Book of Abstracts and Final Program

Organization

Mediterranean Control Association

KoREMA – Croatian Society for Communications, Computing, Electronics, Measurement and Control

Support

University of Zagreb Faculty of Electrical Engineering and Computing

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International Conference on Unmanned Aircraft Systems Association, Inc.

Advanced Methods and Technologies in Data Science and Cooperative Systems (DATACROSS)

robotics@fer.hr

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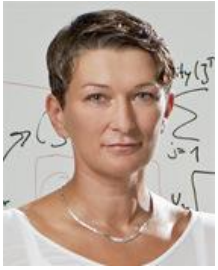

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Kenneth Scerri, University of Malta, Malta

Horst Schulte, HTW-Berlin, University of Applied Sciences, Germany

Olivier Sename, Grenoble INP / GIPSA-lab, France

Hyo-Sang Shin, Cranfield University, United Kingdom

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Elena Zattoni, Alma Mater Studiorum – University of Bologna, Italy

Youmin Zhang, Concordia University, Canada

Message from the President of the Mediterranean Control Association

On behalf of the Mediterranean Control Association, WELCOME to MED '18, the 26th Mediterranean Conference on Control and Automation! Welcome to Zadar, Croatia!

The Mediterranean Control Association (MCA) is the sponsoring, parent organization, which selects the organizers and venues, and oversees all the MED conferences. MCA was founded in 1998 and is registered in Cyprus as a non-profit organization (see the MCA website at www.med-control.org).

The very first MED took place in 1993 in Chania, Greece and over the next quarter century the MED has been in Cyprus, Malta, Italy, France, Croatia, Turkey, Israel, Portugal, Morocco, Spain and several times in Greece (for a complete list of the MED conferences, see www.med-control.org). This year we are meeting for the second time in Croatia. Dubrovnik, Croatia was the venue for the 9th MED Conference, MED '01.

The MED conferences have always been about bringing together researchers in the area of Control Systems and Automation from the Mediterranean countries, who share much more than technical interests, among other things, culture and history. Since the beginning, the MED conferences have been technically co-sponsored by the IEEE Control Systems Society and the IEEE Robotics and Automation Society, and they have consistently kept high quality standards both in the technical program and the conference organization. This is primarily due to the authors, who submit technically sound papers, and also to the tremendous effort of all the volunteers involved in the technical evaluation of these papers and in the organization of the conferences. I would like to take this opportunity to thank them all for their time, effort and wonderful work. Thank you!

As a reminder, the MED Conference Proceedings may be found on line in the IEEE Xplore Digital Library at http://ieeexplore.ieee.org. The Proceedings of early MED Conferences may be downloaded from www.med-control.org.

Looking ahead, the next MED, MED '19, goes to Akko (Acre), Israel (July 1-4, 2019) and I am looking forwards to seeing you all there, as well!

I hope you do experience and enjoy what MED '18 has to offer, and you also take full advantage of your stay in Zadar, enjoying the sites.

Thank you for your participation and contributions to MED '18!

Panos Antsaklis, President

Mediterranean Control Association

Message from the General Co-Chairs of the 26th Mediterranean Conference on Control and Automation

Dear Colleagues, on behalf of the Organizing Committee of the 26th Mediterranean Conference on Control and Automation we would like to welcome you in Zadar, one of the oldest coastal cities in Croatia!

This is the second time that MED conference takes place in Croatia. This called for exceptional motivation and responsibility of the Organizing Committee as we wanted to make MED 2018 even better than MED 2001 and to keep high standards of MED conferences series. That is why all committee members put a lot of effort in organizational activities of this year's conference. As General Co-Chairs we would like to thank them all for their hard work. We also would like to thank the technical program committee members who have done great work on selection of the papers to be presented at the conference.

Our main goal was to provide an opportunity for the academic, research and industrial community to exchange ideas and experiences regarding future research directions. That is why a broad range of topics is covered by accepted articles, following current trends of combining control/systems theory with software/communication technologies, as well as new developments in robotics and mechatronics, autonomous systems, unmanned systems, cyber physical systems, network controlled systems. We hope this will also help strengthen cooperation of control and automation scientists with industry.

This year's MED conference paid special attention to students' activities, which was the motivation behind *Industrial challenges*, a novelty in MED conference series. Industrial challenges were organized in three domains: i) aerial robotics and perception, ii) automotive control, and iii) process automation, and supported by leading industrial partners – Siemens, MathWorks, dSPACE and Rimac Automobili. Industrial challenges provided students with an opportunity to work on the state of the art equipment and to gain experience in implementation of theoretical results in real systems.

At the end we wish you joyful and memorable conference and a pleasant stay in Zadar and Croatia.

Sandra Hirche

Stjepan Bogdan

MED 2018 General Co-Chairs

MED 2018 general information

The 26th Mediterranean Conference on Control and Automation, MED ’18, takes place at the town of Zadar, Croatia. The theme of MED ’18 centers on the growing societal and economic challenges, as well as possible solutions brought by the control, automation and robotics technologies and systems. A broad range of topics is proposed, following current trends of combining control/systems theory with software/communication technologies, as well as new developments in robotics and mechatronics, autonomous systems, unmanned systems, cyber physical systems, network controlled systems, with the goal of strengthening cooperation of control and automation scientists with industry.

The town of Zadar has exceptional history and rich cultural heritage, spanning over 2,000 years. The Old Town, located on a natural peninsula, is surrounded by historical ramparts, within which one can find a mix of archaeological and monumental treasures from ancient and medieval times to Renaissance and contemporary architectural achievements such as the first Sea Organ in the world. In the year 2016, Zadar received the prestigious “Best European Destination 2016” award.

Panorama of the Old Town of Zadar

Church of St. Donatus from 9th century

Conference Venue - Hotel Kolovare

Hotel Kolovare (4*) is located near the historical sights of Zadar, in a peaceful and picturesque part of the city.

The hotel has a modern architectural structure adapted to the Mediterranean style and it has modern and luxurious equipped rooms with air conditioning. The hotel has 191 rooms (double or twin bedrooms, king-size bedrooms) and 12 apartments. All rooms are non-smoking. All rooms are furnished in modern style with 100% cotton bed linen. There is also an à la carte restaurant with 270 seats, wine boutique, a bar, hair salon, massage parlour, congress hall, rent-a-car, an outdoor swimming pool for children and adults and a sports-recreation centre with tennis courts, volleyball court and miniature golf court. There is a beach near the hotel.

View of the conference venue, Hotel Kolovare

Hotel Kolovare lobby

Conference Program Innovations

As the part of the conference program, there are two roundtables dedicated to challenges in control and automation, particularly to societal and economic challenges related to increase in the system autonomy. The panelists from industry, academia and public bodies are attending.

The second innovative aspect of the conference program is related to industrial challenges planned for M. Sc. and Ph. D. students. Three challenges are organized with topics in: i) industrial automation, ii) automotive control design, and iii) autonomous systems control design. Challenges i) and ii) are supported by industrial partners, while the third one is organized under support of *robotics@fer.hr*, an organization of robotics laboratories at the University of Zagreb Faculty of Electrical Engineering and Computing.

Travel and accommodation for the finalists is covered by the conference organizers and challenges supporters. The winners will be announced at the gala dinner.

Registration desk

All Conference attendees must register, either by using on-line early registration (preferred option), or on-site. All registered participants must check in at the Registration Desk to pick up their registration packages. Personal badges will be provided to identify registered participants.

The Registration Desk will be open during the following hours:

Tuesday, June 19	19:00 – 20:00
Wednesday, June 20	07:30 – 15:00
Thursday, June 21	09:00 – 15:00
Friday, June 22	09:00 – 12:00

Events and Receptions

Welcome Reception	Tuesday, June 19	20:00 – 22:00
IEEE Young Professionals Meet Up	Wednesday, June 20	21:00 – 23:00
Gala Dinner	Thursday, June 21	20:30 – 23:00
Farewell	Friday, June 22	15:10 – 15:30

Plenary lectures

The MED 2018 includes three plenary lectures of leading scientists - we are honoured to have their talks as part of this year's Conference program. The names of plenary lecturers, place, time and day of their talk, as well as the title of their talk are listed below.

Back to the roots: Multivariate polynomial optimization by numerical linear algebra

Prof. Dr. Bart De Moor
Department of Electrical Engineering (ESAT-STADIUS)
KU Leuven, Leuven, Belgium

Wednesday, June 20, 11:30-12:30

Congress hall Kolovare

Abstract
Finding some or all of the roots of a set of multivariate polynomials has numerous applications. This century old problem is at the foundation of algebraic geometry sometimes called the 'queen of mathematics'. In this discipline, typically, numerical computations are done symbolically, and only quite recently, it was realized that the multivariate polynomial rooting problem can be tackled using the machinery of numerical linear algebra, because of the fundamental insight that it is equivalent to an eigenvalue problem. In order to find some or all roots, we deploy tools like the QR- and singular value decomposition, and (possibly large scale) iterative eigenvalue solvers. We will discuss several eigenvalue decomposition based algorithms to calculate the global minimum of multivariate polynomial optimization problems. We will illustrate our approach with the numerical solution of two open problems in system theory: Calculating from (noisy) data linear dynamic models that are least squares optimal, and finding the least squares global optimum of the H2 model reduction problem.

Prof. Dr. **Bart De Moor** received his MS (1983) and PhD (1988) degrees from the KU Leuven, Belgium, in electrical engineering (control theory). He is a full professor at the department of Electrical Engineering (ESAT-STADIUS) of KU Leuven, where he also holds the 'CM Health Insurance' endowed chair in 'Health Care Systems Quality and Accessibility'. He is a guest professor at the University of Siena, Italy. He was visiting research associate at Stanford University (1988-1991). Between 1991-2007, he was the chief advisor on science and technology and head of cabinet of several federal and regional ministers. He was vice-rector of International Policy of KU Leuven (2009-2013) and head of its Industrial Research Fund (2006-2015). He has published more than 400 scientific journal papers, 450 conference papers, eleven books, and numerous science popularizing contributions. Currently, he is the promoter of 10 PhD students and 4 postdocs and 82 PhDs were obtained under his guidance. His research interests are in numerical linear algebra and algebraic geometry, dynamical systems theory and identification, advanced control theory, machine/deep learning, bioinformatics, digital health and clinical genomics. Dr. De Moor received the Leybold-Heraeus Prize (1986), the Leslie Fox Prize (1989), the Guillemin-Cauer Best Paper Award of the IEEE Transactions on Circuits and Systems (1990), the Laureate of the Belgian Royal Academy of Sciences (1992), the bi-annual Siemens Award (1994), the Best Paper Award of Automatica (IFAC, 1996), the IEEE Signal Processing Society Best Paper Award (1999) and the excellence award of the Flanders Research Foundation (2010) from King Albert II of Belgium. He became fellow of IEEE (2003) and SIAM (2017) and is a member of the Belgian Royal Academy. He co-founded or contributed to 8 spin-off companies, 7 of which are still active or had a successful exit (IPCOS, Data4S, Transport & Mobility Leuven, Trendminer, Cartagenia, Ugentec, Lindacare). He is chair or board member in several cultural, scientific and funding organizations, and member of numerous scientific assessment committees worldwide.

Robotics and Wireless Communications: Opportunities and Challenges

Prof. Yasamin Mostofi
Department of Electrical & Computer Engineering
University of California, Santa Barbara, CA, USA

Thursday, June 21, 11:30-12:30

Congress hall Kolovare

Abstract

Recent years have seen a great progress in the area of robotics. Communication signals are also ubiquitous these days. In this talk, I will explore the opportunities and challenges at this intersection, for robotic sensing and communication. For instance, imagine two unmanned vehicles arriving behind thick concrete walls. They have no prior knowledge of the area behind these walls, but are interested in imaging every square inch of the invisible area through the walls with a high accuracy. Can the robots achieve this with only WiFi signals? In the first part of the talk, I will show that this is indeed possible. I will discuss how our methodology for the co-optimization of path planning and communication has enabled the first demonstration of 3d imaging through walls with only drones and WiFi. I will also discuss other new sensing capabilities that have emerged from our approach, such as occupancy estimation and crowd analytics with only WiFi signals.

In the second part of the talk, I will focus on communication-aware robotics, a term coined to refer to robotic systems that explicitly take communication issues into account in their decision making, in order to enable robust connectivity and networked task accomplishment. This is an emerging area of research that not only allows a team of unmanned vehicles to achieve the desired connectivity during their operation, but can also extend the connectivity of the existing communication systems through the use of mobility. I will then discuss our latest theoretical and experimental results along this line. I will show how each robot can go beyond the over-simplified but commonly-used disk model for connectivity, and realistically model the impact of channel uncertainty for the purpose of path planning. I will then show how the unmanned vehicles can properly co-optimize their communication, sensing and navigation objectives under resource constraints. This co-optimized approach can result in a significant performance improvement, as we shall see in the talk. I will also discuss the role of human collaboration in these networks.

Yasamin Mostofi received the B.S. degree in electrical engineering from Sharif University of Technology, and the M.S. and Ph.D. degrees from Stanford University. She is currently a professor in the Department of Electrical and Computer Engineering at the University of California Santa Barbara. Yasamin is the recipient of the 2016 Antonio Ruberti Prize from the IEEE Control Systems Society, the Presidential Early Career Award for Scientists and Engineers (PECASE), the National Science Foundation (NSF) CAREER award, and the IEEE 2012 Outstanding Engineer Award of Region 6 (more than 10 Western U.S. states), among other awards. Her research is at the intersection of robotics and communications, on mobile sensor networks. Current research thrusts include X-ray vision for robots, communication-aware robotics, human-robot networks, occupancy estimation, RF sensing, and see-through imaging. Her research has appeared in several reputable news venues such as BBC, Huffington Post, Daily Mail, Engadget, TechCrunch, NSF Science360, ACM News, and IEEE Spectrum, among others. Yasamin is currently an associate editor for the IEEE Transactions on Control of Network Systems. She has served on the Control Systems Society conference editorial board 2008-2013.

Multiagent decision making: learning from observations

Asst. Prof. Maryam Kamgarpour
Automatic Control Laboratory
Swiss Federal Institute of Technology Zurich, Zurich, Switzerland

Friday, June 22, 11:10-12:10

Congress hall Kolovare

Abstract
We began using robots to help us with simple and repetitive tasks. Now, we are introducing automation in ever increasing safety critical and complex tasks: intelligent transportation networks, smart power grid, robotics search and rescue, personalized medicine. How do we ensure that these autonomous systems contribute to making our societies safer and more efficient? To answer this question, we have to address two main control challenges: 1) The autonomous systems need to complete complex tasks in partially known changing environments; 2) Network of interacting autonomous systems need to coordinate their decision making and optimise their choices using only local information. Guided by addressing these two challenges, I will present the two main threads of my research. Specifically, I discuss my latest works on data-driven safe control synthesis in uncertain environments and on game theory and mechanism design for coordinating multi-agent decision making. In both cases, I present the underlying theoretical tools and discuss potential applications.

Maryam Kamgarpour is an assistant professor at ETH Zurich, Automatic Control Laboratory. She obtained Doctor of Philosophy in Engineering from the University of California, Berkeley (2011) and Bachelor of Applied Sciences from the University of Waterloo (2005). She addresses multiagent decision making and safe control synthesis using game theory, mechanism design, online stochastic and robust optimization. Her work is applied to electrical power systems, transportation systems, and rescue robotics. She is the recipient of NASA High Potential Individual Award, NASA Excellence in Publication Award (2010) and the European Union (ERC) Starting Grant 2015.

Industrial challenges

Process automation challenge

Partnership: Organized by the 3Smart project and supported by Siemens and MathWorks

Application: Cooling of a three-room building

Summary:
The challenge focuses on the process of cooling a building that consists of three rooms with fan coils units. The building is connected to a smart electricity grid. The goal is to design a controller for fan coils fans on-off state and the chiller setpoint temperature that will make the building smart, and to make it work on a programmable logic controller (PLC). Tools used for controller design and simulation are Matlab/Simulink from MathWorks and TIA portal from Siemens.

Finals at MED 2018:
For the finalist teams, there are the following elements of evaluation:

1) there is a small change of the assignment and the teams are asked to perform the necessary adaptations of the controller, which will be evaluated in MATLAB environment,
2) the selected 1-hour window of the test-scenario is evaluated via a real PLC connected via MATLAB OPC toolbox to the Simulink scheme where the building process is simulated in real time and the performance will be evaluated according to the same criterion J. Weights for the evaluation elements in the finals are 0.25 and 0.25, respectively.

The challenge winner team will be announced at the conference gala dinner and each of the two representatives of the winning team will be awarded with an Industrial IOT device Simatic IOT 2040.

Finalist teams

FTSEI team
Dušan Čohadžić
Stefan Šoić

School of Electrical Engineering, University of Belgrade and Faculty of Technical Science, University of Novi Sad

SapiEngineering
Tamás Kardos
Zsolt Hobaj

Sapientia Hungarian University of Transylvania

Automotive challenge

Partnership: Organized by Rimac Automobili and supported by dSPACE and MathWorks

Application: Automated drift control of an automobile

Summary:

The goal of this challenge is to drive a given vehicle down a short, curved road segment, in such a way that the vehicle "drifts" as impressively as possible. To achieve this, contestants needed to design a control algorithm that intentionally drives the vehicle into an unstable equilibrium state and maintains this state through careful application of control inputs.

