REAL TIME CONTROL OF LARGE SCALE SYSTEMS

by

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Abstract

In this note a brief description is given of the origins of the EEC real time control project and of this workshop. A summary is also given of two of the "state of the art" reports i.e. that on hierarchical optimisation and control and the one on decentralised control. The final report on reliability and fault detection will be given by Professor Tzafestas at the workshop whilst the hierarchical and decentralised control will be covered respectively by Professor Schmidt and Professor Titli.

1. Introduction

The Commission of the European Communities (DG III) awarded a grant to myself at U.M.I.S.T. in Manchester in 1982 to collaborate with the groups of Professor André Titli in Toulouse, Professor Gunther Schmidt of the Technical University of Munich and Professor Spyros Tzafestas of the University of Patras in developing and examining the current state of the art of the important subject of real time control for large scale systems. It was agreed that the work of the four teams concentrates on the following three areas of real time control i.e. (1) Decentralised Control (2) Hierarchical Control and (3) Reliability and Fault Detection.

Since the award of the grant, major reports have already been provided to the EEC Commission describing the current state of the art of the real time control aspects of HIERARCHICAL CONTROL and DECENTRALISED CONTROL. My colleague Professor André Titli will present in our workshop a condensed version of our report on Decentralised Control whilst Professor Gunther Schmidt will do the same for our report on Hierarchical Control. Professor Tzafestas will be presenting here at this workshop our report on reliability and fault detection techniques for large scale systems. It was a condition of the award of the grant by the EEC Commission that a workshop be held at the conclusion of the grant to present their "state of the art" reports to the international scientific community for comments and criticisms. It was agreed that the workshop be held in Patras and my colleague Professor Tzafestas very kindly agreed to organise it. In order to ensure that the results of the work on real time control are adequately disseminated within the EEC and at the same time, the work is seriously assessed by the wider international scientific community, it was agreed to open the workshop for participation from the United States and elsewhere. We are very pleased that the response from the international
scientific community has been excellent and we welcome delegates from a large number of countries.

In the rest of this note, I will describe the basic problems of hierarchical and decentralised control which will be further elaborated by Professors Schmidt and Titli.

2. Decentralised Control

The decentralised control problem arises when a system is acted upon by a number of controllers which are unable to communicate amongst themselves on-line, even though they may have a set of a priori rules which allow them to have some structural knowledge about each other. In the last 15 years, a significant body of knowledge has been built up on the behaviour of such systems and ways of controlling them. In our state of the art report we provided a classification of this knowledge and touched upon some of the more interesting results which have been obtained.

It should be emphasised that, although decentralised controllers have been designed and used for controlling interconnected dynamical systems for over two decades, the design was based on ad hoc methods. For example, one usually assumed that the system comprised weakly interacting subsystems so that it was plausible to design the controllers independently for each subsystem. This is still the basis for most industrial control systems design. However, with the increased interest in optimisation techniques in the 1960s, there was an attempt to translate the notions of optimal centralised controller design to decentralised situations. It is only at this point that the intrinsic difficulty of decentralised control become apparent. For example, one of the best known and most useful results in the theory of control for centralised systems is the separation theorem. This, broadly speaking, states that for linear dynamical systems subject to Gaussian disturbances, it is possible to design a controller which minimises the expected value of a quadric cost function by designing separately an optimal state estimator and an optimal controller. Moreover, the state estimator is finite dimensional and the optimal controller is linear. These results fail in the case of decentralised control. A lot of the work on decentralised control could therefore be seen as an attempt at justifying the ad hoc design procedures used in current industrial practice and the new issues which emerged during these studies.

In the real world, decentralised decision making and control situations arise in many different fields. In Engineering, a typical example would be power systems control where different parts of the network are under the control of different authorities who have some a priori rules for acting based on previous knowledge but which do not have time or the physical possibility of exchanging information on-line. In manag-