Preface

A permanent increase in the complexity, efficiency and reliability of modern industrial systems necessitates a continuous development in control and fault diagnosis. A moderate combination of these two paradigms is intensively studied under the name of fault-tolerant control. This real world's development pressure has transformed fault diagnosis and fault-tolerant control, initially perceived as the art of designing a satisfactorily safe system, into the modern science that it is today.

Indeed, the classic way of fault diagnosis boils down to controlling the limits of single variables and then using the resulting knowledge for fault alarm purposes. Apart from the simplicity of such an approach, the observed increasing complexity of modern systems necessitates the development of new fault diagnosis techniques. On the other hand, the resulting fault diagnosis system should be suitably integrated with the existing control system in order to prevent the development of faults into failures, perceived as a complete breakdown of the system being controlled and diagnosed.

Such a development can only be realised by taking into account the information hidden in all measurements. One way to tackle such a challenging problem is to use the so-called model-based approach. Indeed, the application of an adequate model of the system being supervised is very profitable with respect to gaining the knowledge regarding its behaviour. A further and deeper understanding of the current system behaviour can be achieved by implementing parameter and state estimation strategies. The obtained estimates can then be used for supporting diagnostic decisions and increasing the control quality, while the resulting models (along with the knowledge about their uncertainty) can be used for designing suitable control strategies.

Although the majority of industrial systems are nonlinear in their nature, the most common approach to settle fault diagnosis and fault-tolerant control problems is to use well-known tools for linear systems, which are widely described and well documented in many excellent monographs and books. On the other hand, publications on integrated fault diagnosis and fault-tolerant control for nonlinear systems are scattered over many papers and a number of book chapters.

Taking into account the above-mentioned conditions, this book presents selected *Fault Diagnosis and Fault-Tolerant Control Strategies for Non-Linear Systems* in a unified framework. In particular, starting from advanced state estimation strategies up to modern soft computing, the discrete-time description of the system is employed. Such a choice is dictated by the fact that the discrete-time description is easier and more natural to implement on modern computers than its continuous-time counterpart. This is especially important for practicing engineers, who are hardly ever fluent in complex mathematical descriptions.

The book results from my research in the area of fault diagnosis and fault-tolerant control for nonlinear systems that has been conducted since 1998. It is organised as follows. Part I presents original research results regarding state estimation and neural networks for *Robust Fault Diagnosis*. Part II is devoted to the presentation of integrated fault diagnosis and fault-tolerant systems. It starts with a general fault-tolerant control framework, which is then extended by introducing robustness with respect to various uncertainties. Finally, it is shown how to implement the proposed framework for fuzzy systems described by the well-known Takagi–Sugeno models.

This book is primarily a research monograph which presents, in a unified framework, some recent results on fault diagnosis and fault-tolerant control of nonlinear systems. It is intended for researchers, engineers and advanced post-graduate students in control and electrical engineering, computer science, as well as mechanical and chemical engineering.

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