Finals at MED 2018:

Stage B (the finals) consists of implementing the control algorithm in a format suitable for execution on the dSPACE MicroAutoBox II Rapid Development Platform (RDP). The Stage B teams are provided with a software package that will allow them to adapt their control algorithm in Simulink and generate code for the RDP. In addition, teams will receive a specification for the CAN communication between the RDP and the vehicle, which the control algorithm will need to adhere to.

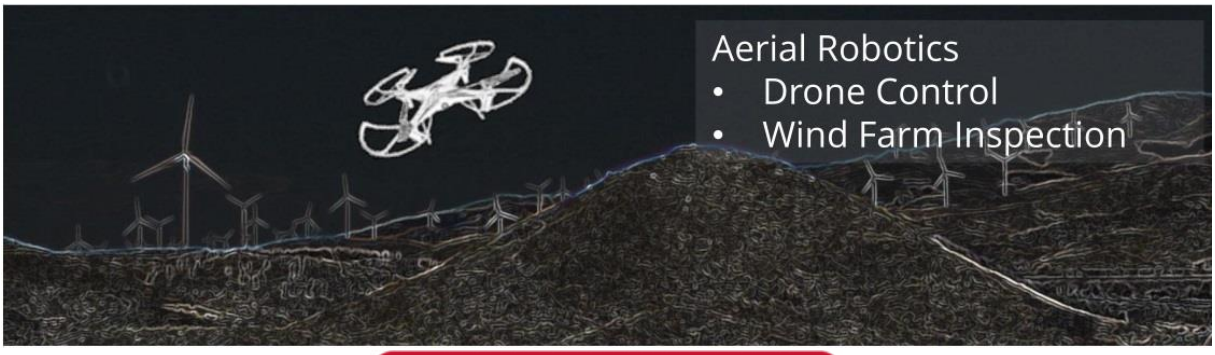
Finalist teams

Team YDrive
Miloš Stojanović
Marko Skakun
Faculty of Electrical Engineering, University of Belgrade

Team Asgardus
Ansh Gandhi
Chitranjan Singh
KTH Royal Institute of Technology

Team Oversteer
Marin Bogdan
Vjekoslav Diklić
Faculty of Electrical Engineering and Computing, University of Zagreb

Aerial robotics control and perception challenge



ROBOTICS@FER.HR

Partnership:	Supported by *robotics@fer.hr*, organization of robotics laboratories at the University of Zagreb Faculty of Electrical Engineering and Computing, Croatia
Application:	Wind Farm inspection

Summary:
In the first stage, teams competed in three tasks, all performed in a simulation environment, using Robot Operating System (ROS) and Gazebo simulator: hovering under wind conditions for 2 minutes, localizing the plane of rotation of a wind generator, detecting up to 5 blade defects.

Finals at MED 2018:
First three teams have been promoted to the second stage and have won a chance to apply their algorithms on real platforms and compete during the conference. The second stage will be held at the conference venue, using Parrot Bebop platform in a mockup wind farm environment.

Finalist teams

Crobots
Giuseppe Silano,
Pasquale Oppido,
University of Sannio

Teamsannio
Filip Zorić,
Bojan Spahija,
Lovro Marković,
Faculty of Electrical Engineering and Computing,
University of Zagreb

Workshops

Assistive Technologies for People with ASD and other Disabilities (June 19, 2018)

Organized by:
Zdenko Kovačić (University of Zagreb Faculty of Electrical Engineering and Computing)
Maja Cepanec (University of Zagreb Faculty of Education and Rehabilitation Sciences)

Abstract:
The development of new technologies enables changes in all spheres of social activity. Particularly vulnerable social categories are people suffering from autistic spectrum disorders, as well as people with other forms of disability. The aim of the workshop is to share knowledge about the different technologies that should facilitate the easier inclusion of these people in society. Special attention is devoted to technologies that enable the diagnosis of autistic spectrum disorders and appropriate therapy from the earliest years of life. Particularly important roles are referred to robotics and information technology. Very common side effects of autistic spectrum disorders are motoric dysfunctions, where advanced robotic systems can play a very important role in successful rehabilitation. The half-day workshop will bring together top experts - trainers from the field of robotics, information technology, human-robot interaction, rehabilitation and other related areas.

Agenda:

09:00 – 09:05	Opening and welcome address *Maja Cepanec, Zdenko Kovačić*
9:05 – 9:40	Keynote talk: NAO and Autism: an update on SoftBank Robotics's projects *Alexandre Mazel*
9:40 – 10:00	DE-ENIGMA – Robot-based emotion-recognition and emotion-expression teaching programme to school-aged autistic children *Vesna Petrović, Sunčica Petrović*
10:00 – 10:20	CareTOY - Rehabilitation at Home based on Mechatronic Toys *Marko Munih*
10:20 – 10:40	ADORE – Autism Diagnostic Observation with Robot Evaluator *Zdenko Kovačić*
10:45 – 11:00	Coffee break
11:00 – 11:20	QTrobot, programmable by everyone *Aida Nazarikhorram*
11:20 – 11:40	Digital stimulating environment for children with multiple impairments *Željka Car*
11:40 – 12:00	Assistive technology for environmental control, education, and communication *Miroslav Vrankić*
12:00 – 12:20	Voice Conversion and Expressive Speech as Assistive Technologies *Vlado Delić, Darko Pekar*
12:20 – 12:40	Children with ASD and Robots - What's the Connection? *Sanja Šimleša*
12:40 – 13:00	Robot-assisted Autism Spectrum Disorder Diagnostics using Partially Observable Markov Decision Processes *Frano Petric*
13:00 – 14:00	Lunch break

Contributors (in alphabetical order):

1. *Željka Car, Head of Laboratory for ICT-based alternative and augmentative communication, University of Zagreb Faculty of Electrical Engineering and Computing, Zagreb, Croatia.*

   Digital stimulating environment for children with multiple impairments
   Within ICT-AAC software application portfolio, there is a variety of mobile and web applications for communication and education that resulted from the multidisciplinary competence network. Focus in each phase of the application life cycle is on the continuous multidisciplinary cooperation with stakeholders from information and communication technology, education and rehabilitation, graphic design as well as a number of parental and professional associations, organizations and individuals who represent user needs. Their continuous involvement in the process of software solution development as well as participation in the evaluation process is required in order to make the applications accessible and highly usable. So far, more than 30 ICT solutions for education and communication, as well as for raising awareness in the field of assistive digital technology and Alternative and Augmentative Communication (AAC) were developed and published at digital application stores for most popular platforms, such as Android, iOS and Web. Also, several prototypes are

developed for smart-watches and virtual reality applications, and they are currently in the evaluation process with users. The main research focus is on personalization and adaptation of both content and user interface in order to best accommodate user needs.

During UNICEF funded project recently, the research was directed toward the children with multiple and severe impairments. Not much literature from this field can be found as well as developed digital assistive solutions due to an inherent complexity and diversity of this user group and according lack of experience and systematic approach in the assessment and digital technology utilization. New technology comes with devices and features that can provide digital stimulating environment for children with multiple impairments. Working together with the professionals from Special hospital Gornja Bistra, two multiplatform software solutions are developed: one for teaching the cause-and-effect relationship and one for teaching colors. The lecture will provide experience and lessons learnt during the research and development process and try to motivate different stakeholders to get involved in investigating the possibilities offered by new technology in making the life of children and persons with severe and multiple impairments better.

2. *Vlado Delić, Head of Group for Acoustics and Speech Technology, professor at University of Novi Sad Faculty of Technical Sciences, Novi Sad, Serbia. Darko Pekar, CEO, AlfaNum Ltd, Novi Sad, Serbia.*

   Voice Conversion and Expressive Speech as Assistive Technologies
   Authors will present their experience in speech technology applications as aids for people with different forms of disabilities. They will also present the project „Design of Robots as Assistive Technology for the Treatment of Children with Developmental Disorders“, particularly its dialogue system based on ASR and TTS in South Slavic Languages. A new generation of DNN-based TTS enables easier conversion of both voice and style of speech in human-robot interaction. Expressive humanoid robots are proven to be preferable over more efficient ones.

3. *Zdenko Kovačić, Head of Laboratory for Robotics and Intelligent Control Systems, professor at University of Zagreb Faculty of Electrical Engineering and Computing, Zagreb, Croatia.*

   ADORE – Autism Diagnostic Observation with Robot Evaluator
   Notwithstanding intensive research and many advances, diagnosing autism spectrum disorders remains a slow and tedious process. Due to the absence of any physiological tests, the outcome depends solely on the expertise of the clinician, which takes years to acquire. The goal of our HRZZ funded ADORE project is to develop a robotic assistant, which will facilitate the diagnostic process and make it more reliable.

4. *Alexandre Mazel, Software Innovation Director at Aldebaran - Softbank Group, Paris, France.*

   NAO and Autism: an update on SoftBank Robotics's projects
   In this talk, we'll give you an overview of our company's recent developments in the uses of our robot related to autism. Including the EC funded DREAM Project on Robot Enhanced Therapy for Autism; the new version of the AskNAO solution, and other related projects.

5. *Marko Munih, Head of Laboratory of Robotics, professor at Faculty of Electrical Engineering, University of Ljubljana, Slovenia.*

   CareTOY - Rehabilitation at Home based on Mechatronic Toys
   The project CareToy promoted early intervention in the first year of life with a portable, low cost, smart system using telemonitored therapy. The CareToy system is composed of different modules: a) an instrumented baby gym with mechatronic hanging toys, so that the infants' actions on the gym can be measured and stimulated, b) a vision module, for measuring and promoting infants' attention and gaze movements and c) a sensorized mat and Inertial Measurement Units (IMU) for measuring and promoting postural control. A fourth telerehabilitation module allows for remote communication with the rehabilitation staff for monitoring and the rehabilitation task definition. CareToy was validated by a RCT on 60 preterm infants with different brain lesions.

6. *Aida Nazarikhorram, Co-founder, LuxAI, Luxembourg.*

   QTrobot, programmable by everyone
   Social robots are effective tools to make healthcare and education more accessible, affordable and effective through standardization and mass replication. Today, however, working with robots requires extensive IT knowledge. LuxAI, a spin-off of the University of Luxembourg has brought social robots for healthcare and education from research centres to the autism centres, by developing user-friendly robots which are accessible for everybody to script custom robot applications. QTrobot enables therapists and teachers to develop robot-enhanced therapeutic or educational curriculums and be an effective part of the new era of Artificial Intelligence and robotics. Dr. Aida Nazari is a research fellow at SNT department of the University of Luxembourg and the co-founder and Chief Communication Officer of LuxAI. In this talk, she will present the QT social robot platform and the findings from a research project at the University of Luxembourg on using QTrobot for emotional ability training of children with autism.

7. *Frano Petric, postdoctoral researcher in Laboratory for Robotics and Intelligent Control Systems, University of Zagreb Faculty of Electrical Engineering and Computing, Zagreb, Croatia.*

   Robot-assisted Autism Spectrum Disorder Diagnostics using Partially Observable Markov Decision Processes

In this talk the focus is on robot reasoning for ASD diagnostics. The method being presented is a hierarchical Partially Observable Markov Decision Process framework that enables a humanoid robot to process the observations of child's behaviour, infer information about the unobservable state of the child and autonomously make decisions by selecting actions and tasks within the robot-assisted ASD diagnostic protocol. Each task of the protocol is modelled using a Mixed Observability Markov Decision Process model as a template. In order to formulate observation probabilities of task models, ASD experts are surveyed and their knowledge is encoded in the observation probabilities of task models. Expert knowledge also allowed for implementation of child behavioural models which are used to validate developed models. The model of the protocol is defined as a POMDP whose actions are tasks of the protocol. The interface between task and protocol models is formulated using regions of belief space of the task as observations for the protocol model.

Following the successful validation through simulations with child behavioural models, task and protocol models are validated through experimental sessions with seven typically developing children and eight children with ASD. Results obtained through experiments show that the robot can recognize the behaviour of the child and capable of differentiating different types of children, since the belief of the robot over the states of the child was comparable to assessment of autism experts.

8. *Vesna Petrović, president of the Serbian Association for helping autistic people, Belgrade, Serbia. Sunčica Petrović – researcher on the project DE-ENIGMA*

Project DE-ENIGMA – Robot-based emotion-recognition and emotion-expression teaching programme to school-aged autistic children

There are over 5 million people with autism in the European Union. If you include their families, autism touches the lives of over 20 million Europeans. It affects the way a person communicates, understands and relates to others. People with autism often have difficulty using and understanding verbal and non-verbal language. This often makes it difficult to understand others and interact with them. Getting the right support and therapies makes a substantial difference to people with autism. On the other hand, people with autism often have intact and sometimes even superior cognitive abilities to comprehend predictable systems, such as robots. Children with autism perceive a humanoid robot as being less complicated, less threatening, and more comfortable to communicate with than humans. Research has demonstrated that the best treatments are early and specialized behaviour-based therapies that helps people with autism to develop skills to cope with the individual challenges they face.

The DE-ENIGMA project is developing artificial intelligence for a commercial robot (Robokind's Zeno). The robot will be used for an emotion-recognition and emotion-expression teaching programme to school-aged autistic children. This approach combines the most common interests of children of school age: technology, cartoon characters (that Zeno resembles) and socializing with peers. During the project, Zeno will go through several design phases, getting 'smarter' every time. It will be able to process children's motions, vocalizations, and facial expressions in order to adaptively and autonomously present emotion activities, and engage in feedback, support, and play.

9. *Sanja Šimleša, Child Communication Research Laboratory, professor at University of Zagreb Faculty of Education and Rehabilitation Sciences, Zagreb, Croatia.*

Children with ASD and Robots - What's the Connection?

Various technological devices have long been an essential part of diagnostics and rehabilitation of many disorders. In the field of autism spectrum disorder (ASD) research, enhancement of diagnostics process and therapy of individuals with ASD, scientists have become rather interested in potential of socially-assistive robotics. So far, in the field of human-robot interaction, research goals were mainly directed to measurement and analysis of children's reactions in relation to the robot partner. Future goals include detailed analysis of certain behaviours which are considered important in the process of diagnosis and intervention of individuals with ASD. One of those behaviours is an imitation. Individuals with ASD have considerable imitation deficit. Imitation is correlated with positive social behaviours and is considered predictive to social skills. Robots have so far been successful in eliciting desirable social behaviours in children with ASD, such as joint attention or sharing of the enjoyment. The purpose of the current study was to examine the differences in interactions of children with ASD in relation to the demonstrator of the task (robot-human) and to give a detailed description of the imitation skills. The results will be elaborated in the presentation.

10. *Miroslav Vrankić, professor at Technical Faculty University of Rijeka and founder of E-glas d.o.o., Rijeka, Croatia.*

Assistive technology for environmental control, education, and communication

E-Glas is a Croatian company which produces and distributes assistive technology solutions. It was founded in 2009. at the Science and Technology Park of the University of Rijeka. The first product of E-Glas was Servus, which was later named Serwantess. Serwantess is an electronic system which enables users to control their home through voice commands. Serwantess helps people with physical disability to be more independent and safe at their home. Another product of E-Glas is ABC Maestro, an educational rehabilitation software for learning how to write, type, and read. It is a didactic tool that can be a valuable equivalent to the pedagogical methods of active literacy learning for children with special educational needs. The lecture will be concluded with a presentation of an EEG-based communication system which was created in order to enable communication with patients suffering from the locked-in syndrome patients.

Tutorials

Graph Theoretic Methods in Networked Dynamic Systems (June 19, 2018)

Organized by:
Airlie Chapman (University of Melbourne, Australia) and Mehran Mesbahi (University of Washington, USA)

Abstract:
In this half-day tutorial session, two leading researchers in the area of networked systems provide a concise, yet thorough tutorial on the key concepts in graph theory that have proved instrumental in the analysis and synthesis of multi-agent networked systems. The tutorial will first motivate a number of applications where the interaction topology between dynamic nodes plays a fundamental role on their stability and performance properties. These examples include robotic networks, formation flight, aerial swarms, distributed estimation and filtering, and distributed optimization, as well as infrastructure and social-cyber-physical systems. Examining system theoretic properties of such systems have direct implications for their performance, resilience, and security; as such, they provide a compelling motivation for abstracting these networks-and how their structure dictates their system theoretic properties-in terms of graph theoretical constructs.

Graphs are useful abstractions for networked systems that facilitate examining the role of the underlying information-exchange and interaction geometry on the behavior (e.g., noise attenuation, tracking, robustness, synchronization patterns) that these systems exhibit. In the meantime, graph theory is an elegant branch of discrete mathematics with a rich history and a number of sub-disciplines, such as algebraic graph theory, random graphs, and extremal graph theory. When graphs are embedded in linear control systems, the (linear) algebraic framework for analyzing graphs becomes particularly useful. One of the key components of this tutorial is delving into the necessary theoretical and computational results that highlight the elegance and the utility of such linear algebraic perspective that have been particularly useful for networked systems. In the meantime, the speakers will also provide insights and connections to other areas of graph theory that complements this linear algebraic framework for the analysis and synthesis of networked systems.

