can be adequately described by a linear, finite-dimensional, input-output model. We further suppose that process behaves as low-pass filter and such assumption is valid for many processes. In this paper we use for the process model the low-pass Butterworth filter and in that situation we have very simple estimator by which only two parameters (gain and cut-off frequency) must be estimated on-line from available measurement. We further considered the tasks of estimation and controller synthesis separately so that each can be tuned to optimize the overall performance (Middleton and others, 1988). Such approach is known as the indirect adaptive control systems (Åström and Wittenmark, 1984, 1989).

We assume that model of the process is stochastic and further, supposed that a priori known class of distributions to which disturbance belongs.

That assumption is very important in engineering practice because present of outliers in observations disables us to exactly known distribution of disturbance. Con-

siderable efforts have been oriented towards the design of robust estimation algorithms possessing a low sensibility to distribution changes usually valid locally within a prespecified distribution class. A precise mathematical treatment of this problem may be found in (Huber, 1981; Martin and Yohay, 1986). The problem of recursive robust identification of linear discrete-time single-input single-output dynamic systems with correlated disturbances is considered in (Tsytkin, 1984; Kovačević and Filipović, 1988). The convergence of developed algorithms is established theoretically using the ordinary differential equation approach and also presented quantitative performance evolution of the proposed algorithm using Monte-Carlo simulation results (Kovačević and Filipović, 1988). Linear algorithm for process modeled by Butterworth filter is proposed in (Neborai and Stoica, 1988). Robust recursive algorithm for such situation and convergence of estimated parameters with probability one is considered in (Filipović, 1989a). In this paper an improved robust recursive algorithm is proposed. Improvements are: data filtering; data normalization; a variable forgetting factor which maintains the trace of the covariance matrix; scaling of the regressor vector for making the algorithm numerically more robust. Sampling interval is adaptive. Increasing sampling rate as the process moves further away from the set-point allows disturbance to be detected earlier and for controller action to be initiated sooner and the process is returned to the set-point faster.

When the nominal model is known, there exist many possible choices for the control system design procedure. In this pa-

