ECMSM 2021

15th International Workshop IEEE
Electronics, Control, Measurement,
Signals and their application to
Mechatronics

Book of Abstracts

Technical University of Liberec
Liberec, The Czech Republic

June 21–22, 2021

Preface

Dear IEEE ECMSM 2021 conference participants,

on behalf of the national organizing team as well as an international steering committee, it is our pleasure to welcome you to the 15th International Workshop IEEE Electronics, Control, Measurement, Signals and their application to Mechatronics organized this year at Technical University Liberec, Faculty of Mechatronics, Informatics and interdisciplinary studies.

The IEEE Workshop on Electronics, Control, Measurement, and Signals ECMS provides a forum for exchanging ideas, discussing research results, and presenting theoretical and practical applications in several areas of mechatronics. This conference is established on the close long-lasting cooperation between the Technical University of Liberec (TUL) and the Federal University of Toulouse from France. It is a biennial event (odd-numbered years) alternately taking place in the Czech Republic, Spain, and France. Previous ECMS Workshops were organized in Liberec – Czech Republic (1993 Electro Workshop), 1995, 1999, 2003, 2007, 2011, 2015, 2019), Toulouse – France (1997, 2001, 2005, 2013) and Mondragon – Spain (2009, 2017). The conference starts at the beginning, like "conference and summer doctoral school," to provide the Ph.D. students from post-communist countries an opportunity to discuss their results in as a wide community as possible. By the time the conference was developed into a worldwide participant event organized under the IEEE co-sponsoring. ECMS has finally become ECMSM in 2015 by specifying the cover topic of mechatronics. ECMSM means Workshop of Electronics, Control, Measurement, Signals and their application to Mechatronics.

We would like to thank our co-sponsor of the conference, the IAS – IEEE Industrial Application Society, which supports us since this edition of 2021.

Unfortunately, with most of you, dear participants, we can meet only via hybrid session. We really appreciate that some of you can come and the others are ready to join us via an online event. The conference this year is much smaller than previous years, we can manage the conference without a parallel session.

We wish you all the best during conference time, interesting papers, inspirational discussions, new ideas, and contacts for further research. Please follow actual local rules to protect against COVID 19 pandemic and stay healthy.

June 21-22, 2021
Liberec

Francois Pigache (Programme chair)
Josef Cernohorsky (Conference chair)

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2 About the Double Degree Master´s Programmes between University Toulouse III-Paul Sabatier and Technical University of Liberec

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The paper is focused to the development of cooperation between University Toulouse III – Paul Sabatier (UPS, newly UT3) and Technical University of Liberec (TUL), culminating in the completion of the Double Degree Master´s programme "Engineering of Interactive Systems" (2009–2015) and "Computer Science for Aerospace" (2017–2021). The development of the International doctoral workshop ECMS(M), which is newly implemented under the patronage of IEEE, is mentioned briefly.

3 Vector Controlled Ultrasonic Transducer Applied to Soft Material Mechanical Impedance Estimation

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The study of skin mechanical impedance is a clue to analyse its health. We use a Langevin Transducer at 60kHz to excite the skin. In return, we observe the acoustic forces generated by the interaction. To achieve that, the system is identified and presented in the rotating reference frame, and we describe the design of two PI controllers that accurately control the vibration velocity. However, in vivo analysis can be tricky when it comes to the safety and duration of tests. Thus, phantom tissues are used as a substitute to simulate skin behaviour. Due to its mechanical properties similar to skin, and its simple manipulation, Dragon Skin ®, a silicone rubber type of phantom, was chosen. The paper presents the characterisation of the mechanical impedance of three silicon phantoms with different properties based on force observation. The results show that the phantoms can be indeed identified based on this method.

4 Design of an ice detector for electric tramways

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The article describes design and development of an ice detection device that uses a real 1 m part of an electric copper trolley wire for its operation. The wire part is oriented in the same direction as the trolley wire in the given place and thus a high compliance of the ice sensor with real conditions (spatial dimensions, orientation and heat capacity) is achieved. An ice meter equipped with this sensor can determine the robustness and duration of ice phenomena on trolley wires much more accurately and uses this information to deduce the risk of endangering public transport. The ice detector works on the principle of strain gauge load cell weighing. For its own diagnostics, the device can also measure temperature and relative humidity and is equipped with heating wires so that the movable parts of the device do not freeze.