The tutorial is organized along the following topics:

1. Motivation for networked systems
    a. Centralized vs. decentralization
       Dichotomy between centralization, decentralization, and networked systems. Fundamental aspects of coordination in large-scale systems with particular attention to trade-offs between computation, sensing, and communication.
    b. Information-exchange
       What are the mechanisms for information exchange through sensing and communication? Overview of models and parameterizations for sensing and communication networks.
    c. Structure vs. function
       Why does the structure matter in the performance and behavior of certain networked systems? We provide examples of scenarios where networks play a central role in characterizing dynamic behavior of systems as well as instances where the network structure plays a secondary role.
    d. Representing networks as graphs; what aspects of networks are captured by graphs and what information is lost through such an abstraction.

2. Graph theory
    a. Basic concepts from graph theory, including walks, paths, cycles, diameter, cutsets, and partitions.
    b. Linear algebra of graphs
       Matrices associated with graphs, including adjacency, incidence, and Laplacian matrices and their variants; their eigenvalues and eigenvectors. What do spectral properties of networks say about the structure of the underlying network? Introduction to spectral graph theory.
    c. Introduction to algebraic graph theory
       Algebraic properties of graphs, characteristic polynomials and their coefficients and roots.
    d. Operations of graphs, e.g., joints, unions, products.
    e. Some useful operations on graphs with prescribed effect on the algebraic properties, including, joining graphs or taking various products of graphs, including Cartesian and tensor products.

3. Graph-theoretic methods for analysis of networked systems
    a. Connectivity and convergence rate
       How network connectivity dictates convergence properties of distributed dynamic processes evolving on the network.
    b. Lyapunov analysis on networks

How spectral graph theory has been used in the context of Lyapunov stability analysis?

c. Cycle structure and H2 performance
d. What is the role of cycles and other substructures in the network on the H2 performance and coherence?
e. Effective resistance and noise attenuation
   How is effective resistance of the graph related to its noise attenuation properties and properties of random walks.
f. Symmetry and controllability/observability
   How network symmetry can be parameterized and how it is related to controllability and observability of networked systems?

4. Graph-theoretic methods for synthesis of networked systems
   a. Network synthesis via semi-definite programming
      How networks can be synthesized so that they have favorable structures as viewed from a system theoretic perspective?
   b. Distributed learning on networks
      How networks can evolve in a distributed manner to attain a favorable structure over time, as viewed from a system theoretic perspective; connections with distributed optimization and online learning.

If time permits, the speakers will also delve into distributed optimization and techniques for characterizing networks from time-series data, including connections between spectral graph theory, system identification, and reduced order modeling techniques such as principle component analysis and dynamic mode decomposition.

This half-day tutorial session will provide a concise introduction to the necessary theoretical framework as well as computational means of analyzing and synthesizing networks in the context of networked dynamic systems. The participants will have access to the hand-outs and exercises that will accompany the tutorial.

IEEE Young Professionals Meet Up

As a group of young scientists and engineers at early stage of our careers we share knowledge, enthusiasm and collaboration readiness around the globe. Multidisciplinarity and diversity in perspectives are our tools for pushing new technologies. We are IEEE Young Professionals and we will see you there at MED 2018. On Wednesday, June 20, you will have a chance to meet us at our networking event "Young Professionals Meet Up" within a casual atmosphere of a nearby bar.

"Meet Up" is a social networking event, a place to form new contacts and explore collaboration opportunities among Young Professionals, suited to a casual bar ambience and open to all interested visitors: conference participants, local IEEE members or any other passing individual. The meeting point is the bar "The Garden Lounge" in the old town, within the walking distance from the conference venue. This reception is organized by IEEE Young Professionals Croatia. Entrance is free.

IEEE youngprofessionals croatiasection

Program at a glance

MED 2018 Technical Program Tuesday June 19, 2018	
Track T1	**Track T2**
09:00-10:45 Kolovare Industrial Challenge TueA01 ***Industrial Challenges (Part 1)***	09:00-10:45 Meeting Room 1 Workshop TueA02 ***Assistive Technologies for People with ASD and Other Disabilities (Part 1)***
10:45-11:00 **Coffee Break**	
11:00-12:45 Kolovare Industrial Challenge TueB01 ***Industrial Challenges (Part 2)***	11:00-12:45 Meeting Room 1 Workshop TueB02 ***Assistive Technologies for People with ASD and Other Disabilities (Part 2)***
12:45-14:00 **Lunch Break**	
14:00-15:45 Kolovare Industrial Challenge TueC01 ***Industrial Challenges (Part 3)***	14:00-15:45 Meeting Room 1 Tutorial Session TueC02 ***Graph Theoretic Methods in Networked Dynamic Systems (Part 1)***
15:45-16:00 **Coffee Break**	
16:00-17:45 Kolovare Industrial Challenge TueD01 ***Industrial Challenges (Part 4)***	16:00-17:45 Meeting Room 1 Tutorial Session TueD02 ***Graph Theoretic Methods in Networked Dynamic Systems (Part 2)***
20:00-22:00 **Welcome Reception**	

MED 2018 Technical Program Wednesday June 20, 2018					
Track T1	**Track T2**	**Track T3**	**Track T4**	**Track T5**	**Track T6**
08:30-09:00 Kolovare **Opening Ceremony**					
09:00-11:00 Kolovare Regular Session WedA01 ***Robotics 1***	09:00-11:00 Meeting Room 1 Regular Session WedA02 ***Control Systems***	09:00-11:00 Meeting Room 2 Regular Session WedA03 ***Modelling and Simulation***	09:00-11:00 Meeting Room 3 Regular Session WedA04 ***Linear Systems***	09:00-11:00 Meeting Room 4 Regular Session WedA05 ***Autonomous and Unmanned Systems 1***	09:00-11:00 Meeting Room 5 Regular Session WedA06 ***Optimisation***
11:00-11:30 **Coffee Break**					
11:30-12:30 Kolovare Plenary Session ***"Back to the Roots: Multivariate Polynomial Optimization by Numerical Linear Algebra" - Prof Bart De Moor***					
12:30-14:00 **Lunch Break**					
14:00-15:40 Kolovare Regular Session WedB01 ***Aerospace Control 1***	14:00-15:40 Meeting Room 1 Regular Session WedB02 ***Intelligent Transportation Systems***	14:00-15:40 Meeting Room 2 Regular Session WedB03 ***Real-Time Control***	14:00-15:40 Meeting Room 3 Regular Session WedB04 ***Intelligent Control Systems***	14:00-15:40 Meeting Room 4 Regular Session WedB05 ***Autonomous and Unmanned Systems 2***	
15:40-16:00 **Coffee Break**					
16:00-17:30 Kolovare Round Table ***Control Systems and AI in the Quest for Autonomy***					
21:00-23:00 **IEEE Young Professionals Networking Event @ the Garden Lounge (bar in the center of Zadar)**					

MED 2018 Technical Program Thursday June 21, 2018				
Track T1	**Track T2**	**Track T3**	**Track T4**	**Track T5**
09:00-11:00 Kolovare Regular Session ThuA01 ***Robotics 2***	09:00-11:00 Meeting Room 1 Regular Session ThuA02 ***Industrial Automation and Process Control***	09:00-11:00 Meeting Room 2 Regular Session ThuA03 ***Cyber-Physical and Networked Systems***	09:00-11:00 Meeting Room 3 Regular Session ThuA04 ***Robust Control 1***	09:00-11:00 Meeting Room 4 Regular Session ThuA05 ***Adaptive Control***
		11:00-11:30 **Coffee Break**		
		11:30-12:30 Kolovare Plenary Session ***"Robotics and Wireless Communications: Opportunities and Challenges" - Prof Yasamin Mostofi***		
		12:30-14:00 **Lunch Break**		
14:00-15:40 Kolovare Regular Session ThuB01 ***Aerospace Control 2***	14:00-15:40 Meeting Room 1 Regular Session ThuB02 ***Marine Control***	14:00-15:40 Meeting Room 2 Regular Session ThuB03 ***Biomedical Engineering***	14:00-15:40 Meeting Room 3 Regular Session ThuB04 ***Robust Control 2***	14:00-15:40 Meeting Room 4 Regular Session ThuB05 ***Fault Diagnosis and Fault Tolerant Control 1***
		15:40-16:00 **Coffee Break**		
		16:00-17:30 Kolovare Round Table ***Social Implications of Autonomy and Automation***		
		20:30-23:30 **Gala Dinner**		

MED 2018 Technical Program Friday June 22, 2018				
Track T1	**Track T2**	**Track T3**	**Track T4**	**Track T5**
09:00-10:40 Kolovare Regular Session FriA01 ***Fault Diagnosis and Fault Tolerant Control 2***	09:00-10:40 Meeting Room 1 Regular Session FriA02 ***Disturbance Rejection***	09:00-10:40 Meeting Room 2 Regular Session FriA03 ***Nonlinear Systems and Control 1***	09:00-10:40 Meeting Room 3 Regular Session FriA04 ***Signal and Image Processing***	09:00-10:40 Meeting Room 4 Invited Session FriA05 ***Control in Smart Cities***
		10:40-11:10 **Coffee Break**		
		11:10-12:10 Kolovare Plenary Session ***"Multiagent Decision Making: Learning from Observations" - Prof Maryam Kamgarpour***		
		12:10-13:30 **Lunch Break**		
13:30-15:10 Kolovare Regular Session FriB01 ***Automotive Control***	13:30-15:10 Meeting Room 1 Regular Session FriB02 ***Identification***	13:30-15:10 Meeting Room 2 Regular Session FriB03 ***Nonlinear Systems and Control 2***	13:30-15:10 Meeting Room 3 Invited Session FriB04 ***Integrating Wireless Sensor Networks in Distributed Control Systems (SENSYS'18)***	
		15:10-15:30 **Closing - Farewell**		

Book of Abstracts

Technical Program for Wednesday June 20, 2018

WedA01	Kolovare
Robotics 1 (Regular Session)	
Chair: Kovacic, Zdenko	Univ. of Zagreb
Co-Chair: Sjøberg, Alexander Meyer	Norwegian Univ. of Science and Tech

09:00-09:20 WedA01.1

Human-Robot Interaction Control through Demonstration, pp. 1-6

Lyu, Shangke — Nanyang Tech. Univ

Cheah, C.C. — Nanyang Tech. Univ

In human-robot interaction (HRI) tasks, robots are required to change the behaviours according to different applications. As different interaction behaviours require different task requirements, it is difficult to formulate a HRI control problem in a general or unified way that enables robots to learn a set of task requirements or behaviours through human's demonstrations and then execute the tasks by using one controller. This paper aims to solve this problem by using a dynamic potential energy function to describe a set of different task requirements so that the motion behaviours demonstrated by human can be acquired or learned by the robot systems in a unified way. A control strategy is proposed to enable the robots to perform various tasks demonstrated by human and also change the behaviours during HRI according to different applications in a stable manner. The stability of overall system is shown using Lyapunov-like analysis and experimental results are presented to illustrate the performance of the proposed control strategy.

09:20-09:40 WedA01.2

Kinematic Feedback Control Using Dual Quaternions, pp. 7-12

Sjøberg, Alexander Meyer — Norwegian Univ. of Science and Tech

Egeland, Olav — Norwegian Univ. of Sci. & Tech

This paper presents results on kinematic controllers for the stabilization of rigid body displacements using dual quaternions. The paper shows how certain results for quaternion stabilization of rotation can be extended to dual quaternions stabilization of displacements. The paper presents a relevant background material on screw motion and the screw description of lines and twists. Moreover, results are presented on the computation of the exponential functions for dual quaternions for use in numerical integration. The paper presents and analyzes different controllers based on feedback from dual quaternions, where some of the controllers are known from the literature, and some are new. In particular, it is shown which controllers give screw motion, and it is discussed how this will affect the performance of the controlled system compared to other controllers that are not based on screw motion. This analysis is supported by Lyapunov analysis. Also, certain passivity properties for dual quaternions are presented as an extension to previously published results on passivity for quaternions.

09:40-10:00 WedA01.3

On the Experiments about the Nonprehensile Reconfiguration of a Rolling Sphere on a Plate, pp. 13-20

Serra, Diana — Rete Ferroviaria Italiana SpA

Ferguson, Joel — The Univ. of Newcastle

Ruggiero, Fabio — Univ. Degli Studi Di Napoli "Federico II"

Siniscalco, Andrea — ALTEN Italia

Petit, Antoine — INRIA, Mimesis Group

Lippiello, Vincenzo — Univ. Di Napoli Federico II

Siciliano, Bruno — Univ. Degli Studi Di Napoli Federico II

A method to reconfigure in a nonprehensile way the pose (position and orientation) of a sphere rolling on a plate is proposed in this letter. The nonholonomic nature of the task is first solved at a planning level, where a geometric technique is employed to derive a Cartesian path to steer the sphere towards the arbitrarily desired pose. Then, an integral passivity-based control is designed to track the planned trajectory. The port-Hamiltonian formalism is employed to model the whole dynamics. Two approaches to move the plate are addressed in this paper, showing that only one of them allows the full controllability of the system. A humanoid-like robot is employed to bolster the proposed method experimentally.

10:00-10:20 WedA01.4

Dynamic Parameters Identification of an Industrial Robot: A Constrained Nonlinear WLS Approach, pp. 21-26

BAHLOUL, Abdelkrim — Univ. Paris Sud

Tliba, Sami — Univ. Paris-Sud; CNRS; CentraleSupelec;

Chitour, Yacine — Univ. Paris-Sud, CNRS, Supelec

This paper brings an identified model for a 6 degrees of freedom (dof) industrial robot, the Denso~VP-6242G robot, with an end-effector composed of a spherical handle, fixed on a force sensor. This robot is intended to experiments in the field of Physical Human-Robot Interactions (PHRIs), for co-manipulation purposes. The control algorithms that are necessary to achieve a good PHRI, require a good knowledge of the robot dynamical model, especially the inertia matrix which should be positive definite whatever the configuration of the robot. However, most of industrial robots are supplied without any datasheet containing the inertial parameters nor Computer-Aided-Design (CAD) model. Hence, we propose to apply an identification procedure to experimental data, based on the Inverse Dynamic model Identification Method (IDIM). To ensure the positive definiteness of the inertia matrix, the used optimization step addresses the problem of nonlinear Weighted Least Squares (WLS), derived from the mathematical formulation of the identification problem, under a set of nonlinear constraints in the parameters. A validation step permits to check the efficiency of this approach for the Denso robot.

10:20-10:40 WedA01.5

Classification of Child Vocal Behavior for a Robot-Assisted Autism Diagnostic Protocol, pp. 27-32

Kokot, Mirko — Univ. of Zagreb, Faculty of Electrical Engineering and Comp

Petric, Frano — Univ. of Zagreb

Cepanec, Maja — Univ. of Zagreb, Faculty of Education and Rehabilitation Sc

Miklic, Damjan — Faculty of Electrical Engineering and Computing, Univ

Bejić, Ivan — Univ. of Zagreb, Faculty of Electrical Engineering and Comp

Kovacic, Zdenko — Univ. of Zagreb

Autism is a neurodevelopmental disorder affecting an increasing fraction of children, with severe social and economic consequences for affected persons and their families. Including robotic technologies in the diagnostic process could potentially increase its speed and reliability, opening the way towards earlier and more efficient therapy. The diagnostic process requires multimodal interaction, in which the vocal behavior of the child plays an important role. In this paper, we present a method for

automatic classification of child vocal behavior, based on supervised learning, which is suitable for real-time execution on an autonomous robot with limited computational resources. The main contribution of the paper is an empirically determined minimal set of sound features, which allow efficient vocal behavior classification of preschool children, relevant in the context of autism diagnostics. The classifier is verified on a dataset combined from publicly accessible audio recordings and recordings collected during diagnostic and therapeutic sessions.

10:40-11:00 WedA01.6

A Phri Framework for Modifying a Robot's Kinematic Behaviour Via Varying Stiffness and Dynamical System Synchronization, pp. 33-38

Kastritsi, Theodora — Aristotle Univ. of Thessaloniki
Sidiropoulos, Antonis — Aristotle Univ. of Thessaloniki
Doulgeri, Zoe — Aristotle Univ. of Thessaloniki

In this work, we propose a robot control framework for modifying a desired robot kinematic behavior encoded in dynamical movement primitives (DMP) by physically interacting with the robot during its autonomous operation. The proposed method is based on variable stiffness and DMP time synchronization with the user during the interaction. The overall controlled system is proved to be stable. After the user stops interacting with the robot, the robot motion continues according to the learned kinematic behavior until it reaches the final task goal. At the next execution cycle a new DMP can been learned to generate the modified trajectory. In this way, explicit robot programming and separation of learning and execution stages is eliminated. The proposed approach is implemented and evaluated on a 7-degree-of-freedom KUKA LWR4.

WedA02 Meeting Room 1

Control Systems (Regular Session)

Chair: Schuster, Eugenio — Lehigh Univ
Co-Chair: Miller, Boris — Inst. for Information Transmission Problems RAS and Monash Univ

09:00-09:20 WedA02.1

Optimization-Based PV/PI Design for a DC-Motor System with Delayed Feedback, pp. 39-45

ozer, suleyman mert — Anadolu Univ
YILDIZ, SENEM — ANADOLU Univ
Iftar, Altug — Anadolu Univ

Proportional velocity (PV) and proportional integral (PI) controllers are designed to regulate the angular position and angular velocity, respectively, of a DC motor system with a pointwise time-delay in the feedback loop. Because of the time-delay, the system is described by delay differential equations which have infinitely many modes that can not be assigned by using classical pole placement methods. The proposed method is based on minimizing the real part of the rightmost closed-loop mode, i.e., spectral abscissa, as a function of the controller parameters. The effectiveness of the method is illustrated by simulations and real-time experiments.

