ENGLISH ABSTRACTS

Chapter 1. Issues of fault diagnosis and fault tolerant control for aerospace systems. This plenary work presents two Active Fault Tolerant Control (AFTC) systems for aerospace applications. One case study regards an aircraft longitudinal autopilot and another one concerns a satellite attitude control system, both in case of faults affecting the actuators. The main features of the presented AFTC schemes are the Fault Detection and Diagnosis (FDD) module and its design technique, *i.e.* a Non-Linear Geometric Approach (NLGA). Using adaptive filters in the FDD module, such an approach allows fault detection, isolation and estimation. The fault estimates obtained by different methods including recursive least squares and neural network, are exploited by a controller reconfiguration mechanism. In particular, in case of spacecrafts, by means of NLGA, it is possible to obtain fault estimates decoupled from wind components in case of aircraft and aerodynamic disturbances, thus giving the overall control system very good robustness properties and performances. The effectiveness of the designed AFTC systems is shown by means of high fidelity simulators, in several flight conditions, and in the presence of faults in actuators, turbulence, measurement noise, and modeling errors.

Chapter 2. A validation of a robust passive fault-tolerant control approach for a linear parameter varying jet engine systems. In this work, we propose a validation of an Aircraft Variable Geometry Fault-Tolerant Control (AVG-FTC) approach applied to a linear parameter-varying aircraft system. The AVG-FTC approach is used to ensure a permanent availability of control signals by designing a virtual sensor based on robust on-line estimation. It aims at providing performance required in the specifications in spite of occurrence of an unexpected fault or complete loss of the sensor during the operation. The AVG-FTC is based on a hierarchical cascade scheme, where off-line closed-loop identification is first used to elaborate local linear state-space models, then a multi-model observer is used to build a virtual sensor. Finally, a Neural Extended Kalman Filter **(**NEKF) is added to circumvent online model accuracy problems. The validation proposed in this chapter is done through the performance and stability analysis of the AVG-FTC approach applied to two linear parameter varying subsystems: Variable Stator Vane (VSV) and Fuel Metering Valve (FMV). The proposed approach is based on the Lyapunov theory and the LMI optimization approach. Simulations on a certificate flight engine simulator, describing the overall behaviour of the jet engine system for a given flight envelope point, are presented.

Chapter 3. Matrix inverse approach to minimum-energy fault-tolerant control. The work presents an approach to the synthesis of robust fault-tolerant control systems based on minimum-energy perfect control algorithm. Implementation of a new inversion technique for nonsquare polynomial matrices applied to perfect control design for damaged processes, is shown. This solution provides the high robustness of control systems without the need for the classical identification and adaptation of controller parameters (in case of presence of faults). The effectiveness of the presented approach is confirmed by a simulation example.

Chapter 4. Diagnosing multiple faults from FDI perspective. In this chapter, some selected issues of multiple fault isolation from the perspective of FDI are presented. Particularly, the survey of the author's contribution to the subject is exemplified. The chosen methods, approaches and theoretical background of diagnosing multiple faults in engineering systems based on structures of residual sets are characterized. The weaknesses and strengths of the discussed approaches are briefly outlined. Multiple fault indistinguishability metrics are defined. The robustness regarding structural changes in the diagnosed system are discussed. Furthermore, some myths and paradigms of multiple fault isolation are discussed from the FDI perspective.

Chapter 5. A vision-based system for a quantification analysis of bacterial cultures. The optical microscopic observations of microorganisms have still application in medicine, biology, biotechnology and industry. However, such method is also labor-intensive and human factors play an important role in it. An alternative to direct cells counting by researcher is automatic analysis of images of bacterial cultures. The main objective of the following study is to develop a new method for quantification analysis of bacterial cells. This algorithm is related with the HSV representation of colors. This is used to localize and count the number of microbes in samples. This allows to estimate rapidly a bacterial population in cultures and monitor its behaviour in presence of different contaminants.