5 Peristaltic pumping by huge amplitude piezoelectric traveling wave actuator

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This article deals with the design and drive of a thin plate wall, bended by piezoelectric fibers (MFC – Macro Fiber Composite). The purpose of this deformable membrane is to drive a moving fluid inside a channel according to a principle similar to peristaltic pumping. To promote this pumping effect, the deformation of the wall must be as a traveling-like wave with sufficiently high amplitude to transfer of momentum to the fluid.

6 Multiport Power Converter

Adrián Marcinek, Jozef Ivan, Juraj Biľanský and František Ďurovský

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Multiport power converters are used to connect various types of energy sources and loads. These sources are usually connected via DC-DC converters to a common DC bus. However, such approach requires multiple power conversions, which reduces the efficiency of the whole system. The article describes a multiport converter with a parallel connection of transformers. The proposed topology uses a smaller number of power conversions, which increases the efficiency of the whole system. Furthermore, the topology allows easy addition or removal of next power sources or loads. A new approach is also used in deriving of a mathematical model of converter. The proposed control allows the transfer of energy between arbitrary converter ports. The proposed topology and its control were verified by simulation, and the results are presented in the article.

7 Cyclic Tester of Battery Cells for Electric Vehicles

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The paper presents an approach to the designing and implementing of a cyclic battery tester and contains observations about lithium-ion (Li-ion) batteries, charging/discharging procedures, conditions and protections, which must be observed during the testing process. The main goal was to design a universal converter that is capable of charging and discharging battery cells according to electric vehicles purposes. Our universal charging process offers user-defined parameters, which are required in order to properly test different types of battery cells. Discharging process can be done in two ways: constant current discharging and variable discharging current using a drive profile. The final result is a fully functional device that communicates with a superior system, which records actual data from the battery tester with the intention of future diagnostics of the state of health of battery cells.

8 The Perspective of Electric Network Load by Electric Car Charging Stations

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The paper presents an analysis of the actual situation of the number of electric cars in the Czech Republic and the state of infrastructure in the form of charging stations. Baseline scenarios for the future expected increase in the number of electric cars and charging stations follows. This trend of increasing the number of cars will lead to increased demands on the supply and production of electricity that drives such cars. The electrical network in the Czech Republic certainly has capacity reserves in the area of production, less so in the area of distribution. The article provides an overview of how much the demand for electricity will increase and how this demand is likely to spread in the daily load diagram. This global view is the first necessary analysis to enable the development of electromobility in the Czech Republic.

9 Development of a CAN Bus datalogger for recording sensor data from an internal combustion ECU

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The CAN Bus protocol is widely used in various technological areas such as industrial, medical, or automotive. Developed by Bosch in the 1980s, this protocol is predominantly used in commercial vehicles to reduce emissions with the introduction of electronic control. It makes data from sensors and diagnostics codes available through the OBD-II connector. Many vendors sell devices and software tools to read CAN Bus data in a friendly way in exchange for a monthly fee. The aim of this work is to develop a low cost OBD-II device controlled with an open-source software. A dedicated board using an Arduino Nano with a microSD slot and on-board LCD screen was developed for this purpose. This device collects information emitted by a vehicle ECU with the MCP2515 through an OBD-II connector. This article presents the stages of the design and construction of the board, and the validation tests carried out to determine

its functionality as a datalogger. Finally, a graph that plots the sensor data recorded from the OBD-II datalogger is presented as RPM vs. speed.

10 Perfomance evaluation of a 3D printed rotor for a switched reluctance machine

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Metallic additive manufacturing, also known as 3D printing, is greatly improving for the last decade. This new technology brings a greater design freedom than classical manufacturing and allow the production of breakthrough architectures especially thanks to topological optimization. However, metallic additive manufacturing is not mature yet to create parts whit properties equal to those of machined parts. Hence, this article purpose is to evaluate the maturity of metallic additive manufacturing in the field of electromechanical conversion. To achieve this goal, an optimized rotor of switched reluctance machine was built thanks to additive manufacturing. The technology used is Selective Laser Melting. The material powder is Fe-35%Ni which has interesting magnetic properties and low magnetic losses. The performances of this rotor are compared to the performances of a classical laminated rotor with the exact same dimensions, both driven by the same stator. The results will thus help determine the level of maturity of 3D printing in the particular field of electromechanical conversion.

11 Load Emulation for Testing of Electrical Actuators in Industrial Applications

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Geared servodrives are tested with different types of short-term or long-term

tests. This paper presents the industrial approach to load emulation in the testing process of electrical actuators. Presented testing method is based on the real data provided by the customer. This data is modified, processed, and then used for the calculation of a load torque reference for the drive loading actuator under test. Final implementation is based on industrial drives controlled by PLC. NI PXI was used for graphical user interface and data acquisition. Experimental results that confirm the correctness of the implementation are included.