09:20-09:40 WedA02.2

Repetitive Process Based Design of PD-Type Iterative Learning Control Laws, pp. 46-51

Paszke, Wojciech — Univ. of Zielona Gora
Rogers, Eric — Univ. of Southampton
Boski, Marcin — Faculty of Computer, Electrical and Control Engineering Univ

New results on the design of iterative learning control laws are developed. The analysis is in the repetitive process setting. The iterative learning law combines a PD-type learning function and state feedback, where only a relatively small number of parameters need to be tuned. The analysis is extended to allow different finite frequency range performance specifications, where this facility is relevant to many applications. The design computations required are linear matrix inequality based. The new design is illustrated by a simulation based study on robotic manipulator behavior, where the model used has been constructed from experimental data.

10:00-10:20 WedA02.4

Combined Current Profile and Plasma Energy Control Via Model Predictive Control in EAST, pp. 52-57

Wang, Hexiang — Lehigh Univ
Wehner, William — Lehigh Univ
Schuster, Eugenio — Lehigh Univ

Extensive studies have shown that the toroidal current density profile, which is closely related to the poloidal magnetic flux profile, is a key factor to achieving advanced tokamak operating scenarios characterized by improved confinement and possible steady-state operation. In this work, a first-principles-driven, control-oriented model of the poloidal magnetic flux profile evolution is used to design a feedback controller via model predictive control (MPC). The aim of the feedback controller is to track a desired profile for the gradient of the poloidal magnetic flux by solving an optimal control problem in the presence of disturbances, non-modeled dynamics, and arbitrary initial conditions. The simulation results illustrate the capability of the proposed controller in dealing with perturbed initial conditions and disturbances.

10:20-10:40 WedA02.5

Rational Approximation of Distributed-Delay Control Laws Via Moment-Matching, pp. 58-64

Malka, Omer — Technion
Palmor, Zalman J. — Technion

This paper presents a novel method for approximating distributed-delay (DD) control laws by rational transfer functions. It does so via Moment-Matching (MM). Unlike existing methods, the inherent degrees of freedom in this method offer the designer the ability to preserve closed-loop (CL) properties and assure stability of approximation regardless of its order. A formula for the approximation of the modified Smith predictor is suggested and simulations are presented and compared with some known methods from the literature.

10:40-11:00 WedA02.6

Joint Continuous and Impulsive Control of Markov Chains, pp. 65-69

Miller, Alexander — Inst. for Information Transmission Problems, RAS
Miller, Boris — Inst. for Information Transmission Problems RAS and Monash U
Stepanyan, Karen — Inst. for Information Transmission Problems

This work considers the continuous and impulse control of the finite state Markov chains in continuous time. In general continuous control governs the transition rates between the states of Markov chain (MC), so the instants and directions of the state changes are random. Meanwhile sometimes there is an urgent necessity to realise the transition which leads to immediate change of the state. Since such transitions need different efforts and produce different effects on the function of the MC itself, one can consider this situation as an impulse control, and if at the same time there is a possibility of graduate control we are coming to the problem of joint continuous and impulse control. In the article we develop the martingale representation of the MC governed by joint continuous and impulse control and give an approach to the solution of the optimal control problem on the basis of the dynamic programming equation. This equation has a form of quasivariational inequality which in the case of finite state MC can be reduced to the solution of the system of ordinary differential equation with one switching line, which may be easily determined with the aid of numerical procedure.

WedA03 Meeting Room 2

Modelling and Simulation (Regular Session)

Chair: Hure, Nikola — FER Zagreb

Co-Chair: Uchiyama, Naoki — Toyohashi Univ. of Tech

09:00-09:20 WedA03.1

Modeling of the Citric Acid Cycle and Its Two Shuttle Systems, pp. 70-77

Sváb, Gergely — Semmelweis Univ

Horvath, Gergo — Semmelweis Univ

Szederkényi, Gábor — Pazmany Peter Catholic Univ

A dynamical model is proposed in this paper for describing the key quantities of mitochondrial metabolism. Mitochondria are very important cell organelles, because they take part in the bioenergetic functions of the cells, control metabolic pathways, participate in heat production, in upholding the equilibrium of reactive oxygen species, in Ca^{2+} metabolism, and in the control of apoptotic procedures of the cells. In this work the citric acid cycle and its two transport systems are modeled, namely the malate-aspartate and the citrate-pyruvate shuttle. The overall model containing three modules is given in the form of kinetic ordinary differential equations with 39 state variables. Simulation results are presented and discussed from a biological point of view.

09:20-09:40 WedA03.2

An Introductory Overview about Systems and Control - a Motivation Lecture in Control Education, pp. 78-83

Vamos, Tibor — Computer and Automation Res. Inst

Keviczky, Laszlo — Hungarian Acad. of Sciences

Bars, Ruth — Tech. Univ. of Budapest

Benedek, András — Budapest Univ. of Tech. and Ec

Sik, David — Budapest Univ. of Tech. and Ec

Systems and control are all around us. System view, understanding systems and how they are controlled is important for everyone. By understanding systems and control in different areas of life better decisions could be done influencing our everyday life. Systems and control, control engineering is a basic subject in engineering education. In the paper the main aspects of system view, model building, control objectives, control structures and algorithms, among them YOULA parameterization as an important paradigm are considered. This overview about systems and control can be provided in the first lecture of control giving a motivation for the students for studying systems and control. A multi-layer e-book, Sysbook has been developed which could contribute to understanding the concepts as a supplement to the conventional teaching materials. Students also can contribute to its contents through the Student Area. Interactive learning tools as Java applets and software MATLAB/SIMULINK provide possibilities for active learning.

09:40-10:00 WedA03.3

Modeling Task Dependencies in Project Management Using Petri Nets with Arc Extensions, pp. 84-89

Tsinarakis, George — Tech. Univ. of Crete

Alternative ways of modeling the four possible types of task dependencies in Project Management are introduced. The approach presented makes possible modeling and simulation of the execution procedure of complicated projects that can be analyzed in interconnected tasks, using Petri Nets and their extensions. The proposed method allows the calculation of the overall duration, as well as other useful measures according to the task durations and the interconnections between them. The advanced modeling power of Petri Nets makes possible the inclusion of random events (following a distribution or not) that in real world may disturb the project execution, as well as may change its duration and may lead to more accurate calculations compared to the traditionally used Project management tools and methods such as Network and Node diagrams. This can be used for more efficient project planning as well as for designing necessary actions to correct real time behavior of Project execution.

10:00-10:20 WedA03.4

Approximation of Advance Element in Consecutive Compensator Design for Plant with Control Delay, pp. 90-95

Bystrov, Sergey — ITMO Univ

Sinetova, Madina — ITMO Univ

Vunder, Nina — ITMO Univ

The article describes the algorithm of analytical construction of a consecutive compensator for controlling a plant with delay. The algorithm is based on the approximation of the advance element. The problem of approximation of the advance element appears when the synthesis of the consecutive compensator is performed on the basis of the desired typical polynomial model of the «input-output» system. Ignoring the delay element in a plant while constructing a consecutive compensator results in the appearance of the advance in its composition. An advance element approximation is better than the approximation of a delay element, since the stability problem of the approximant disappears. Approximants in the form of differentiating links of first and second order are used to construct a consecutive compensator with an advanced element in its composition. The article gives the results obtained by the research.

10:20-10:40 WedA03.5

Cascade Control Approach for a Cart Inverted Pendulum System Using Controller Synthesis Method, pp. 96-101

PEKER, Fuat — Dicle Univ

KAYA, Ibrahim — Dicle Univ

cokmez, erdal — Dicle Univ

Atic, Serdal — Batman Univ

Inverted pendulum is a basic benchmark in the field of control engineering. It is a well-known example of single input multi output (SIMO) systems. A commonly used type of the inverted pendulum systems is cart inverted pendulum which has a cascade structure inherently. In this paper, a cascade control approach based on controller synthesis method is used for controlling a cart inverted pendulum system. Controller synthesis technique is used to tune both inner and outer loops of the cascade control system. Simulation results are given to demonstrate the use of the proposed approach.

10:40-11:00 WedA03.6

Time and Energy Optimal Trajectory Generation in Feed Drive Systems Using Kinematic Corner Smoothing with Interrupted Acceleration, pp. 102-107

Nshama, Enock William — Toyohashi Univ. of Tech

Uchiyama, Naoki — Toyohashi Univ. of Tech

This paper proposes a method of systematically generating corner smoothed trajectories for feed drive systems that offer the best trade-off between two contradicting objectives, namely, cycle time and energy consumption. An energy model for feed drive systems is used to define the bi-objective optimization problem. A geometry is subdivided into linear and corner segments, where the linear segments are defined by jerk limited acceleration profiles and the corner segments are defined using a kinematic corner smoothing technique with interrupted acceleration. By a normalized normal constraint method and a divide and conquer algorithm, Pareto fronts are generated and the best trade-off trajectory is obtained as the Pareto optimal point that minimizes both objectives. Simulation results for an industrial bi-axial machine are shown.

WedA04 Meeting Room 3

Linear Systems (Regular Session)

Chair: Vukic, Zoran — Univ. of Zagreb, Faculty of Electrical EngineeringandComputing

Co-Chair: Bajcinca, Naim — Univ. of Kaiserslautern

09:00-09:20 — WedA04.1

Control of a Time-Variant 1-D Linear Hyperbolic PDE Using Infinite-Dimensional Backstepping, pp. 108-115

Anfinsen, Henrik — NTNU
Aamo, Ole Morten — NTNU

We derive a state-feedback controller for a scalar 1-D linear hyperbolic partial differential equation (PDE) with a spatially- and time-varying interior-domain parameter. The resulting controller ensures convergence to zero in a finite time d_1, corresponding to the propagation time from one boundary to the other. The control law requires predictions of the in-domain parameter a time d_1 into the future. The state-feedback controller is also combined with a boundary observer into an output-feedback control law. Lastly, under the assumption that the interior-domain parameter can be decoupled into a time-varying and a spatially-varying part, a stabilizing adaptive output-feedback control law is derived for an uncertain spatially varying parameter, stabilizing the system in the L_2-sense from a single boundary measurement only. All derived controllers are implemented and demonstrated in simulations.

09:20-09:40 — WedA04.2

Assignment of Invariant and Transmission Zeros in Linear Systems, pp. 116-120

Kucera, Vladimir — Czech Tech. Univ. in Prague

The paper generalizes the result of Rosenbrock on the assignment of invariant and transmission zeros from systems (A, B, C, 0) with equal number of inputs and outputs to general (A, B, C, D) quadruples. The generalization, while straightforward, improves the solvability conditions and leads to a new construction of C and D matrices having least number of rows.

09:40-10:00 — WedA04.3

Parameter Space Approach for Performance Mapping Using Lyapunov Stability, pp. 121-126

Pyta, Lorenz — RWTH Aachen Univ
Vosswinkel, Rick — Tech. Univ. Dresden
Schrödel, Frank — IAV GmbH
Bajcinca, Naim — Univ. of Kaiserslautern
Abel, Dirk — RWTH Aachen Univ

Calculating the complete controller parameter space, which guarantees specified closed loop performance requirements of a given linear system, is non-trivial. In this paper, a new approach to solve this problem is presented using Lyapunov stability formulations. This method has several advantages in comparison to the existing parameter space approach methods: Currently, the parameter space calculation methods are only applicable for a very restricted system class. They rely on frequency sweeping and the stabilizing parameter space may only be calculated through means of discretization. The proposed method avoids this while reducing the computational complexity and increasing the practicality of the method at the same time. An extensive analysis of the presented method is shown on a practical application example: the longitudinal vehicle guidance (ACC).

10:00-10:20 — WedA04.4

A Comparison of Two Methods for State Estimation: A Statistical Kalman Filter, and a Deterministic Interval-Based Approach, pp. 127-132

MESLEM, Nacim — INP Grenoble (GIPSA-Lab)
RAMDANI, Nacim — Univ. D'orléans

In an uncertain framework the performance of two methods of state estimation for discrete-time linear systems are compared on a pedagogical example. The first one is the well known Kalman filter, which is accurate when the measurement noises and the state disturbances are assumed Gaussian white noises and their statistical properties are available. The second one is a set-membership state estimator, which is also based on the prediction-correction principle. Based on the observability assumption of linear systems combined with interval analysis, both stages of this estimator are carried out in a guaranteed and efficient way. In this study, the performance of both state estimation algorithms are evaluated under two scenarios. In the first scenario, the state disturbances and measurement noise are considered Gaussian and in the second scenario these signals are considered unknown-but-bounded with known bounds.

10:20-10:40 — WedA04.5

On the Eigenvalue Placement by Static Output Feedback Via Quantifier Elimination, pp. 133-138

Röbenack, Klaus — TU Dresden
Vosswinkel, Rick — Tech. Univ. Dresden
Franke, Matthias — HTW Dresden

The static state feedback controller design, which achieves a desired behavior of the closed loop system, was solved in linear control theory decades ago. This is not true for static output feedback controller design, which is still an open problem. Here an approach is presented which handles the existence and design problem using quantifier elimination methods. Our approach allows the formal verification of arbitrary eigenvalue placement and enables the construction of controllers which lead to specified dynamic behavior. The design method is illustrated on examples known from literature.

10:40-11:00 — WedA04.6

Parameter Space Mapping of Eigenvalue Performance Specifications by Means of Real Root Classification, pp. 139-142

Bajcinca, Naim — Univ. of Kaiserslautern

This paper provides a method based on real root classification (RRC) for computation of parameter space regions for LTI systems, guaranteeing certain system performance specifications described by the eigenvalue location. To this end, parameter-dependent state-space system descriptions are considered and Lyapunov equation is utilized as the basic vehicle to derive the mapping conditions.

WedA05 — Meeting Room 4

Autonomous and Unmanned Systems 1 (Regular Session)

Chair: Fedele, Giuseppe — Univ. of Calabria
Co-Chair: Tamas, Levente — Tech. Univ. of Cluj-Napoca

09:00-09:20 — WedA05.1

Reactive Control Technology for 3D Navigation of Nonholonomic Robots in Tunnel-Like Environments Based on Limited Sensory Data, pp. 143-148

Matveev, Alexey S. — St.Petersburg Univ
Magerkin, Valentin — Saint Petersburg State Univ
Savkin, Andrey V. — Univ. of New South Wales

A constant-speed nonholonomic robot should pass through an unstructured and unknown 3D tunnel-like cave environment. The sensors provide information about the nearest point of tunnel's surface and the distance to the surface along any ray going from the robot at an upper-limited angle with respect to the direction toward the nearest point. A new navigation law is presented that solves the mission, respects a given safety margin to the surface, drives the robot to the pre-specified distance to it, and then maintains this distance. This law generates the control as a reflex-like reaction to the current observation. Mathematically rigorous justification of this law is provided; its applicability is confirmed by computer simulation tests.

09:20-09:40 — WedA05.2

Collaborative Visual Area Coverage by Aerial Agents under Positioning Uncertainty, pp. 149-154

Tzes, Mariliza — Univ. of Patras
Papatheodorou, Sotiris — New York Univ. Abu Dhabi
Tzes, Anthony — New York Univ. Abu Dhabi

In this article a control scheme for the coverage of a convex region by a team of Mobile Aerial Agents (MAAs) is presented. Each MAA is outfitted with a downwards facing camera, the sensed area of which is dependent on the MAA's altitude. Additionally, the MAAs' footprints are assumed to be known with a certain degree of uncertainty. In order to take into account the MAAs' positioning uncertainty as well as their varying sensed areas, an Additively Weighted Guaranteed Voronoi (AWGV) partitioning of the region is utilized. Based on this partitioning scheme, a gradient–based algorithm is derived in order to guarantee monotonic increase of an area coverage metric, while also constraining the MAAs' altitudes and it is extended to offer collision avoidance. The proposed scheme is evaluated through simulation studies.

09:40-10:00 WedA05.3

Relative Pose Estimation of Unmanned Aerial Systems, pp. 155-160

Tsoukalas, Athanasios New York Univ. Abu Dhabi
Tzes, Anthony New York Univ. Abu Dhabi
Khorrami, Farshad NYU Tandoon School of Engineering (Pol. Inst

The relative accurate pose estimation problem of collaborating Unmanned Aerial Systems (UASs) in GPS-denied environments is addressed in this article. The on-board system uses fiducial markers attached in the facets of a truncated rhombicuboctahedron placed on top of the UAS. A visual marker-tracking mechanism using a global shutter camera is used to estimate the relative pose between the UASs under the Line-of-Sight (LoS) constraint. The pose estimator operates in parallel with an Ultra-wideband (UWB) system that transmits extremely short RF-pulses, spreading the radio energy over a wide frequency band, and measures the relative distance using Time Of Arrival (TOA) measurements from a set of off-board anchors. Experimental studies show that the UWB-system can provide satisfactory measurements at large distances (2m to 50m) but the resolution is not sufficient for operating the UASs in very short relative distances (under 5m). Therefore, the visual system is used to improve the relative position measurements at short distances (0.2m to 5m) in addition to providing orientation measurements.

