A COMPARISON STUDY ON THE DECENTRALIZED DISCRETE STOCHASTIC ESTIMATION PROBLEM.

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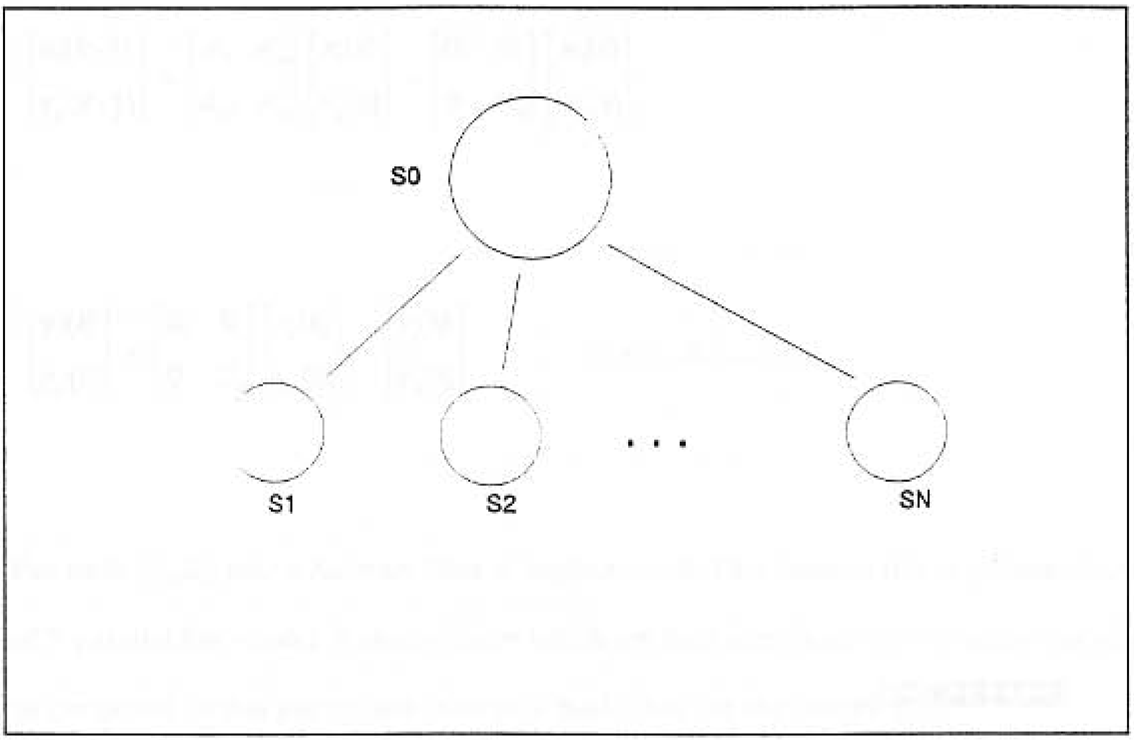
EXTENDED SUMMARY

In recent years, there has been an increasing interest in modelling and control in the area of Large Scale systems (LSS). This is due to rapid advances in computer technology and due to the fact that most man made systems are large in dimension, high in complexity and of great challenge to both the system analysts and the control system designers. Due to the complexity and the high dimensionality of LSS, a centralized approach to the joint problem of estimation and control of such systems can be economically infeasible and computationally impossible. For these reasons a certain type of decomposition and decentralization is not only beneficial, but essential as well. However, till today most decentralized approaches to the control/estimation problem of LSS have been ignoring the natural hierarchical structures of such systems although there have been a few exceptions (singular perturbation with slow and fast subsystems). Thus there is a need to systematically analyze any inherent hierarchical structural models.

In this paper this need is addressed. A two - level structural modular LSS being composed of a central dynamical coordinator S_0 is dynamically interconnected with N

uncoupled, from each other, subsystems $S_1, S_2, \ldots, S_N$ as shown in the following figure.



This model is referred to as the Block-Arrow-Structure (BAS) decentralized model. This approach departs from the completely decentralized as well as general multilevel hierarchical approaches (local and global) to the estimation and control problem since it takes into account from the beginning the interconnections and explores their overall effect on the estimation problem. The concept of a " partially decentralized " estimator based on the BAS approach is used. The problem of discrete stochastic estimation by exploiting the BAS structure of a LSS has not yet been addressed. So an algorithm, similar to that of [1] is proposed to estimate the states of a LSS which naturally appears or can be modelled (through similarity transformations) by the BAS model. (figure1). The proposed algorithm is based on the BAS approach which briefly can be explained as follows : The BAS - LSS is decomposed into N " partially decentralized " structures (S_0,S_1) (S_0,S_2) ... (S_0,S_N). The above decomposition translates to:

$$\begin{bmatrix} x_i(k+1) \\ x_o(k+1) \end{bmatrix} = \begin{bmatrix} A_i & A_{io} \\ A_{oi} & A_o \end{bmatrix} \begin{bmatrix} x_i(k) \\ x_o(k) \end{bmatrix} + \begin{bmatrix} G_i & 0 \\ 0 & G_o \end{bmatrix} \begin{bmatrix} w_i(k) \\ w_o(k) \end{bmatrix}$$

$$\begin{bmatrix} y_i(k) \\ y_o(k) \end{bmatrix} = \begin{bmatrix} C_i & 0 \\ 0 & C_o \end{bmatrix} \begin{bmatrix} x_i(k) \\ x_o(k) \end{bmatrix} + \begin{bmatrix} v_i(k) \\ v_o(k) \end{bmatrix} \qquad i = 1, 2, ..., N.$$

For each (S_0,S_i) pair a Kalman filter is implemented. This leads to the implementation of N parallel low - order Kalman filters which are then combined appropriately (as will be proposed in this paper) will lead to a BAS filter for the overall LSS.

The two level structural estimator will be of the form

$\hat{x}_{k+1} = \hat{x}^-_{k+1} + P_{k+1} C^T R^{-1} (y_{k+1} - C \hat{x}^-_{k+1})$, in which the steady state error covariance matrix P is in the block arrow structure form (BAS).

It is important to point out that the final filter will maintain the original BAS - structure of the model. An example will be given to demonstrate the applicability and usefullness of this new structural approach. Comparisons with other decentralized techniques will be given especially on the computational advantages of the proposed approach. The method is compared to the centralized approach and to the method proposed by Malur K. Sundareshan in [3].

The proposed approach has the following advantages:

a) Parallel processing implementation.

b) Reduction in computations.

c) Structural flexibility as the addition or deletion of a subsystem does not require the solution of the overall system from the beginning.

References.

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