12 An off-line Optimization of Torque Sharing Functions for Switched Reluctance Motor Control

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This paper presents an optimization procedure to find optimal parameters of torque sharing functions (TSF) used in switched reluctance motor control. A finite element method simulation model of the motor is built and verified to evaluate the objective function. The result of the optimization is a set of functions that calculate optimal values of start angle and overlap angle of sinusoidal TSF for every operational point of the motor. Different objective functions, including efficiency and a torque ripple, can be used.

13 3D Finite Difference Model of the Open Circuit Field of Permanent Magnet Spoke Type Axial Flux Machines

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This paper deals with Spoke Type Permanent Magnet Axial Flux Machines which have a great interest in transportation applications. Indeed, as the other

permanent magnet axial flux machines they can have very high specific torque. The spoke type architecture has ability for flux weakening. 3D finite difference model of the open circuit field is developed. In order to reduce the number of unknowns, the magnetic scalar potential formulation is used. According to the geometrical symmetries of the motor, the study domain can be reduced strongly. These choices contribute to get a fast computation time. The obtained results from this approach are compared to the results obtained by 3D finite element analysis.

14 Efficiency Measuring of Electric Drive with Traction Synchronous Motor with Permanent Magnets

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Traction drives are the main propulsion drives for electric vehicles. Electric vehicles need to operate with the maximum available drive efficiency to maximise driving range per a single charge. Research into advanced traction electric propulsion for vehicles is still asking for data on individual electric drive components' efficiency. Available data on the efficiency of electrical components from manufacturers and suppliers are often relatively difficult to obtain. Other ways to obtain data on drive components' efficiency are results from simulations using mathematical models and results from efficiency measurements. As part of this work, an experiment was conducted to measure an electric drive's efficiency consisting of a three-phase controller and a permanent magnet synchronous motor on an available test stand equipped with an electric dynamometer and a torque sensor. A power analyser was used to measure and process electrical and mechanical quantities in the experiment. The experiment resulted in separate maps of the efficiency of the electric drive, controller and motor.

15 Virtual Reality and interactive and immersive planning for the assistance to manipulation or navigation

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In industry, whereas the economic competition increases, up-to-date industrial products are more and more integrated and the tasks related to their lifecycle (assembly, maintenance, disassembly. . .) have to be performed under sometimes very strong geometric constraints. In the context of Industry 4.0 (Factory of the Future) and PLM (Product Lifecycle Management), industrial companies therefore express the needs to validate these tasks from design stage on, in order to be able to update the design of these products (before manufacturing the physical prototypes) if needed. Such an approach allows to reduce development time and cost, to detect errors as early as possible, and to target more environment friendly development processes. When simulating such complex scenarios, it is necessary to deal with the relative positioning or to the movement of objects and of resources (machines, robots, human operators) that manipulate them. A key issue is then to find a path, a trajectory, a movement to show the feasibility of scenarios and simulate what the execution of a task will be. Our works deal with the assistance to the simulation and validation of such complex scenarios in Virtual Reality. We present the original scientific approach on which these works are based: the joint use of motion planning and VR techniques to validate the feasibility of the movement for the simulated scenarios in an interactive and immersive way, with visuo-haptic guidance to the human operator in the loop. The initial approach was based on the use of purely geometric models. In order to improve the relevance of the assistance and the modalities of interaction and control sharing (authority sharing and intents detection) between the VR platform and the human operator, we then considered higher abstraction level (topological and semantic) data than the purely geometrical data traditionally used. Finally, for a better, task- or trade-oriented assistance, and in order to move from the "virtual experience" to the "trade-oriented experience", our work now targets the development of joint, interactive and immersive task and path planning strategies.

16 Path planning control using high abstraction level environment model and industrial task-oriented knowledge

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In order to face an increasing economic competition, industrial manufacturers wish to reduce the time and cost of product development. Furthermore, up-to-date products are more and more integrated, and have to be assembled, disassembled or maintained under potentially very strong geometric constraints. In the context of Industry 4.0, manufacturers are therefore expressing the desire to validate all the tasks related to their products lifecycles, from design stage on, by simulation using a digital mock-up, and before building the physical prototypes. A key issue is then to find a trajectory, a movement, to show the feasibility of the simulated scenarios. Automatic path planning algorithms, developed by the robotics community from the 1980s on, have been widely used for this purpose. In this paper, we intend to improve the relevance of the trajectories proposed by such algorithms and the associated computation times. In order to do so, we consider: a) the use of path planning algorithms or of combinations of these; b) the involvement for the environment modelling of data with a higher abstraction level than the purely geometric data traditionally used [Cailhol et al., 2019]; and c) the representation of the knowledge related to the task to be performed by using ontologies [Zhao et al., 2018]. The approaches developed and associated improvements of the state of the art are validated experimentally through the simulation of highly geometrically constrained manipulation tasks.

