ON DECENTRALIZED HIERARCHIC STABILIZATION OF A LARGE-SCALE SYSTEM WITH CONSTRAINTS*

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Abstract. A new stabilization method of a large-scale dynamic system, consisting of a set of interconnected subsystems, is presented in this paper. The topology of the interconnected subsystems is given as a network containing nodes with only one ingoing link, and none, one, or more outgoing links. Here, when the notion "node" is used a subsystem is assumed, and the links stand for the subsystem interconnections. The stabilization method is made only by the use of local linear state feedback around each subsystem, in order to satisfy constraints given in the problem. The interconnections among the subsystems are assumed to be nonlinear, time-varying. According to the topology of the large-scale system, the method of stabilization is hierarchic, one proceeds from node to node, and is applicable from a computer standpoint. A design algorithm follows directly, and can be made using the Generate and Test method for each subsystem independently, thus enabling designers to use a computer which has a video terminal as a peripheral unit and providing a possibility for interactive applications.

1. Introduction

A new stabilization method of a large-scale system is considered in this paper. The large-scale system is given as a set of low-order subsystems interconnected in such a way as to form a tree network consisting of $s$ levels where $s \in \mathcal{N}$. This stabilization-method approach is justified by the fact that many practical problems met in engineering, biology, neurology, economy, etc., are concerned with distribution systems. These systems, however, can very often be treated, due to their complexity, as large-scale systems with the interconnection structure given by a tree network. This network topology provides the addition of new subsystems to the already stabilized large-scale

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system in such a manner that only the stabilization of the new additions is required. This way of network expansion is analogous to tree branching and, consequently, such a network is called the tree network and the stabilization method, according to such topology, is hierarchic. One starts with the higher-level nodes and proceeds downward ending with the lowest-level node under consideration. The main aim of this paper is to show that it is possible to control the overall large-scale system, in order to satisfy constraints, dealing with each subsystem individually, without affecting interconnections among them. An approach to the problem of controlling the set of interconnected subsystems is given by Davison [4] and Vukčević [7].

It is also shown that in a special case, there is always a solution to the problem.

Such an approach is based on the works of Davison [4] and Vukčević [10]. The main result and the contribution of the paper is the calculation of the correction multipliers [4], and the development of the recurrent formula for their evaluation as one proceeds from the higher-level node to the lower-level node along the chosen line (path) of the tree network. These correction multipliers are applied to the stabilization procedure calculating the local feedback gain vectors using the pole placement method [3]. The method assumes, for the purpose of practical realization, the use of the feedback control with constant gain vectors. This necessitated the development of a design procedure based on the implementation of local feedback control around each subsystem individually, avoiding the use of second-level control due to the nonlinear, time-varying interconnections. This approach was introduced by Davison [4] and Vukčević [7].

Thus, the proposed method is fully justified by the fact that the subsystems are with constraints while the above-mentioned works do not deal with such problems, neither does Vukčević [6], [8]. Also, the necessity for such an approach lies in the fact that the subsystems are connected so as to form a tree network, where each subsystem (node) has its own input, consequently requiring decentralized control. Using a particular large-scale system structure and particular Lyapunov functions, this work supplements the work of Michel et al. [5].

The paper is organized as follows. The network structure is discussed in Section 2 and Section 3 defines the problem and develops the stabilization procedure. The derivation of the correction multipliers is given in Section 4 and in Section 5 the stabilization algorithm based on the use of the multipliers is developed for the class of subsystems with nonlinear, time-varying interconnections.

In Section 6 a numerical example is presented to illustrate the stabilization of a tree network consisting of a stem and two branches, following the algorithm given in Section 5. Finally, the conclusions are given in Section 7.