10:00-10:20 WedA05.4

Cooperative Object Transportation by Two Underwater Vehicle-Manipulator Systems, pp. 161-166

Cataldi, Elisabetta Univ. Di Cassino
Chiaverini, Stefano Univ. Di Cassino
Antonelli, Gianluca Univ. of Cassino and Southern Lazio

Intervention Autonomous Underwater Vehicle, also denoted as interaction control of Underwater Vehicle-Manipulator Systems, is a topic receiving increasing attention in the last years due to the need to decrease costs and improve safety of underwater operations. From the control perspective the problem at hand is challenging due to the hostile environmental conditions. Cooperative control of underwater vehicle-manipulator systems is addressed in this paper. An architecture is proposed which takes into account most of the underwater constraints, namely, uncertainty in the model knowledge, low sensors' bandwidth, position-only arm control, geometric-only object pose estimation. Numerical simulations provide promising results on its possible real application.

10:20-10:40 WedA05.5

Prescribed Interactions among Agents for Swarm Aggregation on a Circle, pp. 167-172

Fedele, Giuseppe Univ. of Calabria
D'Alfonso, Luigi Univ. Della Calabria

In this work a kinematic model for the evolution of a swarm of agents is proposed. The model benefits of an intuitive structure formed by three main terms, accounting for attraction to a common swarm target, for interactions among all the agents and for peculiar relationship among each agent and a subset of elements. The overall agents evolution is studied and analyzed showing that the swarm tends to a common goal while simultaneously ensuring a set of aggregation properties. Moreover it will be proved that the proposed kinematic model exhibits an equilibrium point on a circular shape. Numerical simulations and experimental tests using a swarm of real mobile robots have been also carried out.

10:40-11:00 WedA05.6

Augmented Reality for Digital Manufacturing, pp. 173-178

Blaga, Andreea Tech. Univ. of Cluj-Napoca
Tamas, Levente Tech. Univ. of Cluj-Napoca

The focus of this paper is on enhancing the possibilities of manufacturing operations by taking advantage of augmented reality (AR) technology and highlighting its benefits by implementing a product manufacturing case. The latter appearance of augmented headsets, such as the Microsoft HoloLens allows more opportunities for creating innovative solutions. After introducing concepts about smart manufacturing, improvements regarding human-robot collaboration in assembly tasks are presented. The developed scenario is based on the integration of AR, a cobot, see-through device, CAD and an algorithm for assembly visualization. This approach pledges a compelling interaction of the 3D real and virtual unit, so that the operator can work in a more natural and intuitive environment. This methodology has been implemented on a assembly case to investigate users' enhanced perception using the virtual world while cooperating with the robot.

WedA06 Meeting Room 5

Optimisation (Regular Session)

Chair: Rodrigues, Luis Concordia Univ
Co-Chair: Iacoviello, Daniela "Sapienza" Univ. of Rome

09:00-09:20 WedA06.1

An Optimal Displacement-Based Leader-Follower Formation Control for Multi-Agent Systems with Energy Consumption Constraints, pp. 179-184

Babazadeh, Reza Concordia Univ
Selmic, Rastko Concordia Univ

In this paper, we propose an optimal control method for a displacement-based leader-follower formation control of multi-agent systems with energy consumption constraints. We developed a model for electric energy consumption of an agent and then formulate the formation control problem for a set of multi-agents in optimal control context. The proposed method minimizes a weighted cost function that includes formation and energy consumption for a given mission. To solve the formulated problem, we use State-Dependent Riccati Equation (SDRE) method. We choose the weighting matrices of the cost function to be dependent on the energy level of the agents, thus allowing for autonomous adjustment of the agents' trajectories that preserve the integrity of the overall formation in spite of energy levels. Simulation results illustrate the effectiveness of the proposed method in both two- and three-dimensional spaces.

09:20-09:40 WedA06.2

Constrained Transient Optimization Using B-Splines Functions As Control Inputs, pp. 185-191

Orsini, Valentina Univ. Pol. Delle Marche
Jetto, L. Univ. Di Ancona
Romagnoli, Raffaele Univ. Pol. Delle Marche

The purpose of this paper is to propose a new method for the optimal output transition problem under saturation constraints on the control effort. The recently proposed preview based pseudo inversion approach is here adopted to determine a feedforward action optimizing the set-point following response of a given stable closed-loop system $Sigma_{f,c}$. The optimal external input reference $r(t)$ forcing $Sigma_{f,c}$ is assumed to be given by a B-spline function, a second B-spline $hat u(t)$ is used to optimally approximate the actual control effort $u(t)$ produced by $r(t)$. The control points which define the convex

hull containing $hat u(t)$ are chosen in such a way to respect the saturation constraints on $u(t)$. In the first part of the transient interval the actual control input $u(t)$ is replaced by $hat u(t)$, after this initial period has elapsed the control law is definitely switched to $u(t)$. Application to a benchmark problem shows the effectiveness of the method.

09:40-10:00 WedA06.3

An Output Feedback Control with State Estimation for the Containment of the HIV/AIDS Diffusion, pp. 192-197

Di Giamberardino, Paolo	Sapienza, Univ. of Rome
Iacoviello, Daniela	"Sapienza" Univ. of Rome

An optimal control problem formulated to reduce the infection diffusion of an epidemic disease is solved in a locally linearised context. The approach has been driven by the necessity of using a state observer, since the state variable to be controlled is not directly measurable. The solution is computed making reference to a recently introduced model for HIV/AIDS diffusion and control, in which five classes of individuals are considered: two classes of susceptible subjects, the wise and the incautious individuals, and three classes of infectious subjects, the ones not aware of their condition and the subjects in the pre-aids or in the aids status. The control inputs are represented by information campaigns and medication actions. The initial formulation as an optimal control problem, aiming also at minimising the non measurable number of infected subjects, is enriched with an asymptotic state observer for which a local linear approximation has been chosen for simplicity purpose. The structure of the cost index for the reformulated control problem after the observer introduction, suggests to compute the solution in an approximated way referring to a classical LQR control design. The effectiveness of the control, as well as the effects of the linear approximations, are evidenced by some numerical simulation results.

10:00-10:20 WedA06.4

Model Predictive Control for Aerial Collision Avoidance in Dynamic Environments, pp. 198-203

Castillo-Lopez, Manuel	Univ. of Luxembourg
Sajadi-Alamdari, Seyed Amin	Univ. of Luxembourg
Sanchez-Lopez, Jose Luis	SnT, Univ. of Luxembourg
Olivares-Mendez, Miguel A.	SnT - Univ. of Luxembourg
Voos, Holger	Univ. of Luxembourg

Autonomous navigation in unknown environments populated by humans and other robots is one of the main challenges when working with mobile robots. In this paper, we present a new approach to dynamic collision avoidance for multi-rotor unmanned aerial vehicles (UAVs). A new nonlinear model predictive control (NMPC) approach is proposed to safely navigate in a workspace populated by static and/or moving obstacles. The uniqueness of our approach lies in its ability to anticipate the dynamics of multiple obstacles, avoiding them in real-time. Exploiting active set algorithms, only the obstacles that affect to the UAV during the prediction horizon are considered at each sample time. We also improve the fluency of avoidance maneuvers by reformulating the obstacles as orientable ellipsoids, being less prone to local minima and allowing the definition of a preferred avoidance direction. Finally, we present two real-time implementations based on simulation. The former demonstrates that our approach outperforms its analog static formulation in terms of safety and efficiency. The latter shows its capability to avoid multiple dynamic obstacles.

10:20-10:40 WedA06.5

A Toolbox for Optimal Control Based on Symmetry Analysis with Applications to Aircraft Maximum Endurance and Maximum Range, pp. 204-209

Botros, Alexander	Univ. of Waterloo
Walker, Kevin	Maplesoft
Rodrigues, Luis	Concordia Univ

Solutions of optimal control problems are the solutions of the Hamilton-Jacobi-Bellman equation. The main contribution of this paper is to propose a symmetry analysis approach to find solutions of the Hamilton-Jacobi-Bellman equation and to introduce a Toolbox to automate the procedure. Several examples will be presented illustrating the effectiveness of the procedure including the maximum endurance and maximum range of an aircraft.

10:40-11:00 WedA06.6

Risk Adverse Virtual Power Plant Control in Unsecure Power Systems, pp. 210-216

Giuseppi, Alessandro	La Sapienza
Germanà, Roberto	Univ. of Rome "La Sapienza"
Di Giorgio, Alessandro	Univ. of Rome "La Sapienza"

This paper presents a control strategy for enabling a large scale Virtual Power Plant (VPP) constituted by a traditional power plant, distributed Energy Storage Systems (ESSs) and wind turbine driven Doubly Fed Induction Generators (DFIGs) to virtual slack bus functions in electricty transmission networks. The VPP in question is in charge of covering the network losses and a portion of the day ahead generation schedule of unsecure power plants, in presence of short term notifications about possible malicious/natural adverse events affecting them. The objective is pursued by integrating a dynamic optimal power flow problem in a real time Model Predictive Control framework, and applying a second level of control aimed at keeping the dynamics of the real nonlinear plant subject to wind turbulence in line with the dynamics of the MPC model. Simulation results provide a proof of the proposed concept, showing as the joint coordination of storage devices and wind turbines can be part of the task of providing support actions to the network traditionally delivered by expensive and pollutant legacy power plants.

WedB01 Kolovare

Aerospace Control 1 (Regular Session)

Chair: Lesic, Vinko	Univ. of Zagreb
Co-Chair: Petric, Frano	Univ. of Zagreb

14:00-14:20 WedB01.1

Constrained Control of UAVs in Geofencing Applications, pp. 217-222

Hermand, Elie	Univ. Libre De Bruxelles (ULB)
Nguyen, Tam Willy	Univ. Libre De Bruxelles
Hosseinzadeh, Mehdi	Free Univ. of Brussels
Garone, Emanuele	Univ. Libre De Bruxelles

This paper focuses on the constrained control of UAVs in geofencing applications. Although geofence systems are becoming more attractive as a research topic, most recent works are focusing on defining the boundaries of the admissible geographical region without addressing the control issues and boundary-handling problems. In this paper, we propose a constrained control scheme to steer an UAV to the desired position while ensuring constraints satisfaction at all times. To do so, we make use of the so-called Explicit Reference Governor framework. Finally, the proposed scheme is validated through extensive experimental studies carried out in a laboratory environment.

14:20-14:40 WedB01.2

Vector Field Based Guidance Law for Intercepting Maneuvering Target, pp. 223-228

Lee, Suwon	Seoul National Univ
Lee, Seokwon	Seoul National Univ
Ann, Sungjun	Seoul National Univ
Lee, Jaeho	Seoul National Univ
Kim, Youdan	Seoul National Univ

A vector field based guidance law for intercepting maneuvering target is proposed. The vector field based guidance laws are easy to implement and show high accuracy in path following problems. To adopt the vector field based guidance law for missile system, target interception problem is considered as

path following problems. After modeling the predicted target trajectory as an implicit function, a vector field is calculated to make missile converge to the predicted target trajectory. The performance of the proposed guidance law is demonstrated by numerical simulations comparing the interception performance with that of proportional navigation guidance laws. The vector field based guidance law shows high interception accuracy (small miss distance) and accomplishes ideal head-on interception.

14:40-15:00 WedB01.3

Missile Guidance Based on Tracking of Predicted Target Trajectory, pp. 229-234

Lee, Seokwon	Seoul National Univ
Cho, Namhoon	Seoul National Univ
Kim, Youdan	Seoul National Univ

This study presents missile guidance methods based on path-following approach for the interception of a high-speed maneuvering target. In the problem of high-speed incoming target interception, it is usually preferred to form a stable head-on engagement geometry a few seconds before the end of engagement to allow enough time for improved hit-to-kill performance. One plausible approach in this regard is to let the missile first track the predicted target trajectory and then encounter the target while moving along the predicted path. To this end, two approaches based on path-following guidance are proposed; one is to modify the parameters of guidance law, and the other is to design the path to be followed by the missile. The effectiveness of the proposed methods is verified by comparing their performances with pure proportional navigation guidance.

15:00-15:20 WedB01.4

Intercept Point Prediction for Midcourse Guidance of Anti-Ballistic Missile, pp. 235-240

Ann, Sungjun	Seoul National Univ
Lee, Seokwon	Seoul National Univ
Kim, Youdan	Seoul National Univ

Interception of the ballistic missile is one of the most challenging issue in the missile defense system. Except the powered phase intercept, the speed of the ballistic missile is usually much faster than that of the intercept missile. Therefore, hit-to-kill and head-on interception is necessary to increase kill probability. These conditions require a precise guidance scheme. This study focuses on the exo-atmospheric midcourse guidance for the solid propellant missile against the ballistic target in the free flight phase. Due to the characteristics of the solid propellant, the acheivable intercept area is limited, and the performance of the guidance is highly affected by the predicted intercept point(PIP). In this study, the range of the achievable PIP is obtained by the trajectory optimization technique, and the proper PIP selection scheme is proposed to intercept the target. Numerical simulations are conducted to demonstrate the pereformance of the PIP selection for the midcourse guidance.

15:20-15:40 WedB01.5

Robust Attitude Stabilization of a Quadrotor by Using LFT Linear-Parameter-Varying H∞, pp. 241-246

Hasseni, Seif-El-Islam	Univ. De Biskra
Abdou, Latifa	Mohamed Khider Univ. of Biskra

In this paper, robust stabilization of a quadrotor aircraft attitude is investigated. The exact nonlinear attitude of a quadrotor model is presented by Linear-Parameter-Varying system with Linear-Fractional-Transformation represenation (LFT-based LPV), when we took the nonlinearities as a varying parameters. The closed loop interconnection is established by taking into account the external disturbances, measurement noises and actuator dynamics. The synthesis of H∞ gain-scheduling controller is achieved by scaling small gain theorem when the controller is an LFT-based LPV too. The simulations show the efficiency and the robustness of the proposed controller against the disturbances, noises and parametric uncertainties.

WedB02 Meeting Room 1

Intelligent Transportation Systems (Regular Session)

Chair: Nemeth, Balazs	Hungarian Acad. of Sciences
Co-Chair: Framing, Christian-Eike	RWTH Aachen Univ

14:00-14:20 WedB02.1

MPC-Based Coordinated Control Design for Look-Ahead Vehicles and Traffic Flow, pp. 247-252

Nemeth, Balazs	Hungarian Acad. of Sciences
Bede, Zsuzsanna	Budapest Univ. of Tech. and Ec
Gaspar, Peter	Mta Sztaki

The paper proposes a control design method for the coordination of a macroscopic traffic system and individual vehicles. Some of the vehicles are equipped with a look- ahead control system, with which energy-efficient traveling can be achieved. In a mixed traffic system vehicles equipped with look-ahead control and conventional uncontrolled vehicles are traveling together. The traffic system is assumed to have ramp metering control, which has a significant effect on the inflow on the highway. The purposes of the coordinated control are to improve the energy efficiency of the entire traffic flow and simultaneously stabilize the controlled highway, reduce the queue length at the controlled gates and avoid congestion. The design is based on the MPC method, with which the prediction of the traffic flow is also taken into consideration. The efficiency of the method is illustrated through VISSIM simulation examples.

14:20-14:40 WedB02.2

Infrastructure-Based Vehicle Maneuver Estimation with Intersection-Specific Models, pp. 253-258

Framing, Christian-Eike	RWTH Aachen Univ
Hesseler, Frank-Joseph	Inst. of Automatic Control, RWTH Aachen Univ
Abel, Dirk	RWTH Aachen Univ

Advanced Driver Assistance Systems have the potential of making traffic safer, more efficient and convenient. At urban intersections the conflicting intentions of different traffic participants frequently lead to accidents. In order to avoid dangerous situations in such a scenario an ADAS requires an accurate estimation of future driving maneuvers executed by other vehicles. In this work we present a framework that estimates the driving maneuver of vehicles approaching at intersections where the vehicle state can only be observed externally. The high variance in driver behavior that arises from different intersection layouts is met with intersection-specific models that are computed locally. The performance of the estimator and the potential of intersection-specific models are validated with data recorded from real intersections.

14:40-15:00 WedB02.3

Infrastructure-Based Tracking of Road Users in Urban Intersections for Partially Available, Variable-Delay Sensor Data, pp. 259-265

Quack, Tobias Michael	RWTH Aachen Univ
Hesseler, Frank-Joseph	Inst. of Automatic Control, RWTH Aachen Univ
Abel, Dirk	RWTH Aachen Univ

Reliable and accurate tracking of road users is crucial for many applications in intelligent transport systems. Especially in urban intersections, where traffic safety, optimal traffic efficiency and the operation of autonomous vehicles are still technically challenging, the requirements on environment perception systems are very high. In this paper we address the problem of an infrastructure-based multiple object tracking system which makes use of the sensor information provided by a combination of both infrastructure and mobile sensors. Due to the characteristics of wireless V2X communication used to transfer the sensor data, the signals are unsynchronized, have variable delay times and are only partially available. Our sensor fusion approach, which is specifically designed to handle these

characteristics, is validated using simulated sensor data and experimentally tested in an urban test environment.