17 Generative design of 3D printed grippers for robot/human colaborative environments

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The aim of this paper is to design a gripper for disassembling the refrigerator door gasket with a collaborative robot. The design concept is based on a strong and fixed finger used for guiding, whereas the second finger moves to pinch the gasket. The working conditions of the gripper have been characterised in a universal testing machine, and results have shown that the vertical force for extracting the gasket is lower than the nominal 140 N force of the collaborative robot, taking into consideration that its maximum displacement speed is 250 mm/s. The second input for the generative design based on topology optimisation is the design space, with an asymmetrical distribution for the moving and static finger. The resulting optimised material distribution has been reinterpreted taking into consideration the design for additive manufacturing principals. Finally, the gripper has been 3D printed with a short carbon fibre reinforced polyamide in a filament extrusion machine. The resulting gripper is a 40 % lighter than the monolithic solutions designed and manufactured by conventional technologies.

18 Leveraging domain specific modeling to increase accessibility of robot programming

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Despite the popularity of the Robot Operating System (ROS), Model-Driven Engineering (MDE) methods remain not commonly used in the community. The use of such methods would allow to reason at a higher level of abstraction and increase the accessibility of field engineers to effectively write ROS applications, while opening the way to more advanced model analysis for validation and verification. In a previous work, we made an in-depth comparative study to choose which MDE approach to apply when developing ROS applications. This study led us to choose graphical Domain-Specific Languages (DSL) as the means to facilitate the development of ROS applications. In this paper we present the MDE4ROS framework, a graphical DSL we defined to allow high level robotics applications development. This framework aims to provide a better view of the system during the development using a graphical representation and to enable higher level of abstraction with code generation of the ROS system. To illustrate our proposal we use MDE4ROS to develop a TurtleBot use case and we present an analysis of the results.

19 Cetratus: Live Updates in Programmable Logic Controllers

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Manufacturing companies are facing new market demands, mostly driven by global competition and digitalization. In this context, more efficient, flexible, adaptable and evolvable mechatronic and manufacturing systems are required, which enable quick adjustments to the production in order to address (all these) market changes. However, production idle times due to such re-configurations and adaptations might be costly. In this paper, a live updates concept for Programmable Logic Controllers (PLCs) is presented. The proposed design employs a Petri net runtime engine, in which the executed functional program (the Petri net model with its interpretation) is updated while running, without system shutdown and restart being needed. To this end, a quarantine-mode execution and monitoring approach is used for the new PLC program functional validation. A reconfigurable Vernadat machine case study is also presented.

20 Audio-Visual Broadcast Transcription System Using Artificial Neural Networks

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In this paper, a new system for audio and visual TV-broadcast News transcription is proposed. In the last few years, our system for audio-only broadcast transcription has been modified with the possibility of obtaining additional visual information, especially from TV video recordings. New extension modules and algorithms mainly for visual information extraction are described in this contribution. Combined Deep Neural Networks with Hidden Markov Models (DNN-HMM) are used for audio speech signal recognition. A classification of a relevant visual signal was based on Convolutional Neural Networks (CNN). There are the additional modules for detection and identification of human faces, TV logos, and company logos in the newly developed transcription system. Another module was designed for Optical Character Recognition (OCR)

of text, which occurs mainly in video recordings of TV-News very often. The whole audio-visual system for broadcast transcription was tested on a relatively big database (817 hours) which has been completely transcribed. The system also includes the possibility of intelligent search in transcribed data from audio and/or visual signal.

21 A State Space Solution to the Estimation of Interacting Vehicle Trajectories with Deep Neural Networks and Variational Bayes Filtering

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This paper addresses the estimation of trajectories of interacting vehicles at a microscopic scale, as a prerequisite to their prediction for risk assessment. A state space solution is investigated, where both the Markov hidden state (continuous-valued, which captures the joint histories of vehicles) and the measurements (low-dimensional and noisy) admit a vehicle-wise structure. The vehicles' transition models are assumed independent of each other, time- and vehicle-invariant, and coequal to an ""egocentric"" prior dynamics pdf. To cope with the vehicles' interactions, this pdf is conditioned on the full state vector as the past time index, what imposes a centralized estimation/prediction of the fleet motion. The two fundamental pillars of the approach are developed: learning of a Gaussian mixture egocentric transition model by means of Deep Neural Networks; synthesis of a stochastic variational Bayes filtering algorithm which features a decentralized vehicle-wise structure but takes into account interactions. Tests on highway scenarios are presented.

