Preface

This work is the result of the development of reconfigurable control around unknown scenarios known as fault scenarios over system performance that consider distributed communication. In that respect, control law is modified to overcome these unknown scenarios. To perform this task, several issues need to be considered such as fault diagnosis and related time delays.

Several strategies have been reviewed to come up with the implementation and integration of three main stages: fault diagnosis and related heuristic confidence value, fault tolerance strategy and the related real-time scheduling approach, and those control strategies suitable for different scenarios that consider fault presence and time delays.

To accomplish this integration, reconfigurable control is proposed in which the main issue is to keep a system under safety conditions even in the case of self-degradation. Therefore, reconfigurable control is neither only a gain scheduler algorithm nor only a decision-maker algorithm; it is a procedure in which safety degradation and its effects need to be taken into account to overcome hazardous situations. This approach is based on the use of a finite state machine to pursue reconfigurable control. This strategy is not the only feasible one; however, it becomes the most suitable for providing coherence under hazardous situations and when various sources of information are present.

The aim of this book is to describe a complex problem in which two areas are combined, computer and control engineering. From the description of this problem, several algorithms are presented to obtain as much information as possible from the disposable sources that consider two main scenarios, fault and time delay presence. Therefore, how to produce suitable control and process monitoring strategies under hazardous conditions following a feasible and understandable approach is the main issue of this work. To accomplish such a task, a well-known computer engineering strategy is pursued: the finite state machine, in which different healthy and unhealthy conditions are monitored for system status definition.

The objective of this work is to present to the reader a way to perform reconfigurable control on-line without jeopardizing the safety and the stability of the system. This book is written for undergraduate and postgraduate students interested in reconfigurable control as a strategy to overcome local fault conditions and performance degradation during still manageable fault situations. An exhaustive review of model-based and model-free strategies for fault detection is provided to introduce the reader to the area of process monitoring, which looks for a practical approximation of it. Furthermore, an extensive review of network control is given to define how time delays are accommodated due to fault tolerance strategies. To that respect, a guide for how to approximate to this interesting open field is presented.

Special mention should be made of the software used in this work; in this case, three major packages are used: first, MATLAB 6.5, especially the Simulink and State Flow toolboxes. The second package is True Time, which is used to simulate the communication network, and it is available through the Internet http://www.control.lth.se/~dan/truetime/; this package has been found to be an efficient tool for understanding the functionality of a network. Finally, ADMIRE is another useful package (ADMIRE, 2003) that is an aerodynamic model of an aircraft, which has presented interesting scenarios under fault and time delay scenarios worthy to be studied in future work.

This book is divided into five chapters. The first chapter is a basic review of communication networks in which a description of network protocols is provided based on a common standard of open systems interconnection (OSI); particular interest is presented over the control area network databus (CAN bus) because of its common use over real-time distributed systems. The second chapter is focused on the real-time background, and it presents how a real-time system can define time delays based on its inherent deterministic behavior using scheduling algorithms; in fact, an overview of most classic scheduling algorithms is presented.

The outline of the third chapter is based on fault diagnosis strategies for a common and unknown situation, which is an unhealthy scenario. Specifically, this chapter concentrates on a smart element paradigm that understands this element as an autonomous device that can self-diagnose. Chapter 3 presents the most common strategies of fault diagnosis and their use for health treatment.

The fourth chapter presents an implementation of the control reconfiguration strategy based on a review of network control systems to pursue a feasible option for safety during fault conditions. Strategies such as time delay modeling, interloop connection, and others such as fuzzy control or model predictive control are presented as alternatives for network control. This review allows the reader to choose any of these techniques according to the model of the plant. It is obvious that some of these possibilities would not have the proper stability analysis to probe. Moreover, this chapter presents fault tolerance control as a way to overcome fault appearance without any fault accommodation procedure; in this case, control law is designed to loosen peripheral elements such as sensors or actuators. At last, reconfigurable control is presented as a combination of these two strategies; in this case, the use of an automata procedure is followed. For instance, the pursued scenario is a fault environment with inherent communication time delays. To define a feasible strategy suitable for a sporadic situation, it is necessary to design several control laws that can switch from one scenario to another, bearing in mind safety and availability issues. A way to overcome this environment by combining both scenarios using an automata is presented here.

The final chapter provides some implementing examples based on two different approaches. First, an example of three conveyor belts is given, in which modeling is pursued; in this case, time delays are bounded as are possible local faults. The only restriction is that one local fault per belt is allowed.

The second example is based on an aircraft model in which multiple sensors and actuators are presented and the mathematical model is a challenge. In this case, the strategy pursued is based on fuzzy control that provides feasible results during reconfiguration. It is important to mention that fuzzy control is pursued, bearing in mind that the model is a simulation because this implementation is virtually impossible in real-life implementation.

The background of this book is mainly related to a Ph.D. thesis developed by the first author (Benítez-Pérez, 1999) while with the Department of Automatic Control and Systems Engineering, University of Sheffield, U.K. From this experience, several strategies were pursued such as fault diagnosis for smart elements and reconfigurable control (Benítez-Pérez and García-Nocetti, 2003). Moreover, the use of network control is pursued to accomplish stability during unknown and sporadic time delays; in that respect, an interesting issue has been presented by the *IEEE Transactions on Automatic Control* (IEEE TAC, 2004).

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