15:00-15:20 WedB02.4

A Comparison of Different State Representations for Reinforcement Learning Based Variable Speed Limit Control, pp. 266-271

Kušić, Krešimir	Faculty of Transport and Traffic Science, Univ. of Zagreb
Ivanjko, Edouard	Univ. of Zagreb, Faculty of Transport and Traffic Sciences
Gregurić, Martin	Univ. of Zagreb, Faculty of Transport and Traffic Sciences

Variable Speed Limit Control (VSLC) is one control method for alleviating congestions on urban motorways. Machine learning techniques, like Reinforcement Learning (RL), are a promising alternative for setting up VSLC because an optimal control policy can be achieved with a smaller computational burden in comparison with optimal control approaches. A drawback is a large number of learning iterations and the problem of the exponential expansion of the state space dimension. This can be solved with function approximation techniques. Three different approaches for feature-based state representation in RL based VSLC are compared in this paper regarding the convergence of Total Time Spent. The microscopic traffic simulator VISSIM with a representative traffic model is used to evaluate the compared approaches. Results show that function approximation methods outperform RL based VSLC formulated with a lookup table by an average improvement of 10 %, where feature extraction methods (Coarse and Tile) coding showed slightly faster learning rate.

15:20-15:40 WedB02.5

Distributed Leader-Tracking for Autonomous Connected Vehicles in Presence of Input Time-Varying Delay, pp. 272-277

Fiengo, Giovanni	Univ. Del Sannio
Lui, Dario Giuseppe	Univ. Del Sannio
Petrillo, Alberto	Univ. of Naples Federico II
Santini, Stefania	Univ. Di Napoli Federico II
Tufo, Manuela	Univ. Del Sannio

In this paper, the leader tracking problem for a platoon of connected vehicles in presence of homogeneous time-varying Vehicle-to-Vehicle communication delays is addressed. To this aim, the platoon is recast as a network of multiagent systems and consensus is achieved by leveraging a delayed distributed strategy that complements the standard linear diffusive control protocol with additional distributed integral and derivative actions. The asymptotic stability of the closed-loop delayed system is hence analytically proven by exploiting the Lyapunov-Krasovskii theory. Stability conditions are expressed as a set of Linear Matrix Inequalities, whose solution allows the proper tuning of proportional, derivative and integral gains such as to counteract the presence of the time-varying input delay. An exemplar tracking maneuver is considered for evaluating the performance of a connected vehicles fleet and the numerical results confirm the effectiveness of the theoretical derivation.

WedB03 Meeting Room 2

Real-Time Control (Regular Session)

Chair: Hammer, Hugo Lewi	Oslo and Akershus Univ. Coll. of Applied Sciences
Co-Chair: SALAMCI, Metin U.	Gazi Univ

14:00-14:20 WedB03.1

MRAC of a 3-DoF Helicopter with Nonlinear Reference Model, pp. 278-283

Kocagil, Bedrettin Mahmut	Gazi Univ
Ozcan, Sinan	Turkish Aerospace Industries
Arican, Ahmet Cagri	Gazi Univ
Guzey, Umit Mufit	ASELSAN
Copur, Engin Hasan	Necmettin Erbakan Univ
SALAMCI, Metin U.	Gazi Univ

Model Reference Adaptive Control (MRAC) technique, which is considered to be an effective tool for the control of unknown dynamical systems behavior, is widely used in practical applications. In principal, a known stable linear model dynamics is taken as a reference model such that its response is tracked by the unknown dynamical system by means of an adaptive control scheme. In this paper, rather than using a linear reference model, we propose a nonlinear reference model to be used in the MRAC of nonlinear plant dynamics. First, a stable nonlinear reference model is formed by using State Dependent Riccati Equation (SDRE) approach. Then an adaptation rule is derived to ensure the convergence of the response of nonlinear plant dynamics to that of the nonlinear reference model. The proposed method is tested experimentally using a 3-DoF helicopter test bed with different parameters and working conditions.

14:20-14:40 WedB03.2

Efficient Tracking of Statistical Properties of Data Streams with Rapid Changes, pp. 284-289

Hammer, Hugo Lewi	Oslo and Akershus Univ. Coll. of Applied Sciences
Yazidi, Anis	Oslo and Akershus Univ. Coll. of Applied Sc

Many real-life dynamical systems change rapidly followed by almost stationary periods. In this paper, we consider streams of data with such rapidly changing behavior and investigate the problem of tracking their statistical properties in an online manner.

The streaming estimator is accompanied with a second estimator, suitable to adjust to rapid changes in the data stream. When a statistically significant difference is observed between the two estimators, the current estimate jumps to a more suitable value. Such a tracking procedure have previously been suggested in the literature. However, our contribution lies in building the estimation procedure based on the difference between the stationary estimator and a Stochastic Learning Weak Estimator (SLWE). The SLWE estimator is known to be the state-of-the art approach to tracking properties of non-stationary environments and thus should be a better choice to detect changes in rapidly changing environments than the far more common sliding window based approaches.

Extensive simulation results demonstrate that our estimation procedure is easy to tune and performs very well. Further, the suggested estimator outperforms the popular and state-of-the-art estimator ADWIM2 with a clear margin.

14:40-15:00 WedB03.3

A Novel Incremental Quantile Estimator Using the Magnitude of the Observations, pp. 290-295

Hammer, Hugo Lewi	Oslo and Akershus Univ. Coll. of Applied Sciences
Yazidi, Anis	Oslo and Akershus Univ. Coll. of Applied Sc

Incremental quantile estimators like the the deterministic multiplicative incremental quantile estimator by Yazidi and Hammer (2017) are simple and efficient algorithms to estimate and track quantiles when data are received sequentially. The estimators merely relying on the sign of the difference between the quantile estimate and the current observation which seems like a waste of information from the data stream. In this paper we suggest a novel incremental estimator that rather use the magnitude og the observations. The intuition behind our approach is that the magnitude is more informative than the sign of the difference. Extensive experiments show that our estimators clearly outperform legacy state-of-the-art quantile estimators.

15:00-15:20 WedB03.4

Time-Varying Fault Tolerant Control of Nonlinear MIMO Systems, pp. 296-301

Cetin, Meric	Pamukkale Univ
Beyhan, Selami	Pamukkale Univ
iplikci, serdar	Pamukkale Univ

In this study, a recently proposed discretization based observer is designed for the estimation of unknown time-varying fault variable. Using the estimated fault, a model predictive control based fault tolerant controller is proposed and applied for the real-time control of nonlinear multi-input multi-output (MIMO) systems. The main contributions are given as follows. i) An unknown parameter of the nonlinear grey model is estimated to compensate the uncertainty of the nonlinear system. ii) Second, an unknown process fault function of the nonlinear system is estimated and then the model inaccuracy is compensated using the estimated fault function. Fault and unknown parameter estimations are used to improve control performance of model predictive fault tolerant controller. In experiments, time-varying parameter and fault variables are accurately estimated and hence precise tracking performances are provided in real-time.

15:20-15:40 WedB03.5

Single Phase Active Rectifier with Low Harmonic Content in Input Current, pp. 302-307

Sušin, Denis	Univ. of Ljubljana, Faculty of Electrical Engineering
Nemec, Mitja	Univ. of Ljubljana, Faculty of Electrical Engineering
Ambrožič, Vanja	Univ. of Ljubljana, Faculty of Electrical Engineering
Nedeljkovic, David	Univ. of Ljubljana, Faculty of Electrical Engineering

In this paper, an advanced control algorithm in single-phase active rectifier for reduction of grid current harmonics is presented. In addition to PI current controller, three advanced types of controllers are investigated: resonant, discrete cosine transforms (DCT) and repetitive controller. These controllers are able to effectively reduce harmonics, caused by periodic disturbances. A simulation model has been built to test the proposed algorithms. Simulation results confirm significant improvement in grid current harmonic content, achieved by these advanced current controllers. Analysis of memory usage and computing power requirements is also provided.

WedB04 Meeting Room 3

Intelligent Control Systems (Regular Session)

Chair: Boutalis, Yiannis	Democritus Univ. of Thrace
Co-Chair: Radac, Mircea-Bogdan	Pol. Univ. of Timisoara

14:00-14:20 WedB04.1

A New Approach of Neurofuzzy-Based Control Design and Analysis Applied on an EV Electromechanical System, pp. 308-313

Makrygiorgou, Jemma	Univ. of Patras
Alexandridis, Antonios	Univ. of Patras

Electric vehicles (EVs) constitute an attractive solution for transportation caused by both environmental and economic reasons. In view of their complexity as electromechanical structures, EVs are multi-input nonlinear systems which cannot be easily controlled and analysed. Hence, in order to operate an EV in a reliable and desired manner, neurofuzzy controllers (NFCs) are proposed, implemented and examined. The latter can deal with uncertain environments, due to their capabilities in learning, adaptation and fault tolerance by incorporating a properly adapted expert knowledge. However, in the paper, the cumbersome task of proving stability of the NFC driven electromechanical system is provided by slightly modifying the adaptation dynamics needed for the learning procedure. This is the main theoretical contribution presented by this work, since it makes possible to ensure input-to-state stability for the entire system and convergence of the system states to the desired equilibrium. The conducted simulations verify the satisfactory system performance and confirm the attained theoretical results.

14:20-14:40 WedB04.2

Robust Observer–based Control for TS Fuzzy Models Application to Vehicle Lateral Dynamics, pp. 314-319

BUI TUAN, Viet Long	Univ. Picardie Jules Verne
El Hajjaji, Ahmed	Univ. De Picardie-Jules Verne

This paper deals with the observer based robust control design problem for TS fuzzy systems with time-varying uncertain parameters. Sufficient design conditions of the fuzzy observer and the fuzzy controller are first proposed. Due to the use of Young relation, and the cone-complementary, the non-convex and Bilinear problems are then converted into convex optimization one with LMI constraints. Control and observer gains are obtained under $\mathcal{L}2$-bounded disturbance and $\mathcal{L}2$-norm input constraint by set feasible solutions of LMI conditions. The effectiveness of the proposed fuzzy controller and fuzzy observer design methodology is finally demonstrated through numerical simulations on vehicle lateral dynamic model.

14:40-15:00 WedB04.3

Using Particle Swarm Optimization for Fuzzy Antecedent Parameter Identification in Active Suspension Control, pp. 320-325

Herrera, Isabel Elena	Univ. De Málaga
Mandow, Anthony	Univ. De Málaga
Garcia-Cerezo, A.	Univ. De Malaga

This paper addresses fuzzy parameter identification by using Particle Swarm Optimization (PSO) techniques with an application to active suspension control. In particular, the target fuzzy controller is a zero-order Takagi-Sugeno system with a standard fuzzy partition of its antecedent variables. The major contribution of this paper with respect to previous works is that learning of the fuzzy suspension control is not limited to the scale factors of the input-output variables. Thus, the proposed method allows optimization of triangular membership functions for the antecedents. This method has been successfully applied to control a quarter-car test rig.

15:00-15:20 WedB04.4

Adaptive One-Step Model Predictive Control Using Lyapunov Theory-Based Deep Neural Networks, pp. 326-331

Plakias, Spyridon	Democritus Univ. of Thrace
Boutalis, Yiannis	Democritus Univ. of Thrace

Neural network model predictive control has been widely used in the field of automatic control. However, the off-line training of the neural predictor and the appearance of disturbances and parameter variations, during the control phase, affect the system output by inducing steady state error. This paper tries to overcome this problem by proposing an adaptive deep neural network model predictive controller. To ensure the convergence of the adaptive process, we use Lyapunov stability theory, which guides the updating of the weights of the deep neural network. Likewise, a Lyapunov based algorithm guides the updating of the control signal of the one-step model predictive controller. Simulation results for two cases demonstrate the effectiveness of the proposed control scheme.

15:20-15:40 WedB04.5

Data-Driven Model-Free Model-Reference Nonlinear Virtual State-Feedback Control from Input-Output Data, pp. 332-338

Radac, Mircea-Bogdan	Pol. Univ. of Timisoara
Precup, Radu-Emil	Pol. Univ. of Timisoara
Hedrea, Elena-Lorena	Pol. Univ. of Timisoara
Mituletu, Ion-Cornel	Pol. Univ. of Timisoara

In this paper we show that it is possible to learn high performance model reference controllers using a model-free

Q-learning approach, based on input-output (IO) samples collected from the controlled process. Under observability assumptions for the process, virtual extended state-space process models of different orders are built from the IO collected samples. We prove that state-space control of these virtual processes is equivalent to IO control of the initial process. For the virtual state-space process, high performance nonlinear Neural Network (NN) state-feedback controllers are learned based on the IO data collected from the initial process, to achieve output model-reference tracking control. Control learning is a two-step model-free process: an IO model-free controller first drives the process exploration of a wide operating range for IO samples collection that are then used to model-free learn the NN controllers. The approach is successfully validated on a highly nonlinear coupled aerodynamic system.

WedB05 Meeting Room 4

Autonomous and Unmanned Systems 2 (Regular Session)

Chair: Orsag, Matko	Univ. of Zagreb
Co-Chair: Bogdan, Stjepan	Univ. of Zagreb

14:00-14:20 WedB05.1

Mid-Ranging Control Concept for a Multirotor UAV with Moving Masses, pp. 339-344

Haus, Tomislav	Univ. of Zagreb
Ivanovic, Antun	Univ. of Zagreb
Car, Marko	Univ. of Zagreb
Orsag, Matko	Univ. of Zagreb
Bogdan, Stjepan	Univ. of Zagreb

This paper addresses the problem of actuators saturation that occur when one applies a moving mass concept to control the attitude of a multirotor UAV. In particular, we propose to combine the moving mass control (MMC) with rotors' variations in a paradigm known as a mid-ranging control. We show that this control structure ensures reference tracking and disturbance rejection with the moving masses operating in the middle of their range, which eventually reduces the possibility to violate their saturation limits. We also address the stability and design of the proposed controller by employing Routh-Hourwitz criterion and root-locus analysis. The controller is verified within a simulation environment, where we test its performance and compare it with a basic MMC concept under various disturbances. Finally, we present experimental results that we obtained with a modified ArduCopter vehicle, which serves as an experimental platform for the MMC verification.

14:20-14:40 WedB05.2

Design of a Weighted Multi-Controller for Lateral Guidance of Autonomous Vehicles Using Steering Control, pp. 345-351

Monot, Nolwenn	Univ. of Bordeaux / Groupe PSA
MOREAU, Xavier	Univ. Bordeaux 1
Benine-Neto, André	Univ. Bordeaux 1 - Lab. De L'intégration Du Matériau
Rizzo, Audrey	DRIA PSA Peugeot Citroën
Aioun, François	PSA Peugeot Citroën

This study proposes a new approach to control the vehicle lateral position at all speeds. The influence of the longitudinal speed on the vehicle lateral dynamics is taken into account to the design of the controller. The strategy developed uses several PID, weighted in function of the longitudinal speed enabling the vehicle to drive either at high or low speed. A methodology based on stability margin is proposed in order to design the intervals of longitudinal speed used for the multi-controller. The multi-controller is compared to a single PID and a simulation shows that for an overtaking with speed variation, when the weighted multi-controller manage to track the desired trajectory, the PID alone cannot follow it.

14:40-15:00 WedB05.3

CrazyS: A Software-In-The-Loop Platform for the Crazyflie 2.0 Nano-Quadcopter, pp. 352-357

Silano, Giuseppe	Univ. of Sannio in Benevento
Aucone, Emanuele	Univ. Di Pisa
Iannelli, Luigi	Univ. of Sannio in Benevento

In this paper we propose CrazyS, an extension of the ROS (Robot Operating System) package RotorS, aimed to modeling, developing and integrating the Crazyflie 2.0 nano-quadcopter in the physics based simulation environment Gazebo.

Such simulation platform allows to understand quickly the behavior of the flight control system by comparing and evaluating different indoor and outdoor scenarios, with a details level quite close to reality. The proposed extension expands RotorS capabilities by considering the Crazyflie 2.0 physical model and its flight control system, as well.

A simple case study has been considered in order to show how the package works. The use of open-source software makes the platform available for scientific and educational activities.

15:00-15:20 WedB05.4

Consensus Protocol for Underwater Multi-Robot System Using Two Communication Channels, pp. 358-363

Arbanas, Barbara	Univ. of Zagreb, Faculty of Electrical Engineering and Comp
Petrovic, Tamara	FER
Bogdan, Stjepan	Univ. of Zagreb

In this paper, we apply a simple consensus protocol to a simulated underwater multi-robot system using two communication channels. The approach is motivated by a system in which robots, called aMussels, are dispersed in the environment and measure its properties over longer periods of time. Each unit is equipped with two underwater communication devices: green light, short-range communication device based on modulated light, and nanomodem, long-range acoustic communication device. Except for range, the two communication channels differ in the transmission speed. Both are combined in order to attain fast and accurate average consensus. We bring the results of the protocol applied to the simulated system and analyze its convergence.

