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Fault Diagnosis of a Selected Model Application within the Distributed Control System

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***Abstract*—This paper is presenting some activities of research area of the author's dissertation thesis Methods and Approaches Non-destructive Diagnosis of Dynamical Systems. A part of this article is focused on chosen fault diagnosis methods based on dynamic system model or on data obtained by vibration measuring system. In addition, selected model applications for fault diagnosis algorithms design and verification are also presented.**

***Keywords*—fault diagnosis, fault detection, vibration diagnosis, distributed control system**

I. Introduction

Fault diagnosis of dynamic systems is a very actual research area at present, because it is a very useful in increasing of more complex systems reliability and safety. The main goal of the fault diagnosis is the early detection and localization of incurred faults in dynamic system [1].

The fault diagnosis methods and algorithms can be divided into two main branches - to methods and algorithms based on dynamic system model and to methods based on measured data. Both branches can be furthermore divided into qualitative methods, such as finite state machines or statistical methods, or to quantitative methods, which selection is presented in this paper in more detail. Also, the results of fault diagnosis algorithms can be used for fault tolerant control [1], [2].

II. Previous analysis and achieved results in research field

Distributed Control System (DCS) implemented in DCAI FEEI, enables to solve many kinds of problems in area of modelling, control and fault diagnosis. A brief overview of used methods was presented in [3] where the main interest was dedicated to methods, which could be implemented into the technological level, control level or SCADA/HMI level of DCS implemented in DCAI.

In the previous year of study the author's research was oriented to modelling and control design of the selected model application and results are presented in [4], [5].

Very important for the further dissertation thesis research orientation is the selection of fault diagnosis methods, which can be used for the diagnosis of the actuators or sensors malfunction of selected model applications from the DCS of the DCAI.

Research field of fault diagnosis has been subject of research under goals of project Research and Development Operational Program for project: University Science Park Technicom for innovative applications with knowledge technology support.

III. Solved tasks and results

In the last year, the overview of suitable fault diagnosis methods and algorithms for model applications from the DCS of the DCAI was prepared. The overview of selected methods and algorithms of fault diagnosis is listed in the dissertation prospectus [6]. The Dissertation prospectus was oriented mainly to the group of quantitative fault diagnosis methods based on dynamic system model (model-based fault diagnosis methods), specifically on two methods - the first method uses states estimation for fault diagnosis and the second one is based on the parametric identification. Another subject of research was the quantitative method of fault diagnosis that use measured data, namely the vibration of specific dynamic system part. This method is based on measured data frequency analysis.

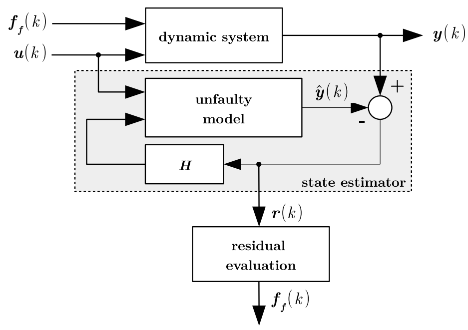

Fig. 1. General structure for fault detection with using state estimator

The first presented approach of the model-based fault diagnosis methods is based on the state estimators, which are used for fault diagnosis and this method comprise residuals $r(k)$ generation and residual evaluation (Fig. 1). Residuals are evaluated in order to detect, isolate and estimate the faults $f_f(k)$ magnitude. For fault isolation purposes, a bank of dedicated state estimators is used. Quick detection of faults and on-line implementation possibility is the main advantage of this method [2].

Another approach for model-based fault diagnosis is based on the system model parameters $\theta(k)$ identification. The occurrence of faults $f_f(k)$ in monitored dynamic system can be reflected by significant changes of model parameters $\theta(k)$. Residuum is generated by comparison of an actual identified parameters $\theta(k)$ and nominal parameters $\theta_{nom}(k)$ of monitored system. Process of faults diagnosis requires to use parametric classifiers. In the comparison with the estimator-based fault diagnosis, this approach is quite slow [2]. On-line identification of the model parameters $\theta(k)$, based on recursive least squares method, is listed in [7].

