PREFACE

Special section on

Towards Self-Healing Systems through Diagnostics, Fault-Tolerance and Design

In many industrial sectors, an enormous interest in self-healing systems can be observed. They have the capability to accommodate the consequences of faults which inevitably occur in complex automated systems, both in industry and consumer use. Currently, several research groups worldwide address the issues involved and contribute enormous advances in terms of sophisticated design characteristics and control solutions to meet the increased performance demands in faulty conditions, as well as those concerning reliability and safety requirements.

This special section presents seven papers discussing innovative approaches to increase fault-tolerance of technical systems. The authors focus on new aspects, algorithms and systems related to fault diagnosis, fault-tolerant control and fault-tolerant design. Their papers describe mathematical, methodical, systemic and algorithmic aspects of technical systems capable of tolerating potential faults in order to improve reliability, safety, and availability while providing desirable performances.

The authors of the article *Fault-tolerant tracking control for a non-linear twin-rotor system under ellipsoidal bounding* investigate a novel fault-tolerant tracking control scheme based on an adaptive robust observer applied to non-linear systems. The authors presume that the non-linear system under consideration may be faulty, i.e., affected by actuator and sensor faults, along with unavoidable disturbances. The performance and correctness of the proposed fault-tolerant tracking control scheme is verified by using a non-linear twin-rotor aero-dynamical laboratory system.

The article entitled *A multi-model based adaptive reconfiguration control scheme for an electro-hydraulic position servo system* proposes a novel reconfiguration control (RC) scheme that combines multi-model and adaptive control to compensate for the adverse effects of faults regarding an electro-hydraulic position servo system. The main contribution is a reconfiguration control method that can handle component faults and maintain the acceptable performance of the system.

The article *Reliability-aware zonotopic tube-based model predictive control of a drinking water network* introduces a robust economic model predictive control (MPC) approach that takes into account the reliability of actuators for the control of a drinking water network. In this network uncertainties in the forecasted demands are present. The authors demonstrate the capabilities of the designed controller with simulated scenarios regarding the Barcelona drinking water network.

In the article *A graph theory-based approach to the description of the process and the diagnostic system*, an original, comprehensive, and methodically consistent graph theory-based approach to the description of the diagnosed process and the diagnosing system is proposed. The main baseline of the presented method is in the dichotomous approach to diagnosing. It involves a separate description of both the process and the diagnostic system. Numerous examples and references to practical applications of the approach are indicated by the authors.

The authors of the article *On some ways to implement state-multiplicative fault detection in discrete-time linear systems* propose new design conditions for observer based residual filter design for linear discrete-time linear systems with zoned system parameter faults. Their major objective is the analysis of the required configuration and a new characterisation of the norm boundaries of multiplicative zonal parametric faults.

In the article *A Kalman filter with intermittent observations and reconstruction of data losses*, the problem of joint state and unknown input estimation for stochastic discrete-time linear systems subject to intermittent unknown inputs on measurements is addressed. A Kalman filter approach is proposed for state prediction and intermittent unknown input reconstruction. The authors present an illustrative example which shows that the proposed filter corresponds to a Kalman one with intermittent observations having the ability to generate a minimum variance unbiased forecast of measurement losses.

The last paper, *Parameter identifiability for nonlinear LPV models*, deals with the models which can be used for introducing varying parameters representing, for example, non-constant characteristics of a component or equipment degradation. This approach is frequently used in several model-based system maintenance techniques. In particular, a method to verify identifiability of unknown parameters for LPV or quasi-LPV state-space models is proposed. It makes use of a parity-space-like formulation to eliminate the states of the model. The resulting input-output-parameter equation is analysed to verify the identifiability of the original model or a subset of unknown parameters. This property is of paramount importance for the design and implementation of self-healing and fault-tolerant systems.

All the presented research works contribute considerably to the development of powerful approaches towards self-healing systems; their importance for both industry application and consumer use cannot be overestimated. As the guest editors of this section, we would like to take this opportunity to thank the authors for their dedication and effort put into preparing their papers. We believe that the presented articles will be of great interest and will make valuable contributions to the development of self-healing systems. We would also like to acknowledge the anonymous referees for their time devoted to reviewing the submitted contributions. Finally, we wish to express our thanks and deep appreciation to Professor Józef Korbicz, the journal's Editor-in-Chief, for accepting this special section as well as for his cooperation, support and assistance.

Marcin Witczak was born in Poland in 1973, received his MSc degree in electrical engineering from the University of Zielona Góra (Poland), his PhD degree in automatic control and robotics from the Wrocław University of Technology (Poland), and his DSc degree in electrical engineering from the University of Zielona Góra, in 1998, 2002 and 2007, respectively. In 2015 he was granted a full professorial title. Since then, Marcin Witczak has been a professor of automatic control and robotics at the Institute of Control and Computation Engineering, University of Zielona Góra. His current research interests include computational intelligence, fault detection and isolation (FDI) and fault-tolerant control (FTC), with the focus on remaining useful life estimation of complex systems and application to self-healing control. Since 2020 he has been a vice-chair of IFAC TC.6.4 on Fault Detection, Supervision and Safety of Technical Processes, SAFEPROCESS. Marcin Witczak has published more than 200 papers in international journals and conference proceedings. He has authored four monographs and 36 book chapters. Since 2015, he has been a member of the Committee on Automatic Control and Robotics of the Polish Academy of Sciences. Since 2018, he has also been an associate editor of *ISA Transactions*.

Ralf Stetter, born in Germany in 1970, holds MSc and PhD degrees, both in mechanical engineering, granted by the Technical University of Munich. He had initially worked as a team coordinator in the product development interior at Audi AG, Ingolstadt, Germany. In 2004 he was appointed a professor of design and development in automotive technology at the University of Applied Sciences Ravensburg–Weingarten (RWU) in Weingarten, Germany. Since 2006 he has also been a project leader at Steinbeis Transfer Center Automotive Systems, Ravensburg. He is currently the director for international affairs at the Department of Mechanical Engineering at RWU. His present research interest is in fault-tolerant control and fault-tolerant design of automated systems. He has published more than 100 papers in international journals and conference proceedings, as well as two monographs and 14 book chapters. He is a member of the German Association of Engineers and the Design Society.

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