15:20-15:40 WedB05.5

Assistive Control Framework for Remotely Operated Vehicles, pp. 364-369

Di Vito, Daniele	Univ. of Cassino and Southern Lazio
Di Lillo, Paolo	Univ. of Cassino and Southern Lazio
Arrichiello, Filippo	Univ. Di Cassino E Del Lazio Meridionale
Antonelli, Gianluca	Univ. of Cassino and Southern Lazio

The paper presents a control framework aimed at supporting a human operator in the guidance and in the coor- dination of an underwater Remotely Operated Vehicle (ROV). Due to environmental conditions and operational scenarios, underwater tele-operations can be very demanding. Thus, a very high experience can be required to the operator that, by providing commands to each actuator, has to successfully perform the assigned task without damaging the vehicle. In this sense, a control algorithm that can help the operator in performing the assigned task may represent a system support element able to ensure the vehicle safety. Based on a survey realized with professional ROV pilots, in this paper we propose a framework that allows the human operator to send position commands to the ROV by a joystick and to set different tasks through a dedicated user-friendly interface. The tasks are managed via a control algorithm represented by a closed loop inverse kinematic algorithm able to manage multiple both equality-based and set-based tasks. The overall framework has been developed in the Robot Operating System (ROS) environment and numerically tested using Gazebo environment.

Technical Program for Thursday June 21, 2018

ThuA01	Kolovare
Robotics 2 (Regular Session)	
Chair: Tzes, Anthony	New York Univ. Abu Dhabi
Co-Chair: Orsag, Matko	Univ. of Zagreb

09:00-09:20 ThuA01.1

Constrained Optimal End-Effector Positioning Using Pseudo-Inversion and B-Splines, pp. 370-376

Orsini, Valentina — Univ. Pol. Delle Marche
Jetto, L. — Univ. Di Ancona
Romagnoli, Raffaele — Univ. Pol. Delle Marche

This paper investigates the potential possibility offered by the recently proposed pseudo inversion approach as a novel solution to the optimal output transition problem in the end-effector positioning task under saturation constraints on the control effort. Exact positioning and high precision tracking of the end-effector along a given path are key requirements. Due to flexibility and non minimum phase nature of the system, achieving high level performances is a challenging problem. To this purpose a two degrees of freedom control scheme is proposed: a feedforward action, denoted by $r(t)$, is applied to the stable closed loop system $Sigma_{f,c}$, given by the feedback connection of the flexible arm with a stabilizing controller. The recently proposed pseudo inversion approach is adopted to compute $r(t)$ yielding an actual end-effector transient trajectory which is the best approximation of the desired transient one. The optimal $r(t)$ is assumed to be given by a B-spline function, and, to take into account saturating actuators, the actual control input $u(t)$ forcing the flexible arm is optimally approximated by a B-spline $hat u(t)$, whose control points $hat u(t)$ are chosen in such a way to satisfy the saturation constraints on $u(t)$. If $hat u(t)$ is a sufficiently accurate approximation of $u(t)$, the exact fulfillment of saturation constraints by $hat u(t)$ are transferred to $u(t)$. The main advantage of the approach is its generality: the method can be directly applied to the linear dynamic model of any multilink flexible arm.

09:20-09:40 ThuA01.2

Distributed Kinematic Control and Trajectory Scaling for Multi-Manipulator Systems in Presence of Human Operators, pp. 377-382

Lippi, Martina — Univ. of Salerno
Marino, Alessandro — Univ. Degli Studi Di Salerno

The objective of the paper is to devise a general framework for handling the human safety in a multi-robot work-cell controlled within a decentralized framework. The paper is motivated by the increasing demand coming from new production paradigms for strict cooperation between humans and robots and for flexibility and robusteness provided by decentralized control frameworks. The cell foresees several robots with different assigned roles. In particular, it is supposed that there are worker agents, that are in charge of performing the cooperative manipulation task, and watcher robots, that are in charge of supervising the cell with particular attention to the human safety. The latter is guaranteed by properly modifying the workers' task trajectory according to a state transition strategy that tries to preserve the task path as much as possible. The overall solution is tested via simulations in order to show the effectiveness of results.

09:40-10:00 ThuA01.3

Development of a Tendon-Driven Robotic Tool Targeting Visual-Servoing Minimally-Invasive Surgical Operations, pp. 383-387

Evangeliou, Nikolaos — New York Univ. Abu Dhabi
Tsampiras, Petros — Univ. of Patras
Tzes, Anthony — New York Univ. Abu Dhabi

The development and experimental evaluation of a prototype laparoscopic robotic surgical tool is presented in this article. Servo motors are used as actuators in a tendon-driven actuation mechanism. The two Degree-of-Freedom (DoF) manipulator is a cascade configuration of two rotational joint modules. Each DoF is actuated independently by the corresponding tendon pair in a pulley-driven configuration. The design, fabrication and kinematics of the tool are analyzed. Moreover, the efficiency of the overall system is investigated in experimental studies, utilizing two performance evaluation methods. The first is an IMU-based, whilst the second utilizes a monocular visual servoing setup.

10:00-10:20 ThuA01.4

Mobile Robot Trajectory Generation from Ordered Point-Set Using Time-Optimal Bezier Segments, pp. 388-393

Giannousakis, Konstantinos — Univ. of Patras
Tzes, Anthony — New York Univ. Abu Dhabi

This paper addresses the problem of constructing a trajectory from a given set of points, considering a mobile robot. Following the initial pose of the robot, the points are connected in sequence by cubic Bezier segments. After selecting the tangential velocity at the connection points, these segments are time-optimized under the velocity and acceleration constraints of the robot, both tangential and angular, using non-linear constrained optimization. The optimization problem is simplified by exploitation of polynomials. Experimental studies demonstrate the effectiveness of the algorithm.

10:20-10:40 ThuA01.5

On-Line Estimation of F/T Sensor Offset for Arbitrary Orientation of Robot Tool by Evaluating Two Machine Learning Algorithms, pp. 394-399

Kulas, Matko — Faculty of Electrical Engineering and Computing
Kovacic, Zdenko — Univ. of Zagreb
Orsag, Matko — Univ. of Zagreb

The offset in the output of a force/torque (F/T) sensor embedded in the robot's wrist is usually handled by deducting the measured force value when the robot tool encounters the surface and achieves the desired orientation. The problem becomes more complicated when the tool's orientation changes continuously or the tool is changed during the robot's work. This paper explored the possibility of using two well-affirmed machine learning algorithms (k-nearest neighbors and polynomial regression) for on-line estimation of F/T sensor offset. Both machine learning algorithms were implemented and evaluated on the state-of-the-art 6-DOF robot arm Schunk LWA4P equipped with the OptoForce HEX-70-CE-2000N F/T sensor. Evaluation of the two on-line offset estimation methods was made during a force-controlled writing on the office board with different robot tool orientations. It was found that the frequency of generating the offset estimate is much higher with the polynomial regression algorithm.

10:40-11:00 ThuA01.6

Ground Extraction from 3D Lidar Point Clouds with the Classification Learner App, pp. 400-405

Pomares, Antonio — Univ. De Málaga
Martinez, Jorge L. — Univ. of Malaga
Mandow, Anthony — Univ. De Málaga
Martínez, María A. — Univ. De Málaga
Morán, Mariano — Univ. De Málaga
Morales, Jesús — Univ. De Málaga

Ground extraction from three-dimensional (3D) range data is a relevant problem for outdoor navigation of unmanned ground vehicles. Even if this problem has received attention with specific heuristics and segmentation approaches, identification of ground and non-ground points can benefit from state-of-the-art classification methods, such as those included in the Matlab Classification Learner App. This paper proposes a comparative study of the machine learning methods included in this tool in terms of training times as well as in their predictive performance. With this purpose, we have combined three suitable features for ground detection, which has been applied to

an urban dataset with several labeled 3D point clouds. Most of the analyzed techniques achieve good classification results, but only a few offer low training and prediction times.

ThuA02 Meeting Room 1

Industrial Automation and Process Control (Regular Session)

Chair: Huba, Mikulas — Slovak Univ. of Tech. in Bratislava

Co-Chair: Garcia-Gabin, Winston — ABB Corp. Res

09:00-09:20 ThuA02.1

Cooling Control of Data Centers Using Linear Quadratic Regulators, pp. 406-411

Garcia-Gabin, Winston — ABB Corp. Res

Mishchenko, Kateryna — Corp. Res. ABB AB

One of the largest contributions to a data center's power usage is its cooling system. One way to decrease the energy usage of a cooling systems by introducing an automatic control adapting the capacity of cooling units is addressed by this paper. Firstly, different configurations of linear quadratic regulators are designed and then evaluated using the nonlinear data center simulator. Design of the controllers is based on the novel idea of regulating the outlet temperature and volumetric airflow of the Computer Room Air Handler units which regulate the cooling power supplied to the servers. As controlled variables for the feedback, maximum and mean temperature of servers were used. Evaluation of controllers performance is based on their estimated energy usage as well as on analysis of the servers temperature profiles with respect to the given data centers' temperature threshold value. Numerical experiments include five LQR controllers with different combination of manipulated variables and analyze their performances. Results of the experiments show that the regulator with maximum servers' temperature as a feedback and Computer Room Air Handler Output temperature as manipulated variable has the best performance. Controlling the maximum server temperature minimizes hot spots occurrences and allows to operate the cooling system with minimal energy consumption.

09:20-09:40 ThuA02.2

Embedded Iterative Learning Contouring Controller Based on Precise Estimation of Contour Error for CNC Machine Tools, pp. 412-417

Hendrawan, Yogi Muldani — Toyohashi Univ. of Tech

Uchiyama, Naoki — Toyohashi Univ. of Tech

In machine tool application, a machined shape of workpiece should be considered in machine tool controller systems. The contour error relates to it directly. Although most existing contouring controllers are based on feedback control, this paper proposes an embedded iterative learning contouring controller (EILCC) by considering actual contour error (ACE) which the minimum distance between actual position and desired trajectory. The proposed method modifies original trajectory by ACE compensation with PID manner, iteratively. The proposed controller can be directly applied to existing commercial machines without any modification of their original controllers. The proposed method has been verified by simulation and experiment in commercial CNC machine tool on a 90o sharp-corner trajectory which normally produces a large contour error around the corner due to unsmoothness. Comparison with a previous EILCC without ACE was done to evaluate its performance. Experiment results have shown that the maximum contour error can be reduced by 78.8% and 9.7% as compared to the feedback controller (FBC) and EILCC without ACE (with estimated contour error), respectively.

09:40-10:00 ThuA02.3

WebNavIGSS Web-Based Software Solution for IGSS SCADA Applications, pp. 418-423

Tidrea, Alexandra — Univ. Pol. Timisoara, Faculty of Automation and Comp

Korodi, Adrian — Univ. Pol. Timisoara

The current automation/SCADA trends are referring mainly interfacing and horizontal/vertical interoperability issues on all levels. The web-based solutions with the inherent advantages and disadvantages are many times viewed as legacy structures but also as current requirements mainly because of their accessibility by wide-range type of operators. Very few web-solutions associated to SCADA software in the industry can be considered full-featured web-based solutions from a software perspective. Generally, the so-called web modules/extensions associated to SCADA software are practically remote-desktop solutions, coming with expensive licenses and high resource consumers. The IGSS (Interactive Graphical SCADA System) software is implemented in many industries in the first level control rooms and in regional/central SCADA centres. IGSS interfaces with external devices using OPC UA/DA server/client and many other drivers, its server-client concept allows connection through networks, respectively its mobile module allows monitoring and control from mobile devices, but it does not include a web-based monitoring/control module. The current paper presents the WebNavIGSS web-based software solution for IGSS applications. The WebNavIGSS will connect to existing structures provided by the SCADA software being in close correlation with the Supervise module. The authors tested the solution in the water industry and the results were satisfactory in monitoring several types of water objectives.

10:00-10:20 ThuA02.4

PID^m_n Control for IPDT Plants. Part 1: Disturbance Response, pp. 424-429

Huba, Mikulas — Slovak Univ. of Tech. in Bratislava

Vrancic, Damir — Jožef Stefan Inst

Bistak, Pavol — Slovak Univ. of Tech. in Bratislava

The paper introduces generalized PID control with the derivative action degrees m and with nth order series binomial filters. Together with the traditional PI (m=0) and PID control (m=1), this setup covers also solutions with higher order derivatives denoted previously as the PIDD2, or PIDD2D3 controllers and remains open to more complex combinations. The novel contribution includes explicit tuning formulas for the integral-plus-dead-time (IPDT) plant models with m=3 and m=4 as well as the systemic approach to design of such a long sequence of controllers. Derived by the multiple real dominant pole method they enable to significantly reduce the measurement noise impact by simultaneously speeding up transients and increasing the closed loop robustness against plant uncertainties. With respect to the necessary extent of the problem description, solution and of the corresponding performance evaluation, the contribution has been split into two parts. The first part focuses on the disturbance response evaluation by simulation. This is limited to some degree by the numerical problems of the available Simulink solvers. To overcome the simulation problems, the second part dealing with design and evaluation of the setpoint responses will consider also real time experiments.

10:20-10:40 ThuA02.5

PID^m_n Control for IPDT Plants. Part 2: Setpoint Response, pp. 430-435

Huba, Mikulas — Slovak Univ. of Tech. in Bratislava

Vrancic, Damir — Jožef Stefan Inst

Bistak, Pavol — Slovak Univ. of Tech. in Bratislava

The paper continues in developing generalized two-degree-of-freedom (2DOF) proportional-integral-derivative (PID) control with the mth order derivative action, and with n>= mth order series binomial filters. By focusing on the setpoint responses, the explicit tuning formulas of a 1DOF PIDmn control for the integral-plus-dead-time (IPDT) plant models derived by the multiple real dominant pole method are augmented by the optimal prefilter enabling to cancel up to $m+1$ of the $m+2$

tuple dominant closed loop poles and thus to accelerate the setpoint step responses. Since in Matlab/Simulink, the simulative setpoint response evaluation of the PIDmn with m>0 and IPDT plant is strongly limited by the numerical solver imperfections, the second part of the contribution brings also an experimental evaluation by real time control of a thermal plant. This fully confirms excellent properties of the novel type of control which, due to its high robustness, enables to simplify the plant identification and to work with the simple IPDT model also in the case of selfregulating processes with significantly more complex dynamics.

10:40-11:00 ThuA02.6

PID Controller Design Based on Generalized Stability Boundary Locus to Control Unstable Processes with Dead Time, pp. 436-441

Atic, Serdal — Batman Univ

KAYA, Ibrahim — Dicle Univ

This paper proposes a method so that all PID controller tuning parameters, which are satisfying stability of any unstable time delay processes, can be calculated by forming the stability boundary loci. Processes having a higher order transfer function must first be modeled by an unstable first order plus dead time (UFOPDT) transfer function in order to apply the method. Later, UFOPDT process transfer function and the controller transfer function are converted into normalized forms to obtain the stability boundary locus in (KKc, KKc(T/Ti)), (KKc, KKc(Td/T)) and (KKc(T/Ti), KKc(Td/T)) planes for PID controller design. PID controller parameter values achieving stability of the control system can be determined by the obtained stability boundary loci. The advantage of the method given in this study compared with previous studies in this subject is to remove the need of re-plotting the stability boundary locus as the process transfer function changes. That is, the approach results in somehow generalized stability boundary loci for unstable plus time delay processes under a PID controller. Application of the method has been clarified with examples.

ThuA03 Meeting Room 2

Cyber-Physical and Networked Systems (Regular Session)

Chair: Bajcinca, Naim — Univ. of Kaiserslautern

Co-Chair: Goodwine, Bill — Univ. of Notre Dame

09:00-09:20 ThuA03.1

Consensus Based Power Update Algorithm for OFDMA-Based Femtocell Networks, pp. 442-447

Sevim, Oguzhan — Bogazici Univ

Akar, Mehmet — Bogazici Univ

In this paper, we study the power assignment problem of the downlink of an OFDMA-based two-tier femtocell network. We aim to provide a global fairness among the user equipments in terms of their SINR values. Because of the potential complexity of the femtocell networks, we propose a distributed consensus–based power update algorithm to keep the required information exchange of the base stations minimal. Even though there exist some power control algorithms serving for the same fairness purpose, they are applicable only for the systems where each base station can have at most one user. Since femtocells are designed to serve more than one user equipment at the same time, the proposed power update algorithm can be considered as more real life applicable, and stands out amongst others by its ability to ensure consensus in multi–user/subchannel systems.

09:20-09:40 ThuA03.2

Wireless Data Rate Controller Design for Networked Control Applications, pp. 448-453

Marton, Lorinc — Cnp: 1760611264372

Tamas, Levente — Tech. Univ. of Cluj-Napoca

This paper presents a design approach for data transfer rate control algorithms meant to assure a prescribed delay in communication channels of wireless networked control systems (NCS). Three types of control algorithms are treated: P, PI and PI + Additive Increase control. Each algorithm is based on delay measurement and computes the transfer rates in the communication channels of NCSs. They are able to compensate the effect of independent communication channels with unknown rates on the expected delay value in the wireless communication medium. By assuming that the communication medium is described by the queue model, the parameters of these control algorithms are explicitly computed such to assure the stability of the closed-loop system and the steady-state control performances. Simulation measurements were performed to compare the behavior of the proposed control algorithms. The applicability of the control approach was tested in a networked bilateral teleoperation system.

09:40-10:00 ThuA03.3

Approximations for Implicitly-Defined Dynamics of Networks of Simple Mechanical Components, pp. 454-459

Goodwine, Bill — Univ. of Notre Dame

In many important engineering systems, including cyber-physical systems, there are often are many interacting simple components. It is well known that, in some cases, such systems may be modeled with fractional-order differential equations, and some of our prior work has shown that in certain cases fractional systems may be considered a subset of a class of systems where the dynamics may only be implicitly defined. In the implicit case, there is no straight-forward corresponding time domain representation. This paper considers series expansion approximations to the implicit operator describing the dynamics of the system to determine time-domain approximations for the implicit non-rational transfer function and validates the results via simulation. The contribution of this paper is to show that such expansions provide good approximations for the types of systems in the range of parameter values we considered, and for the special case of a network of springs and dampers, accurate equivalent spring and damper constants are computed which can provide intuitive insight into the nature of the response of the very high-order system.

