

**ON IDENTIFICATION AND CONTROL OF  
INTERCONNECTED SYSTEMS :  
SOME DECENTRALIZED AND HIERARCHICAL  
SCHEMES**

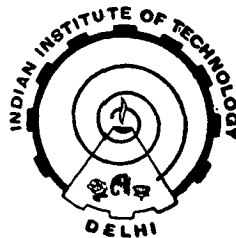
By

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Thesis Submitted

In fulfilment of the requirements of the degree of  
**DOCTOR OF PHILOSOPHY**

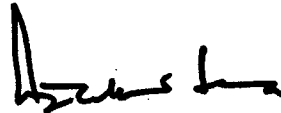


To the

**INDIAN INSTITUTE OF TECHNOLOGY, DELHI**  
**February 1984**

CERTIFICATE

This is to certify that the thesis entitled,  
"ON IDENTIFICATION AND CONTROL OF INTERCONNECTED SYSTEMS:  
SOME DECENTRALIZED AND HIERARCHICAL SCHEMES" being submitted  
by Jagdeo Mahto for the award of the degree of 'Doctor of  
Philosophy' to the Indian Institute of Technology, Delhi is  
a record of bonafide research work he has carried out  
under my guidance and supervision. The results obtained in  
this thesis have not been submitted to any other university  
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Dedicated to

My parents

Smt. and Sri Ramjee Mahto

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## ABSTRACT

Physical configuration, large dimension of interconnected systems and lack of information exchange between various subsystems make direct application of centralized algorithms for estimation, identification and control to an interconnected system impractical and uneconomical. The work presented in this thesis aims at deriving decentralized and hierarchical algorithms for estimation, identification and control of a subsystem that forms a part of an interconnected system. The performance of each subsystem is influenced by the variables of the others because of the interconnections. These variables, called the interaction variables are therefore always present in the subsystem model which have to be taken care of while developing various algorithms. Schemes have been developed in this thesis to tackle the problem of nonavailability of information exchange through two different techniques of estimation of the interaction variables. This is done by either (i) considering them as additional noise with a priori unknown statistics and then estimating them through an adaptive filter or (ii) assuming a dynamic interaction model and then identifying the model on the basis of local measurements. These techniques are then imbedded into an estimation scheme for decentralized state estimation.

The method of state & interaction estimation is then integrated with identification technique for decentralized identification of interconnected system. A two-stage bootstrap method of

centralized identification is extended for this purpose. Divergence occurring in such schemes has been tackled through three different divergence minimization techniques. An extended Kalman filter has also been used for decentralized identification.

The techniques of state and interaction estimation have been imbedded with control algorithm to effect decentralized control of interconnected system. A response matching criterion for designing a controller based on local state and interaction feedback has been used which avoids the arbitrariness in selecting the weighting matrices in linear quadratic cost criterion of optimal control. The control design problem is first converted to a parameter estimation problem and then a two-stage method is employed to get the state and interaction estimates in the first stage and the controller parameter estimates in the other.

To avoid the need for state estimation in control problem and thereby reduce some computational complexities an input-output representation of the subsystem model has then been exploited . The models contain interaction terms besides the local input-output. Based on this representation minimum variance and self-tuning control methods of Astrom have been extended to decentralized control of interconnected systems. The development of this algorithm has been presented through a lemma. Later a hierarchical self tracking control has been

proposed for interconnected systems. The method uses the input-output form of the subsystem model having unknown parameters (to be estimated). The controller is of a priori fixed structure and is designed on the basis of optimum matching of the closed-loop response with a prespecified desired response.

Almost all the algorithms developed in the thesis have been tested through simulation of a two-machine interconnected power system. A multi-input multi-output paper machine head-box model has also been used to test the performance of one of the decentralized control algorithms.

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