Digital Redesign of the Decentralized Adaptive Tracker for Linear Large-Scale Interconnected Systems with EP

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Abstract—A novel model-reference-based decentralized adaptive tracker is proposed for a continuous-time large scale multivariable system consisting of N interconnected linear subsystem with evolutionism programming algorithms (EP). It is perfect to use EP algorithms to look for the best parameter of model system. The adaptation of the analog controller gain is derived by using model-reference adaptive control theory based on Lyapunov’s method. In this paper, it is shown that the sampled-data decentralized adaptive control system is theoretically possible to asymptotically track the desired output with a desired performance. Based on the prediction-based digital redesign methodology, the optimal digital redesigned tracker for the sampled-data decentralized adaptive control systems with EP is newly proposed. An illustrative example of interconnected linear system is presented to demonstrate the effectiveness of the proposed design methodology.

Keywords- decentralized adaptive tracker; multivariable system; evolutionism programming; Lyapunov’s method; digital redesign

1. INTRODUCTION

In the recent years, the decentralized control of large scale interconnected systems has been one of the popular research topics in control theory. Large-scale systems, such as transportation systems, power systems, communications systems, etc., are essential features of our modern life [1,2]. Many works on the subject have appeared in [3].

The decentralized adaptive control methods initially proposed by Ioannou in 1986 [4], and first show that interconnections even though weak can make a decentralized adaptive controller unstable. A wide amount of decentralized adaptive techniques have been developed in [5-7].

An individual class of these techniques is the model reference decentralized adaptive control (MRDAC). However the disadvantage of the MRAC is that the convergence of local tracking errors only limited to a bounded residual set, one needs to develop new methods to avoid this disadvantage [8].

Based on the ideas contained in [9,10], a novel sampled-data decentralized adaptive approach to the solution of the decentralized adaptive tracking problem is developed in this paper.

With the rapid advances in digital technology, we use the digital redesign approach to construct the digital control [11].

By referring the technique, we yield an acceptable optimal digital controller for the sampled-data decentralized adaptive system which closely matches the response of the continuous-time well-designed system with the same inputs and initial conditions, rather than designing a new controller using the digital control theory.

In order to consider the closed-loop performances, one should search the suitable parameters of the decentralized adaptive approach. Among many successful convex optimization techniques, EP is effective in dealing with numerical and combinative global optimization searching problem with some design methodologies [12,13].

Given all the above background and explanation, the rest of the paper is organized as follows. In Section 2, the strictly decentralized adaptive control problem about system which is composed by multi-input multi-output (MIMO) subsystems is mentioned and the derivation of analog adaptive law is introduced. In Section 3, the digital redesign approach is introduced. It leads to the novel model-reference-based adaptive controller for the sampled-data decentralized adaptive control system by digitizing the analog decentralized adaptive controller. In Section 4, we demonstrate the EP approach and an example is illustrated in Section 5 to demonstrate the effectiveness of the methodology proposed in this paper.

2. THE DECENTRALIZED ADAPTIVE CONTROL PROBLEM

Consider a linear time-invariant system \( \Sigma_p \) consisting of \( N \) interconnected subsystems \( \Sigma_1, \Sigma_2, \Sigma_3, \ldots, \Sigma_N \), which is described as follows [10]:

\[
\Sigma_p: \dot{x}(t) = A_p x(t) + b_p u_p(t) + \sum_{i=1}^{N} E_p^i x_i(t) \quad (1)
\]

\[
y(t) = C_p x(t) \quad (2)
\]

The corresponding \( N \) reference models \( \Sigma_p \) are described as

\[
\Sigma_p: \dot{x}_p(t) = A_p x_p(t) + b_p u_p(t) \quad (3)
\]

\[
y(t) = C_p x_p(t) \quad (4)
\]

Assume all subsystems in (1) are completely controllable and the overall system is decentralized stabilization. The matrices \( A_p \) are asymptotically stable constant matrices of appropriate dimensions, and the constant vectors \( b_p \in R^r, C_p \in R^m \) are identical to \( b_p, C_p \in \Sigma_p \), respectively, i.e. \( b_p = b_p \) and \( C_p = C_p \). And the continuous-time state-feedback control law in (3) is given as follows:

\[
u_p(t) = -K_p x_p(t) + E_p r(t)\]

where \( K_p \) and \( E_p \) have been designed to satisfy some specified performance index discussed in the Section 3, and \( r(t) \) is the reference input, we have the closed-loop system as

\[
\dot{x}(t) = (A_p - b_p K_p) x(t) + b_p E_p r(t)\]