Comments On "Accelerated Model-Reference Adaptation Via Lyapunov And Steepest Descent Design Techniques"

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Authors' Reply[2]

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The disadvantages of a perturbation input and the effect on the degradation of the performance of the system to which it is applied are well known and have been anticipated by the authors. However, closed-loop identification from the transient response was insurmountable and was abandoned as demonstrated in Section III of our paper. This emphasizes the major theme of the paper that open-loop and closed-loop identification are completely different problems and must be treated separately (Section I[1]). Therefore, the proposed algorithm was tested for its merits as a closed-loop algorithm without any attempt to evaluate the perturbation method or make any adjustments to compensate for the resulting degradation of performance, e.g., by assuming a different performance index, etc.

Wouters' main criticism of the algorithm, that his experimental evidence puts the method to a disadvantage, is based on an erroneous assumption. The assumption of $\{u(k)\} = 0$ used to derive his conclusions forces the system to an open-loop identification, which is expected to yield completely different results from the closed-loop identification under consideration. Furthermore, all the points plotted on the graphs, even with norm = 0, have been obtained by using the perturbation input and $\{u\} \neq 0$ for compatibility purposes.

The following additional remarks are appropriate in answering Wouters' critical note.

1) The seemingly powerful input perturbation noises have been used in both rather artificially conceived examples to speed up the convergence. They are not necessary for the algorithm and may be the result of scaling of the problem or the influence of the time interval at the discretization of the continuous system [1].

2) All the other parameters were chosen rather arbitrarily since the intention of the two examples is to demonstrate only the feasibility of the algorithm and the comparison of the two specific feedback controllers.

3) The performance index (PI) in Wouters' (3) is a misquotation from the paper; it should read

$$J(u) = E\left\{\frac{1}{3000}\sum_{i=0}^{3000}[x^2(i+1) + 2u^2(i)]\right\}.$$

4) The initial state of the systems is a random variable with $E\{x(0)\} = 0$, $E\{x(0)x^T(0)\} = 20$ I, which has accidentally been left out of the paper as well as out of Wouters' criticism.

5) Wouters' evaluation of the PI is based on his (4), (5), (6), and (7), which are not sufficiently justified. For instance, some of the expressions were only approximations of the limiting values while the influence of the initial state is presented without explanation.

REFERENCE

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[2] Manuscript received April 18, 1972.
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Comments on "Accelerated Model-Reference Adaption via Lyapunov and Steepest Descent Design Techniques"

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In the above short paper,[1] the authors failed to explain a very important requirement for implementation of their "improved" adaption technique. In (14), (15), and (32)–(34), the authors clearly require knowledge of δ_i, the misalignment of the reference model, and controlled plant parameters. Since the reference-model parameters are known, the assumption that δ_i is available permits direct calculation of the unknown process parameters. Who needs an adaptive system in which the unknown plant parameters must be known in order to implement the adaptive scheme? Although it is novel, we question the significance of this contribution to adaptive control.

Improving the dynamics of convergence of the original adaptive scheme [given by (10) and (11)] is certainly a problem of practical interest. We concur with the authors that the root locus is a valuable technique for the study of the dynamics of convergence. The interested reader may refer to [1] for an additional discussion of this approach. In [2]–[4] some other methods for improving convergence dynamics are presented.

The authors are concerned with the problem of asymptotic stability of the original adaptive scheme. The error is guaranteed to approach zero, but the controller parameters are not guaranteed to converge to their appropriate values. However, in [5, Appendix B] a proof of asymptotic stability of a parameter identification scheme is given. This proof is easily extended to cover the model-reference control problem. The assumption of plant controllability and certain requirements on the input $r(t)$ must be made in order to guarantee asymptotic stability. In essence, these restrictions mean that modes of the controlled process and of the reference model must be sufficiently perturbed so that any misalignment of parameters will result in error between the process and reference-model responses.

With a constant input $r(t)$, such as used by the authors, the most that can be expected of any adaptive scheme (excluding those that assume knowledge of the parameter misalignment??) is to match the dc gain of the model and controlled process. That is, for the authors' example,

$$\frac{K_v K_c}{A_0 + K_v h_0} = \frac{K_0}{a_0}.$$

Certainly there are many values of the adaptive parameters K_c and h_0 that will satisfy the above condition. However, if an appropriate random signal is added to the constant input, the parameter misalignment will asymptotically approach zero.

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[1] H. I. H. Shahein, M. A. R. Ghonaimy, and D. W. C. Shen, *IEEE Trans. Automat. Contr.* (Short Papers), vol. AC-17, pp. 125–128, Feb. 1972.

On "Accelerated Model-Reference Adaptation via Lyapunov and Steepest Descent Design Techniques"

C. C. HANG AND P. C. PARKS

In the above short paper,[1] Shahein *et al.* modified the conventional Lyapunov synthesis [1] to arrive at an accelerated scheme for the design of model-reference adaptive control systems. It is felt that, although the new design equations possess attractive advantages, their implementation will be difficult because the parameter misalignments are directly involved. This can be noted, for instance, by

Manuscript received March 21, 1972.
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