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PRACTICAL CONSIDERATIONS FOR NONINTERACTING CONTROL
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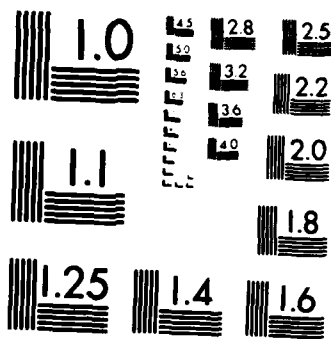
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19. ABSTRACT (Continue on reverse if necessary and identify by block number) The research was concerned with the practical problems of achieving noninteracting control (decoupling). This problem involves finding a feedback controller so that each input of a system affects one and only one output of the closed-loop system and maintains this behavior even in the presence of small modelling errors. This research then led to the investigation of the problem of determining the freedom in assigning eigenstructures when the closed-loop system has repeated eigenvalues. The research results for the problem of noninteracting control has led to a characterization of the closed-loop eigenstructure of decoupled systems. The results of the investigation of the second problem has led to a complete characterization and better understanding of the minimum time control of discrete time systems, better known as deadbeat control systems.					
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Final Report On
Practical Considerations for
Noninteracting Control Synthesis

Problem Statement

The original problem that was to be examined was concerned with investigating some of the practical considerations necessary to achieve decoupling or noninteracting control of a multi-input multi-output (MIMO) system. For a linear system with m independent inputs and p independent outputs modelled by

$$\begin{aligned}\dot{x} &= A x + B u \\ y &= C_1 x \quad i \in p \\ (p &= 1, 2, \dots, p)\end{aligned}$$

the problem becomes that of controlling the system so that the i th input (or combination of inputs) excites only the i th output without affecting the others. The approach generally taken [1-8] has been to find a state feedback matrix F and input reordering matrices G_i , $i \in \underline{m}$ such that for the closed-loop system

$$\begin{aligned}\dot{x} &= (A + BF)x + \sum_i B G_i u_i \\ y_i &= c_i x \quad i \in p\end{aligned}$$

input u_i only affects output y_i . The proposed research was intended to examine approaches to select the $[G_i, i \in \underline{m}]$ and F to reduce the level of interactions that innvariably result in the presence of modelling errors in the system parameters (A, B, C) .

The approach that was used involved the study of controllability subspaces, subspaces that are spanned by closed-loop eigenvectors. A key problem that was quickly encountered was the amount of freedom available in selecting these eigenvectors considering the overlap in the controllability

subspaces. This problem proved to be more difficult and interesting than was initially expected and took up the majority of research time.

Status of Research

As described in the previous section the research problem evolved into two related problems; one problem involving the investigation of the sensitivity of noninteracting control systems and a second problem involving the detailed examination of the available freedom in selecting closed-loop eigenstructures when the system has repeated eigenvalues. The solution of the former problem was found to be dependent on the latter.

Preliminary theoretical work and software development has been completed on the problem of decoupling controller design. This work is summarized in [9] and is included as Appendix 1. The approach was based on developing eigenstructure characterizations of closed-loop systems that are decoupled and then using modified versions of previously developed techniques to assign these eigenstructures in a robust or insensitive manner. The current research has provided a characterization of the decoupled eigenstructure for the case involving distinct eigenvalues (generic) with equal numbers of inputs and outputs and no transmission zeros in the right half-plane. Some preliminary work has been completed on the remaining cases involving repeated eigenvalues, more inputs than outputs and arbitrary numbers of transmission zeros located anywhere in the complex plane. It is intended to pursue this line of research in the future.

The problem of characterizing the freedom in selecting closed-loop eigenstructure involving repeated eigenvalues led to the second research problem that was investigated. The results of this work is summarized in [10,11] (included in the appendix) and in an additional publication based on [11] still in preparation. This work has provided a characterization of the closed-loop eigenstructures that can be assigned when there are repeated eigenvalues. These results were applied to the problems of minimum time

Publications Resulting from the Research

G. KLEIN, "Robust Noninteracting Controller Design", 1983 American Control Conf.

G. Klein, "On the Relationship Between Controllability Indices, Eigenvector Assignment, and Deadbeat Control", IEEE Trans. Automatic Control, Vol. AC-29, pp 77-79, Jan. 1984.

G. Klein, "The Freedom in Selecting the Eigenstructure of Deadbeat Controllers", Invited Paper, 1985 American Control Conf.

G. Klein, "The Eigenstructure of Deadbeat Control Systems", in preparation, to be submitted to IEEE Trans. Aut. Control or Syst. Control Letters.

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