22 A-posteriori synchronization of power quality data in Smart grids

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This paper is concerned with synchronizing smart meter data in post-processing. A-posteriori synchronization is necessary in cases where real time online synchronization failed or was unavailable. In the paper, a simple method to synchronize power quality data series from multiple meters is proposed. The method analyses similarities in voltage data and estimates the lags between the meters. In order to obtain a single data series representing the most relevant phenomena that happen at the location of the smart meter, Singular Value Decomposition is used. It helps to decrease the dimensionality of the smart meter data to one. To synchronize the time of two or more metering devices the correlation between data series were calculated. Distance between zero and the maximum absolute peak of the cross-correlation is taken as a lag. For signals containing transients and dips, accuracy may be increased by correlating the first order difference of the signals. The output of the proposed algorithm is the value of signals' time lags. The accuracy of the algorithm is limited by the aggregation level of data under examination.

23 Image Enhancement using GANs for Monocular Visual Odometry

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Drones, mobile robots, and autonomous vehicles use Visual Odometry (VO) to move around complex environments. ORB-SLAM or deep learning-based approaches like DF-VO are two of the state-of-the-art technics for monocular VO. Those two technics perform correctly in outdoor scenarios but show some limitations in indoor environments. The extreme lighting conditions, non-Lambertian surfaces, or occlusion of indoor environments can disturb the visual information, and so the odometry information. Generative Adversarial Network(GAN) architectures recently proposed in the literature can help overcome image low-light and blurring limitations. This research study aims to assess image enhancement's impact using GANS on the Visual Odometry algorithm DF-VO. Since DF-VO is also based on visual geometric information, the paper first considers the effect of three different GAN architectures in the camera's calibration. Then, the impact in the odometry information computed by DF-VO is evaluated. The preliminary results show that the reprojection error and

the uncertainty of the calibration of a pin-hole-based camera do not increase significantly, and DF-VO's performance is improved.

24 Indoor environment monitoring as a measure to reduce epidemic spreading

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The Covid-19 pandemic has highlighted a major problem that has been neglected for a long time for various reasons - proper ventilation of indoor spaces in public buildings, schools, the industry, but also in households. The national legislation of developed countries usually sets some ventilation requirements, but their parameters often differ and, most importantly, they are practically unenforceable in everyday life. According to WHO, the majority of the population of European countries spend up to 90 % of their time indoors, which by the way significantly contributed to the massive spread of the disease, transmitted mainly by inhalation of aerosols containing the Covid-19 virus. Our paper aims to describe the current state of legislation on indoor environment quality, with some studies dealing with population behavior and its impact on their health. Another goal of our paper is to describe a method that can detect the air exchange quality in a building and predict development of the indoor environment in order to be able to take appropriate measures well in advance either by technical means of forced ventilation or by conventional methods of manual ventilation. In the future, timely and adequate ventilation should not only be one of the important ways to reduce spreading of respiratory diseases in the population but also, more generally, an important way to increase the quality of life and health of the European population.

25 Design and Performance Analysis of Energy Efficient 11T SRAM (E2S11T) Cell for High Performance and Low Power Applications

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The SRAM based cache memory has been radically increasing in low power applications. The on-chip data processing and computations have been consistently increasing for Wireless Sensor Networks (WSN) and Internet-of-Things (IoT) applications. This demands the constant improvement over the power, performance, stability, and energy efficiency. The challenges rely on power and performance of SRAM as the technology node reduces. In this paper, design of Energy Efficient SRAM (E2S11T) cell is proposed. The proposed cell contains 11-Transistors and implemented using 45 nm CMOS technology. The average dynamic power of the proposed cell is minimized by of 86.68 %, 86.77 %, 61.48 % and 38.47 % compared to C6T, S8T, LPHS10T and HSF11T cells, respectively. The write delay is reasonably improved about 32.58 %, 34.3 6% and 8.43 % against C6T, S8T and LPHS10T cells respectively. The read delay is also improved as well as stability have been improved due to three transistors. The proposed E2S11T cell is proven to be stable in worse conditions against temperature and works without any degradation as low as 200 mV. The cell is statistically analysed by performing Monte-Carlo (MC) simulation to validate the stability of the cell.

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