amcs

2015 Volume 25 Number 1

ISSN 1641-876X (print)
ISSN 2083-8492 (online)
QUARTERLY
March 2015

International Journal of

applied mathematics and computer science

Special issue SAFETY, FAULT DIAGNOSIS AND FAULT TOLERANT CONTROL IN AEROSPACE SYSTEMS

Editors Silvio SIMANI, Paolo CASTALDI

University of Zielona Góra Press, Poland

Profile

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The *International Journal of Applied Mathematics and Computer Science* is a quarterly published jointly by the University of Zielona Góra and the Lubuskie Scientific Society in Zielona Góra, Poland, since 1991. It strives to meet the demand for the presentation of interdisciplinary research in various fields related to control theory, applied mathematics, scientific computing, and computer science.

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Impact Factor

1.390 (2013), 1.008 (2012), 0.487 (2011), 0.794 (2010), 0.684 (2009)
5-Year IF: **1.317** (2013), 1.146 (2012)

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Editorial Office

University of Zielona Góra
Institute of Control & Computation Engineering
ul. Podgórna 50
65-246 Zielona Góra
Poland
tel.: +48 683282506
fax: +48 683284751
e-mail: amcs@uz.zgora.pl
website: www.amcs.uz.zgora.pl

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AIMS & SCOPE

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The publication of *AMCS* is financially supported by the Ministry of Science and Higher Education in Poland and the University of Zielona Góra.

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CONTENTS

Rotondo D., Nejjari F. and Puig V. Robust quasi-LPV model reference FTC of a quadrotor UAV subject to actuator faults 7

Hardier G., Seren C. and Ezerzere P. Model-based techniques for virtual sensing of longitudinal flight parameters 23

Franzè G., Furfaro A., Mattei M. and Scordamaglia V. A safe supervisory flight control scheme in the presence of constraints and anomalies 39

Ossmann D. and Varga A. Detection and identification of loss of efficiency faults of flight actuators 53

Rodriguez-Alfaro L., Alcorta-Garcia E., Lara D. and Romero G. A Hamiltonian approach to fault isolation in a planar vertical take-off and landing aircraft model 65

Glizer V.Y. and Turetsky V. Increasing pursuer capturability by using hybrid dynamics 77

Hamayun M.T., Edwards C., Alwi H. and Bajodah A. A fault tolerant direct control allocation scheme with integral sliding modes 93

Hu B. and Seiler P. A probabilistic method for certification of analytically redundant systems 103

Péni T., Vanek B., Szabó Z. and Bokor J. Supervisory fault tolerant control of the GTM UAV using LPV methods 117

Yang X. and Maciejowski J.M. Fault tolerant control using Gaussian processes and model predictive control 133

Ariola M., Mattei M., Notaro I., Corraro F. and Sollazzo A. An SFDI observer-based scheme for a general aviation aircraft 149

Cen Z., Noura H. and Younes Y.A. Systematic fault tolerant control based on adaptive Thau observer estimation for quadrotor UAVs 159

Wu C., Qi J., Song D., Qi X. and Han J. Simultaneous state and parameter estimation based actuator fault detection and diagnosis for an unmanned helicopter 175

Ducard G.J.J. SMAC-FDI: A single model active fault detection and isolation system for unmanned aircraft 189

PREFACE

Special issue on

Safety, Fault Diagnosis and Fault Tolerant Control in Aerospace Systems

Modern technological and safety-critical systems rely on sophisticated control solutions to meet increased performance in faulty conditions, reliability and safety requirements. A conventional feedback control design for a complex system may result in an unsatisfactory performance, or even instability, in the event of malfunctions in actuators, sensors or other system components. To overcome this limitation, new approaches to control system design have been developed in order to tolerate component malfunctions while maintaining desirable stability and performance properties. This feature is particularly important for safety-critical systems, such as aircraft and spacecraft. In such plants, the consequences of a minor (abrupt or incipient) fault in a system component can be catastrophic. Therefore, the demand on reliability, safety, availability and fault tolerance is generally high. It is necessary to design control strategies that are capable of tolerating potential faults in order to improve the reliability, safety and availability, while providing desirable performances. These types of control systems are known as fault tolerant control systems. Particularly, they consist of control systems possessing the ability to automatically accommodate component faults. They are also capable of maintaining overall system stability and acceptable performance in the event of such faults. In other words, a closed-loop control system that can tolerate component malfunctions while maintaining desirable performance and stability properties is considered to be a fault tolerant control system.

On the other hand, over the last four decades, the growing demand for safety, reliability, maintainability, and survivability in technical systems has generated significant research in fault detection and diagnosis, resulting in the development of many solutions. Note that, in the literature, fault detection and isolation or fault detection and identification (estimation) are often used. In fault tolerant control system designs, fault identification (i.e., estimation) is important. Therefore the fault detection and diagnosis tasks are mainly considered to highlight the requirement of fault reconstruction. On a parallel path, research on reconfigurable fault tolerant control systems has increased progressively since the initial research on restructurable control and self-repairing flight control systems started in the early 1970s. More recently, fault tolerant control has attracted more and more attention in both industry and academic communities due to increased demands for safety, high system performance, productivity and operating efficiency in a wider engineering application, not limited to traditional safety-critical systems.

