Scientific Conference of Young Researchers 2017

17th Scientific Conference of Young Researchers

May 16th, 2017
Herľany, Slovakia

Proceedings from Conference

Faculty of Electrical Engineering and Informatics
Technical University of Košice

TECHNICAL UNIVERSITY OF KOŠICE

Sponsors

17th Scientific Conference of Young Researchers
of Faculty of Electrical Engineering and Informatics
Technical University of Košice

Proceedings from Conference

Published: Faculty of Electrical Engineering and Informatics
Technical University of Košice
Edition I, 252 pages, number of CD Proceedings: 50 pieces

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ISBN 978-80-553-3162-1

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Foreword

Dear Colleagues,

SCYR (Scientific Conference of Young Researchers) is a scientific event focused on exchange of information among young scientists from Faculty of Electrical Engineering and Informatics at Technical University of Košice – series of annual events that was founded in 2000. Since 2000 the conference has been hosted by FEI TUKE with rising technical level and unique multicultural atmosphere. The Seventeenth Scientific Conference of Young Researchers (SCYR 2017), conference of graduates and young researchers, was held on 16th May 2017. The primary aims of the conference, to provide a forum for dissemination of information and scientific results relating to research and development activities at the Faculty of Electrical Engineering and Informatics, has been achieved. 95 participants mostly in doctoral categories were active in the conference.

Faculty of Electrical Engineering and Informatics has a long tradition of students participating in skilled labor where they have to apply their theoretical knowledge. SCYR is an opportunity for doctoral and graduating students to use this event to train their scientific knowledge exchange. Nevertheless, the original goal is still to represent a forum for the exchange of information between young scientists from academic communities on topics related to their experimental and theoretical works in the very wide spread field of a wide spectrum of scientific disciplines like informatics sciences and computer networks, cybernetics and intelligent systems, electrical and electric power engineering and electronics.

17th Scientific Conference of Young Researchers at Faculty of Electrical Engineering and Informatics Technical University of Košice (SCYR 2017) was organized in a beautiful village Herľany. The Conference was opened in the name of dean prof. Ing. Liberios Vokorokos, PhD. by the vicedean of faculty, prof. Ing. Alena Pietriková, CSc. In her introductory address she noted the importance of the Conference as a forum for exchange of information and a medium for broadening the scientific horizons of its participants and stressed the scientific and practical value of investigations being carried out by young researchers.

Traditionally, the program includes two parallel sessions:

- Electrical & Electronics Engineering
- Information Technologies

with 95 technical papers dealing with research results obtained mainly in university environment. This day was filled with a lot of interesting scientific discussions among the junior researchers and graduate students, and the representatives of the Faculty of Electrical Engineering and Informatics. This Scientific Network included various research problems and education, communication between young scientists and students, between students and professors. Conference was also a platform for student exchange and a potential starting point for scientific cooperation. The results presented in papers demonstrated that the investigations being conducted by young scientists are making a valuable contribution to the fulfillment of the tasks set for science and technology at Faculty of Electrical Engineering and Informatics at Technical University of Košice.

We want to thank all participants for contributing to these proceedings with their high quality manuscripts. We hope that the conference constitutes a platform for a continual dialogue among young scientists.

It is our pleasure and honor to express our gratitude to our sponsors and to all friends, colleagues and committee members who contributed with their ideas, discussions, and sedulous hard work to the success of this event. We also want to thank our session chairs for their cooperation and dedication throughout the whole conference.

Finally, we want to thank all the attendees of the conference for fruitful discussions and a pleasant stay in our event.