Chapter 6. Detection and repair of faults in cell cycle - is it perfect? Biological evolution led to development of complex mechanisms providing fault detection in DNA structure and its repair. The faults are caused by DNA damage, which is occurs on a large scale due to environmental factors, radiation, but also natural thermal fluctuations. Some of these mechanisms are highly specific, directed at a particular type of damage, whereas others are general and induced any time damage is detected. Despite redundancy in control loops that govern fault detection and repair, these mechanisms may fail, giving rise to carcinogenesis. In this work we discuss this very specific, biological maintenance and fault detection system, with special emphasis put on its weak points that lead to mutagenesis and cancer progression.

Chapter 7. Reliability of multimodal behavioral biometric system. In this chapter, the authors compare the existing multimodal biometric systems and analyze their reliability. The main focus is put on a multi sensorial biometric system, which recognizes two or more different and independent biometric characteristics. The authors also propose a method to calculate the error probability for this system, treating it as a multiple classifier for a multi class. The chapter authors compare the reliability and safety level of multimodal behavioral biometric systems with the systems that operate on just one module for two independent biometric features.

Chapter 8. Knowledge-based functional safety and security management in hazardous industrial plants with emphasis on human factors. Existing and emerging new hazards have significant potential to impact destructively operation of technical systems, hazardous plants, and systems / networks of critical infrastructure. The programmable control and protection systems play nowadays an important role in reducing and controlling risks in the process of hazardous plant operation. It is outlined how to deal with security related hazards concerning such systems to be included in risk analysis and integrated safety / security management. In the process of functional safety and security analysis and management it is necessary to take into account some boundary conditions concerning international and national legal aspects including requirements that evaluate in time. Areas of additional research are identified including cognitive aspects of the human reliability analysis in the context of designing and using computers to enhance process plant diagnostics, and response of operators during abnormal situations and potential accidents.

Chapter 9. SchematicLab.com – a web tool for the design and analysis of electrical circuits. In this chapter a useful Internet application for designing electronic systems is considered. A practical process of prototyping electronic devices by using such a dedicated web tool, hereinafter referred to as SchematicLab, is de-scribed. This solution, still in constant development, is now ready for use.

Chapter 10. Fault isolation with the use of multiple-valued residua evaluation and the knowledge about the sequence of appearance of symptoms. The possibility of generating false diagnoses due to the delays of symptoms appearance is pointed out in this chapter. Therefore, the following question raises: How to conduct the diagnostic reasoning, in this case, in order to formulate correct diagnosis and achieve possibly high fault distinguishability. It is not provided by the known approaches to diagnostic inference. A formal description of the relation between faults and symptoms as well as the notation of the knowledge about symptoms forming sequence and the methods of its acquiring are presented in the chapter. The new method of diagnostic reasoning that protects against the possibility of formulation of false diagnosis due to the existence of unequal delays of symptoms forming of the same fault is given. This method allows to increase the achieved fault distinguishability in several cases. It is tailored for cases, when the analytical models that take into account the fault influence are unknown.

Chapter 11. The method of diagnostic reasoning taking into account uncertainty of diagnostic symptoms joining Bayes theory and fuzzy logic. The values of the diagnostic signals, obtained from measurements and data processing, are not certain. The Bayes theory is a popular approach to deal with uncertainty. Imprecise values can be handled by fuzzy logic. When using the Bayes theory we obtain diagnoses pointing out to possible states of the process with conditional probabilities under current values of the diagnostic signals. This method is hardly applicable in practice, because of the need of conditional probabilities of the values of the diagnostic signals in each state of the process. Fuzzy logic is an easy and intuitive way of dealing with imprecise information contained in diagnostic signals, but it does not allow us to take into account a priori information. In this chapter we present a method of diagnostic reasoning dealing with uncertainty by joining both Bayes theory and fuzzy logic.