Since the 1980s, several milestones have been presented in the literature. In particular, apart from the triennial IFAC Symposium on *Fault Detection, Supervision and Safety for Technical Process (SAFEPROCESS)* started in 1991, in 2010 the first International Conference on *Control and Fault-Tolerant Systems (Systol 2010)* was a success and demonstrated the demand for establishing a permanent scientific forum in the general area of system monitoring, fault diagnosis and fault tolerant control. The second conference on *Control and Fault Tolerant Systems (Systol 2013)*, through its technical program, provided a unique opportunity for the academic and industrial community to formulate new challenges, share solutions and discuss future research directions. Presentations of theoretical results accompanied by practice-related experiments were encouraged, and the best contributions have been selected for this special issue.

Historically, from the point of view of practical application, a significant amount of research on fault tolerant control systems was motivated by aircraft flight control system designs. The key point was to provide fault accommodation features to ensure a safe flight in the event of severe faults in the aircraft. Such effort was also stimulated partly by two commercial aircraft accidents in the late 1970s, involving Delta Flight 1080 (April 12, 1977) and American Airlines DC-10. It is thus evident why the fault tolerant control problem began to draw more and more attention in a wider range of academic and application communities, due to increased safety and reliability demands beyond what a conventional control system can offer. Therefore, the most obvious applications include aerospace and aicraft industries.

This special issue highlights that, maybe due to historical reasons and the complexity of the problem, most of the research on fault diagnosis and fault tolerant control was carried out as two separate tasks. More specifically, many fault diagnosis techniques are developed as a diagnostic or monitoring tool, rather than an integral part of fault tolerant control. As a result, some existing fault detection methods may not satisfy the need of controller reconfiguration. On the other hand, most of the research on reconfigurable controls is carried out assuming the availability of a perfect fault diagnosis. Little attention has been paid to the analysis and design with the overall system structure and interaction between fault diagnosis and fault tolerant control. From the viewpoint of fault tolerant control design, what are the needs and requirements for fault diagnosis? How to design the fault diagnosis and fault tolerant control in an integrated manner for on-line and real-time applications?

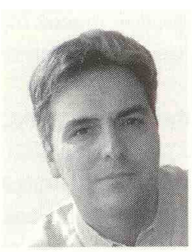
Many challenging topics, which are analysed by the contributions to this special issue properly selected from the *Systol 2013* conference, still remain open for further research and development. One of the motivations of this special issue is to provide an overview on the recent developments in fault tolerant control systems, with application to aerospace systems. At the same time, this publication aims at presenting some challenging open problems for future research. It is the authors' hope that this special issue could provide some useful information to researchers and practitioners in the field in order to facilitate further development of this important area.

Silvio Simani
Department of Engineering
University of Ferrara, Italy

Paolo Castaldi
Department of Electric Energy and Information Engineering
University of Bologna, Italy

March 2015

Silvio Simani was born in Ferrara in 1971. He received the "Laurea" degree (*cum laude*) in electrical engineering in 1996 from the Department of Engineering at the University of Ferrara (Italy), and the Ph.D. in information science (automatic control) at the Universities of Ferrara and Modena (Italy) in 2000. Since 2006 he is an IEEE Senior Member, and since 2000 a member of the SAFEPROCESS Technical Committee. Since 2002 he has been as assistant professor at the Department of Engineering of Ferrara. His research interests include fault diagnosis and fault tolerant control, and system identification. He is author of about 160 refereed journal and conference papers, several book chapters, as well as three books on these topics.



Paolo Castaldi received the "Laurea" degree (*cum laude*) in electronic engineering in 1990 and the Ph.D degree in system engineering in 1994. Since 1995 he has been an assistant professor at the Department of Electrical, Electronic and Information Engineering of the University of Bologna. Since 2009 he has been a member of the IFAC Technical Committee on Aerospace. His research interests include fault diagnosis and fault tolerant control, adaptive filtering, system identification, and their applications to aerospace and mechanical systems. He has published about 100 refereed journal and conference papers, several book chapters, and one monograph on these topics. Moreover, he is a pilot with the ultralight aircraft licence.

Guide

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Authors: R. Zdunek, B. Garda and Z. Galias, R. Makowski and R. Hossa, P. Bilski and J. Wojciechowski, A. Pułka, A. Fabijańska *et al.*

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Contents

Rotondo D., Nejjari F. and Puig V. Robust quasi-LPV model reference FTC of a quadrotor UAV subject to actuator faults . . 7

Hardier G., Seren C. and Ezerzere P. Model-based techniques for virtual sensing of longitudinal flight parameters 23

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Wu C., Qi J., Song D., Qi X. and Han J. Simultaneous state and parameter estimation based actuator fault detection and diagnosis for an unmanned helicopter 175

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International Journal of applied mathematics and computer science Vol. 25 No. 1 2015