Liberios VOKOROKOS
Dean of FEI TUKE

May 16th 2017, Herľany

Contribution to Hybrid Models of Cyber-Physical Systems and their Implementation into Distributed Control System

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***Abstract*—This paper presents results obtained during the last year in the field of cyber-physical systems, specifically modelling and control of the hybrid systems. Within modelling of the hybrid systems various mathematical representation were proposed for hybrid hydraulic system and within hybrid system control supervisory, optimal and predictive control was tested either on the mentioned hydraulic system or on the laboratory model of the inverted pendulum which is a part of the *Multipurpose Workplace for Nondestructive Diagnostics*.**

***Keywords*—cyber-physical system, detector control system, hybrid system, optimal control**

I. Introduction

With a growing complexity of today's world problems in engineering, especially in the system engineering, it was needed to establish a new look on the current state of the art. One of the such a fresh look was an introduction of the cyber-physical systems (CPS) which are considered to be a part of the phenomena Industry 4.0. The term CPS was defined as a response to more complex embedded systems [1] which represent an integration of the physical and computational processes.

Behaviour of the CPS is described with a physical and cyber part of the system. Physical part of the CPS represents HW components including mechanical parts, biological and chemical processes, even human operators. Subsequently CPS contain one or more computational platforms which consist of sensors, actuators and computers. The last part of the CPS is represented by digital networks which provide a way of communication of system's various parts. Together, computational platforms and digital networks form the cyber part of the CPS [2]. To exploit all of the CPS advantages, it is needed to have a model of such a system. Since CPS are complex systems they cannot be described with either continuous or discrete dynamics but hybrid systems framework has to be used.

II. Previous analysis and achieved results in research field

To model and design embedded systems, finite state machines (FSM) framework is commonly used. However, FSM are not suitable to model and design CPS where a dynamical system contains continuous as well as discrete dynamics. By augmenting each of the FSM discrete state by continuous dynamics it is possible to define hybrid system (HS) framework which is suitable to model and design CPS.

One of the most widely used representation of HS is discrete hybrid automata (DHA). DHA represent an interconnection of the FSM and switched affine dynamical systems (SAS) via event generator (EG) and mode selector (MS) [3]. Individual parts of the DHA framework, depicted in Fig. 1, are thoroughly described in [4] and [5].

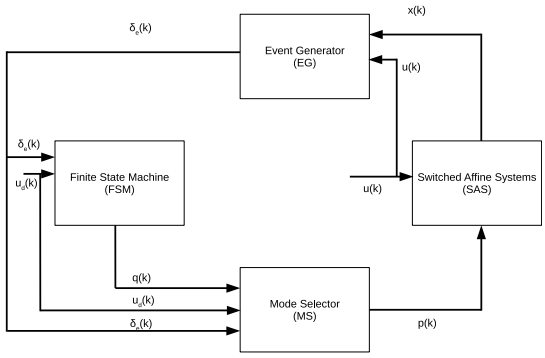

Fig. 1. *Discrete hybrid automata* framework.

Although DHA framework provides a convenient interface to capture system's dynamics, it is not useful when it comes to analysis of hybrid systems or synthesis of control laws based on the optimal or predictive control algorithms.

III. Solved Tasks and Results

According to the statements about DHA provided in the previous chapter, several other HS representations were defined whereas between the most significant ones belong [3]:

1) piece-wise affine systems (PWA),
2) mixed-logical dynamical systems (MLD).

The important characteristic of this enumeration is proven two-sided equivalence of the frameworks DHA, PWA and MLD [6]. In the last year, an example of a hybrid hydraulic system described in [5] was mathematically modelled in the mentioned representations with an emphasis to their utilization within optimal and predictive control algorithms [6]. An excerpt of the obtained results is depicted in Fig. 2 [9].