Chapter 12. State-space models for a class hyperbolic systems with boundary inputs. The chapter presents the methods of state-space description of a certain class of systems with distributed parameters, described by two weakly coupled partial differential equations of hyperbolic type. First, typical assumptions about the number and configuration of boundary input signals and point output signals of the system are made. Next, we describe a homogenous state equation, the so called formal state operator. On the basis of the theory of semigroups of linear operators we present, among others, the results on the internal stability of the system. Appropriate operators are introduced: a boundary operator and an output operator, which take into account the complex configuration of input and output signals. On their basis we introduce state-space equations in a signal form. Finally, we show that the considered systems with distributed parameters can be described in the state-space form which is analogous to that of a finite-dimensional system. In addition to the state system operator A, which is equivalent to the state matrix for finite dimensional systems, we derive expressions describing: the boundary input operator B and point output operator C and we also analyse their properties.

Chapter 13. Modeling of systems to control and diagnostic of the discrete processes in a storehouse of production elements. The work presents a modified Petri nets approach to modeling of discrete control systems used in storehouses of production elements. It is shown that control systems based on this type of network can be extended with diagnostic functions. Diagnostic methods of implementation of the tasks in real time are shown. The possibility of

using of a diagnostic system to improve the quality of control of industrial facilities is discussed. An example of practical implementation of the proposed methods in a control and diagnostic PLC-based environment, using "CASE OF" statements of a structured text language is presented.

Chapter 14. Verification of the safety integrity levels with regard of information security issues. The chapter is devoted to some important issues of the functional safety analysis, and, in particular, to the safety integrity level (SIL) verification of safety functions implemented in the distributed control and protection systems, taking into account information security aspects. A method based on quantitative and qualitative information is proposed for the SIL (IEC 61508, 61511) verification with regard of the evaluation assurance levels (EAL) of ISO/IEC 15408, the security assurance levels (SAL) of IEC 62443, and the number of protection rings described in the Secure Safety (SeSa-SINTEF) methodology. The method was implemented in a prototype ProSIL-EAL application software designed for supporting the functional safety analysts in the design and operation of the safety instrumented systems (SISs) within the functional safety management in life cycle, including the information security aspects.

Chapter 15. Human reliability analysis in the context of safety-related functions in a sample installation. In the functional safety analysis of the control and protection systems we must determine the required safety integrity level SIL in a risk evaluation process, and then to verify that level by using appropriate methods of probabilistic modeling. Human actions can exert a significant impact on the implementation of the safety function. This impact is assessed on the basis of the results of the human reliability analysis (HRA). This chapter presents some methodological issues related to the human factors analysis in the assessment of safety-related systems, including human reliability. It presents a comparison of different methods of assessing human error probabilities for the accident scenario considered within the applied safety function. The chapter presents an exemplary process plant simulator, which has a graphical user interface with extensive features which enable analysis of human–operator actions in abnormal situations.

Chapter 16. Applicability of genetic algorithms to heat-flow diagnostics. The chapter proposes the use of the method of genetic algorithms for heat-flow diagnostics of power units with steam turbines. We can use the main functionality of genetic algorithms consisting in the search of extreme values of a function describing the convergence of simulated thermal and flow signatures. Optimization of the diagnostic system has been performed by a genetic algorithm using a predefined degradation signature. In the applied example, sufficiently short time to come to a proper diagnosis has been obtained. Further extended studies involving more complex degradation cases are required.

Chapter 17. Shepherding by neural agents. The herding problem is solved by the evolutionary training. A neural active agent using the knowledge of positions of other agents by proper movement pushes passive agents into a possibly small area.

Chapter 18. Automated negotiations over collaboration protocol agreements between software agents and execution contexts. The chapter focuses on the augmentation of proactive document-agents with built-in intelligence to recognize execution contexts provided by devices visited during a business process, and to reach a collaboration agreement despite conflicting requirements. The proposed solution, based on intelligent bargaining using neural networks to improve simple multi-issue negotiation between the document and the device, requires practically no excessive cost to the agent with limited RAM and CPU resources, comparing to the other proposed negotiation algorithms that does not take advantage of any AI approach.