Presented methods of fault diagnosis can be implemented to the *diagnosis system*, that is used for monitoring of system state. Depending on characteristics of monitoring system, *diagnosis system* can include fault diagnosis methods based on frequency analysis of measuring system vibration. This method uses for discrete Fourier transformation faults detection algorithms [8]. During the last year, author was involved in laboratory workplace creation for vibration measurement and analysis.

A part of author's dissertation prospectus [6] is focused to analysis of implementation possibilities of select control and fault diagnosis algorithms for selected model applications, which are a part of DCS of DCAI. For this purpose, two model applications from DCS of DCAI were chosen. The faults in selected model applications, which affect the controlled system cause sensors or actuators malfunctions, but not their total failure.

The first model application contains hydraulic system consisting of two cascade-connected cylindrical tanks (http://kyb.fei.tuke.sk/laben/modely/hyd.php). The model application of hydraulic system can be suitable for implementation and verification of the model-based fault diagnosis algorithms. Also, vibrations of the diaphragm pump can be measured and analysis for the detection of pump faults. Control and fault diagnosis algorithms for this model application can be realized directly by the PLC or indirectly, by a connected technological PC. This model application is used for design and verification of modelling methods and control algorithms, some achieved results are presented in [9].

The second model application is an intelligent positioning system and in general, it represents the concept of position control for an object moving on an adjustable plate (http://kyb.fei.tuke.sk/laben/modely/gnk.php). The model application of the intelligent positioning system can be use for the implementation of diagnosis algorithms of actuators (servo-motors) or sensor (camera) malfunctions. For this purpose can be use model-based fault diagnosis algorithms. The specific design solution of the model application enables implementation and verification of proposed control and fault diagnosis algorithms in various programming languages (C/C++/C#) or simulation tools (Matlab/Simulink).

Also, some activities and results in diagnosis research area of our workgroup within DCAI are presented in [10].

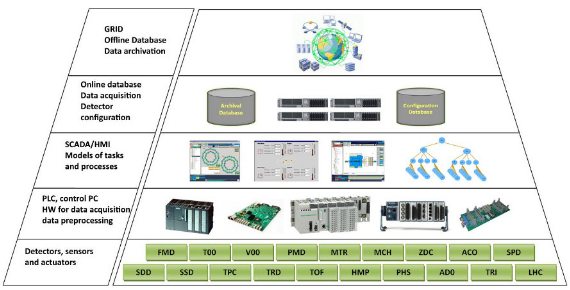

Fig. 2. Infrastructure of the ALICE Detector Control System

During the last year, part of the author research capabilities were focused on solving tasks in terms of the project *Upgrade of the ALICE Inner Tracking System*, related to cooperation of FEEI with European Nuclear Research Center in Geneva (CERN). For purpose of this project a workplace was created, what have a highly similar infrastructure like the ALICE Detector Control System, illustrated in Fig. 2. This workplace can use the data from sensors and actuators of the laboratory models of the DCAI like a substitution of the sensors and actuators of the ALICE Detector Control System. This workplace is used for verification of designed solutions of the project tasks in the FEEI conditions.

IV. Conclusion and Future Research

This paper briefly summarizes the author's research activities during the last year.

The following steps of author's research will be mainly focused on fault diagnosis algorithm design based on state estimators for residual generation and evaluation in order to detect, isolate and estimate faults magnitude. The results of estimator-based fault diagnosis algorithms can be use for fault tolerant control. Approaches to active fault tolerant control, mainly approaches based on predictive control, should be subject of the next year research. Also, algorithms of discrete Fourier transformation for vibration analysis can be designed. The designed fault diagnosis algorithms should be verified by the simulation and laboratory models of DCAI.

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