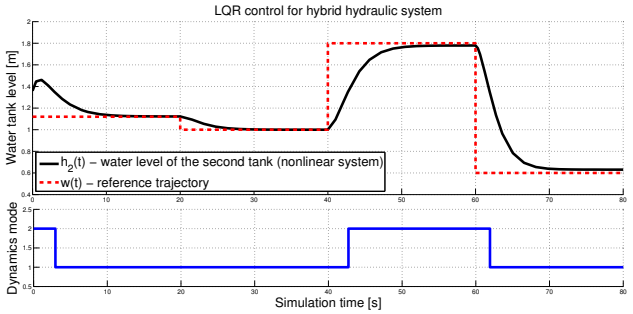

Fig. 2. Application of the linear LQR synthesis on the nonlinear hybrid system represented by hydraulic coupled tanks

Next, the author dedicated focus on hybrid control of the *Single inverted pendulum with linear synchronous motor* which is a part of *Multipurpose workplace of nondestructive diagnosis* solved within a project *USP TECHNICOM, Centre for nondestructive diagnostic of technological processes with standard software package for control and communication*. The hybrid control was based on the switching between controllers, i. e. between stabilizing and swing-up control law [7]. Time behaviour of the real system states and the control input is shown in Fig. 3 and the results were published in [8].

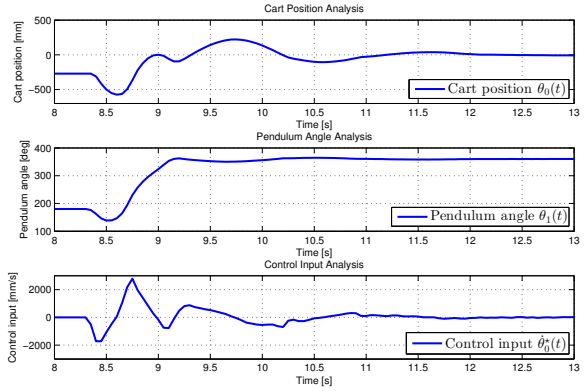

Fig. 3. Time behavior of the cart position, pendulum angle and control input

During the last year, author also focused on solving the tasks within the project *Experiment ALICE on LHC in CERN : Study of strongly interacting matter at extreme energy densities*, in cooperation with European Nuclear Research Center in Geneva.

A testing workplace was created for this project which has a similar infrastructure like the ALICE Detector Control System [10]. 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. The main infrastructure, shown in Fig. 4, consists of three branches: communication, power and cooling systems. Within the last year author focused on the implementation of the communication architecture starting at the detector and ending at *Detector Control System* (DCS).

IV. Future Research Steps

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

The following research steps will be mainly focused on various hybrid control techniques on different hybrid systems

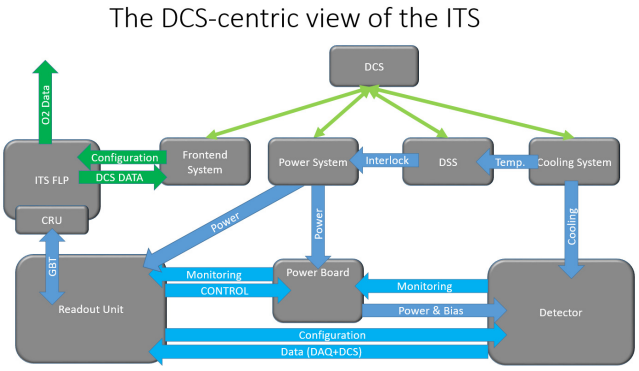

Fig. 4. The DCS-centric view of the Inner Tracking System

representations. Tested modelling and control algorithms will be verified on the real applications within *Center of Modern Control Techniques & Industrial Informatics* (CMCT&II) at DCAI. Another research activities will be dedicated to solving project tasks within the workplace at CERN which will be concentrated on broadening of existing communication and control infrastructure. Subsequently part of the research will be focused on using methods of artificial intelligence and their possible utilization in modelling of hybrid systems.

Acknowledgment

This publication is the result of the Project implementation: University Science Park TECHNICOM for Innovation Applications Supported by Knowledge Technology - II. phase, ITMS: 313011D232 (40%) and "Centre of Information and Communication Technologies for Knowledge Systems", ITMS: 26220120020 (20%), both supported by the Operational Programme Research & Development funded by the ERDF, grant TUKE FEI-2015-33: Research Laboratory of Nonlinear Underactuated Systems (30%) and grant KEGA 001TUKE-4/2015 (10%).

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