10:00-10:20 ThuA03.4

A Game-Theoretical Approach to Cyber-Security of Critical Infrastructures Based on Multi-Agent Reinforcement Learning, pp. 460-465

Panfili, Martina — "Sapienza" Univ. Di Roma,

Giuseppi, Alessandro — La Sapienza

Fiaschetti, Andrea — "Sapienza" - Univ. of Rome

Al-Jibreen, Homoud — La Sapienza

Pietrabissa, Antonio — Consorzio Per La Ricerca Nell'automatica E Nelle Telecomunicazio

Delli Priscoli, Francesco — Univ. Di Roma

This paper presents a control strategy for Cyber-Physical System defense developed in the framework of the European Project ATENA, that concerns Critical Infrastructure (CI) protection. The aim of the controller is to find the optimal security configuration, in terms of countermeasures to implement, in order to address the system vulnerabilities. The attack/defense problem is modeled as a multi-agent general sum game, where the aim of the defender is to prevent the most damage possible by finding an optimal trade-off between prevention actions and their costs. The problem is solved utilizing Reinforcement Learning and simulation results provide a proof of the proposed concept, showing how the defender of the protected CI is able to minimize the damage caused by his/her opponents by finding the Nash equilibrium of the game in the zero-sum variant, and, in a more general scenario, by driving the attacker in the position where the damage she/he can cause to the infrastructure is lower than the cost it has to sustain to enforce her/his attack strategy.

10:20-10:40 ThuA03.5

Distributed Wardrop Load Balancing in Multi-MTU SCADA Systems, pp. 466-472

Suraci, Vincenzo — Univ. Degli Studi E-Campus

Ricciardi Celsi, Lorenzo — Univ. Di Roma "La Sapienza"
Giuseppi, Alessandro — La Sapienza
Manfredi, Gioacchino — La Sapienza
Di Giorgio, Alessandro — Univ. of Rome "La Sapienza"

This paper presents a distributed strategy for load balancing in a multi-MTU SCADA system, whose automatic control layer is such that its MTU Plane is modeled as a networked dynamical system. The proposed control law, under which the considered system is proven to converge to a Wardrop equilibrium, is also used for the purpose of equilibrium recovery in load distribution among MTUs after the occurrence of a possible MTU failure event induced by a cyber-physical attack (e.g., a Denial of Service attack). Numerical simulations with respect to realistic scenarios are reported to show the effectiveness of the proposed approach.

10:40-11:00 — ThuA03.6

Sensitivity Based Event-Triggered TDMA Protocol for Distributed Optimization, pp. 473-480

Guma, Shaban — TU Berlin
Bajcinca, Naim — Univ. of Kaiserslautern

We present the design of a sensitivity based event- triggered TDMA protocol in conjunction with a distributed optimization algorithm utilizing dual subgradient method. The event-triggered protocol is based on a sensitivity analysis and it regards the impact of the information exchange into the evo- lution of the optimization algorithm. The proposed algorithm is evaluated in the context of distributed feedforward control of vehicle dynamics.

ThuA04 — Meeting Room 3

Robust Control 1 (Regular Session)

Chair: Gershon, Eli — Holon Inst. of Tech
Co-Chair: Tremba, Andrey — Inst. of Control Sciences RAS

09:00-09:20 — ThuA04.1

Pareto Suboptimal Robust Controllers in Multi-Objective Generalized H_2 Problem, pp. 481-486

Balandin, Dmitry — Nizhny Novgorod State Univ
Biryukov, Ruslan — Nizhny Novgorod State Univ. of Architecture and Civil Engin
Kogan, Mark M. — Architecture and Civil Engineering Univ

A novel multi-objective robust control problem is studied for systems with structured norm-bounded uncertainty and robust generalized H_2 norms as criteria. Necessary conditions for Pareto optimality are formulated. Pareto optimal solutions turn out to be among optimal solutions for multi-objective costs in the form of Germeyer convolution. Pareto suboptimal controllers are defined as the optimal solutions for the upper bounds of the multi-objective costs and characterized in terms of LMIs. The upper and lower bounds of the multi-objective cost are used to compute a suboptimality measure which allows to estimate a ``difference'' between Pareto suboptimal and unavailable Pareto optimal controllers. Two-criteria robust control problem for a mathematical model of the rotor rotating in active magnetic bearings is considered as an application of this theory.

09:20-09:40 — ThuA04.2

Robust Norm-Bounded H_infty Static Output-Feedback Control of Retarded Stochastic Systems, pp. 487-492

Gershon, Eli — Holon Inst. of Tech
Shaked, Uri — Tel-Aviv Univ

An input-output approach for designing a constant output feedback controller for a linear time-invariant retarded system with stochastic state-multiplicative white noise sequences, that achieves a minimum bound on the hinf performance level is introduced. The stochastic uncertainties appear in the dynamic matrices, which correspond to the delayed and non-delayed states of the system.

The solution of the robust norm-bounded H_infty static output-feedback control problem is solved, for the stationary case, via the input-output approach where the system is replaced by a non-retarded system that contain, instead, deterministic norm-bounded uncertainties. In this problem, a cost function is defined which is the expected value of the standard H_infty performance cost with respect to the stochastic parameters. We extend the results achieved for the nominal case, to the case where the system matrices contain norm bounded uncertainties.

09:40-10:00 — ThuA04.3

Conversion from Full-Order Controllers to Observer-Structured Controllers, pp. 493-498

Sato, Masayuki — Japan Aerospace Exploration Agency

In this note, we compare the structures of Linear Time-Invariant (LTI) full-order controllers and LTI observer-structured controllers (whose structure is similar to that of observer-based controllers; however, they do not necessarily play as observers), and give an insight for the structural differences between those controllers. This insight consequently gives a parametrization of the state-space matrices of observer-structured controllers by using those of full-order controllers. This parametrization contains two free matrices, which can be used to loosely impose some structural constraints for observer-structured controllers in the conversion from full-order controllers to observer-structured ones. Several numerical examples are included to illustrate the usefulness of the two free matrices in our parametrization.

10:00-10:20 — ThuA04.4

Stochastic Discrete-Time Systems with Delay - Robust Vertex-Dependent H_infty State-Feedback Control, pp. 499-504

Gershon, Eli — Holon Inst. of Tech
Shaked, Uri — Tel-Aviv Univ

The theory of stochastic state-multiplicative state-feedback control of retarded discrete-time systems is extended to the robust polytopic case, where a vertex-dependent approach is applied. The latter problem is solved by first deriving a stability condition for uncertain systems based on the application of the Finsler lemma to the studied systems, where a special Lyapunov function is applied to each vertex of the uncertainty polytope. Compared to the stability condition which is obtained by the quadratic approach where a single Lyapunov function is applied to the whole uncertainty polytope, the vertex-dependent approach achieves a significatively less-conservative result than the former approach. Based on the vertex-dependent stability condition, a robust bounded real lemma is derived and solved, leading to the solution of the state-feedback control for uncertain systems.

10:20-10:40 — ThuA04.5

A Set of Chance-Constrained Robust Stabilizing PID Controllers, pp. 505-510

Tremba, Andrey — Inst. of Control Sciences RAS

Stabilization of linear SISO systems with random uncertain parameters is considered. A closed-loop system inherits random parameters, and it is stable with some probability. The probabilistic design problem is to tune a controller (e.g., a PID-controller) to stabilize the closed-loop system with high probability. Finding suitable parameters is a probabilistic robust stabilization problem (specifically, a chance-constrained problem). The ultimate goal is to describe the whole set of such controllers instead of individual representative.

An algorithm is proposed for finding an inner approximation of the set of chance-constrained stabilizing PID-controllers. The method is based on the robust D-decomposition technique and deterministic error set representation of random uncertainty. A few examples with demonstration of the approach are provided

and discussed.

10:40-11:00 ThuA04.6

Anti-Lock Braking Control Design for Electric Vehicles Using LPV Methods, pp. 511-516

Nemeth, Balazs	Hungarian Acad. of Sciences
Fazekas, Máté	Inst. for Computer Science and Control
Gaspar, Peter	Mta Sztaki

The paper proposes a novel Linear Parameter-Varying (LPV) based control approach for the anti-lock braking (ABS) functionality of electric vehicles. Through the advanced control design the hydraulic actuation and the regenerative braking of the electric motor can be coordinated efficiently. In the proposed control architecture the advantages of the different interventions can be combined, such as the the high torque generation capability of the hydraulic system and the fast actuation of the electric motor. The results of the LPV-based control design is presented through simulations using the high-fidelity CarMaker software.

ThuA05 Meeting Room 4

Adaptive Control (Regular Session)

Chair: Landau, Ioan Dore	CNRS
Co-Chair: Kapetanović, Nadir	Univ. of Zagreb, Faculty of Electrical Engineering and Computing

09:00-09:20 ThuA05.1

Adaptive Output-Feedback Stabilization of 2 X 2 Linear Hyperbolic PDEs with Actuator and Sensor Delay, pp. 517-522

Anfinsen, Henrik	NTNU
Aamo, Ole Morten	NTNU

We derive an adaptive output-feedback stabilizing controller for a system of 2 x 2 linear hyperbolic partial differential equations (PDEs) with delayed, anti-collocated sensing and control. This is done by using a series of transformations to show that the system is equivalent to delay-free systems for which such controllers have been derived. The only required knowledge of the system is the system's transport delays, the sensor and actuation delays and the sign of the product of the actuation and sensing scaling constants. The theory is verified in a simulation.

09:20-09:40 ThuA05.2

Stock Trading Via Feedback Control: An Extremum Seeking Approach, pp. 523-528

Formentin, Simone	Pol. Di Milano
Previdi, Fabio	Univ. Degli Studi Di Bergamo
Maroni, Gabriele	Univ. of Bergamo
Cantaro, Claudio	Univ. Degli Studi Di Roma Tre

In finance, the goal of technical analysis is to model stock dynamics to make reliable predictions of future prices. In recent years, Prof. B. Barmish and coauthors have proposed a paradigm shift in which stock trading is reformulated as a control design problem. From such a perspective, unpredictable price variations can be seen as external disturbances and do not need to be accurately modeled for the investment policy to be properly selected. Although very powerful, the tuning of the reactive scheme to stock trading is all but straightforward. In this paper, an Extremum Seeking approach is proposed to directly design the control action from data and make the overall strategy adaptive with respect to trend variations of the stock price. The method is extensively backtested on real stock data.

09:40-10:00 ThuA05.3

Hybrid Adaptive Chassis Control for Vehicle Lateral Stability in the Presence of Uncertainty, pp. 529-534

Jagga, Dhruv	TU Delft, Delft Center for Systems and Control
Lv, Maolong	Delft Univ. of Tech
Baldi, Simone	Delft Univ. of Tech

To guarantee the safety of passengers in a wide range of driving situations, vehicle lateral stability should be achieved in the presence of nonlinear dynamics (consequence of critical maneuvers) and uncertainty (consequence of uncertain parameters). This paper designs a hybrid adaptive strategy to attain vehicle stability in these situations. The design is based on a piecewise affine (PWA) description of the vehicle model where partitions describe both the linear and the nonlinear regimes, and where parametric uncertainties are handled by estimators for the control gains that can adapt to different conditions acting on the system. Comparisons with strategies that merely exploits the linear region of the vehicle dynamics are provided for different driving conditions, and performance improvements of the proposed methodology are assessed.

10:00-10:20 ThuA05.4

MIMO Direct Adaptive Control with Relaxing Constrains on High-Frequency Matrix Gain Assumption, pp. 535-540

Gerasimov, Dmitry	ITMO Univ
Nikiforov, Vladimir O.	ITMO Univ
Miliushin, Aleksandr	ITMO Univ

The problem of direct model reference adaptive control for multi input multi output (MIMO) uncertain plants with unknown high frequency gain matrix (HFGM) is addressed in the paper. Two schemes of adaptive control algorithms using augmented error estimators and relaxed assumption concerning HFGM are proposed. It is assumed that the minimum of modulus of HFGM determinant is known. The first scheme involves the resettable approximation of the inversion of HFGM estimate in control law. The second scheme is based on modification of conventional augmented error estimator by introduction of a switched projection mechanism. The proposed theoretical ideas are wrapped up by simulation examples.

10:20-10:40 ThuA05.5

Can Adaptive Feedforward Control Improve Operation of Cloud Services?, pp. 541-546

Landau, Ioan Dore	CNRS
Saavedra Mendieta, Jaime	Gipsa-Lab, Cnrs
Cerf, Sophie	Univ. Grenoble Alpes
Robu, Bogdan	Univ. of Grenoble
Marchand, Nicolas	GIPSA-Lab CNRS
Bouchenak, Sara	INRIA, Univ. of Grenoble I

To process Big Data, the cloud computing architecture is used since several years. Service Level Objectives (SLO) become key indicators for the performances of the cloud computing providers. Controlling the cluster size is one of the main issues. Static decision procedures are available but they fail to provide an optimal decision in the presence of highly time varying service demands. The cluster has to be viewed as a dynamic system where the service demand is a disturbance to be compensated dynamically by a control action which is in this case the cluster size. PI feedback control has been already considered as a mean for dynamically controlling the size of the cluster[Berekmeri and al, 2014]. However since the disturbance is measurable an adaptive feedforward compensation can be added for improving the performance of a feedback controller. A general algorithm for adaptive feedforward control in the context of cloud computing is proposed and analyzed. Simplified versions are also presented and analyzed. Experimental results obtained on the Grid'5000 (French nation-wide cluster infrastructure) will be presented.

10:40-11:00 ThuA05.6

Output Adaptive Controller Design for Robotic Vessel with Parametric and Functional, pp. 547-552

Vlasov, Sergey	ITMO Univ
Kirsanova, Aleksandra	Saint Petersburg National Res. Univ. of Information Tec
Dobriborsci, Dmitrii	ITMO Univ

Borisov, Oleg ITMO Univ
Gromov, Vladislav ITMO Univ
Pyrkin, Anton ITMO Univ
Maltsev, Maksim ITMO Univ
Semenov, Artem ITMO Univ

The problem of controlling for robotic boat with unknown parameters and unmeasurable velocity and accel- eration is addressed in this paper. The controller design is based on the output robust control law. It was modified with adaptation algorithms, which allowed to eliminate a static error despite parametric and functional uncertainties. As result, the regulator minimized static error compared to robust controller. The efficiency of the proposed algorithm was illustrated by the experimental approval using the robotic boat model in the task of ellipse path movement. There is comparison between of robust controller and adaptive version in the paper.

ThuB01 Kolovare
Aerospace Control 2 (Regular Session)

Chair: Hengster-Movric, Kristian — Katedra ř ídicí Tech. FEL Č VUT
Co-Chair: Bajodah, Abdulrahman H. — King Abdulaziz Univ

14:00-14:20 ThuB01.1

Sliding Mode Control of Launch Vehicles' Flight Path Slope Angle, pp. 553-558

Lungu, Romulus Univ. of Craiova
Butu, Florentin-Alin Univ. Pol. of Bucharest
Lungu, Mihai-Aureliu Univ. of Craiova

The paper presents the design of an adaptive system for the control of flight path slope angle associated to launch vehicles' motion in vertical plane during their second flight stage, after the launch phase, by using the sliding mode control and the dynamic inversion principle. The control law is obtained by means of a Lyapunov positive defined function and it is based on the estimation of an unknown aerodynamic parameters. The theoretical results are validated in Matlab for a concrete example associated to a launch vehicle's motion in vertical plane.

14:20-14:40 ThuB01.2

Reduced-Order Multiple Observer Design for Takagi-Sugeno Models with Unknown Inputs, pp. 559-564

Lungu, Mihai-Aureliu Univ. of Craiova
Boubaker, Olfa INSAT
Lungu, Romulus Univ. of Craiova

The paper presents the design of a new reduced-order multiple observer (ROMO) for state estimation of unknown input Takagi-Sugeno (T-S) models; this is only the second reduced-order multiple observer ever designed for such systems. The proposed observer is obtained by applying the classical methods of reduced-order observers' design for linear multivariable systems with unknown inputs to the case of T-S models. The originality of the designed observer compared to the only existing one is related to: 1) no existence conditions are required, 2) no use of the pole placement method leading to sensitivity problems is necessary and, 3) the solution is designed using available commercial LMI tools. The related algorithm of the proposed ROMO is structured into five steps; its efficiency is proved by using a concrete example of a light aircraft lateral-directional motion

14:40-15:00 ThuB01.3

Spacecraft Collision Avoidance with Constrained Control Via Discrete-Time Generating Functions, pp. 565-569

Lee, Kwangwon Yonsei Univ
Park, Chandeok Yonsei Univ

This study presents sub-optimal collision-free transfers of spacecraft subject to constraints on control magnitude. In order to mitigate the difficulty in solving an optimal control problem considering directly inequality constraints, the penalty and barrier functions are incorporated into the cost function of optimal tracking problem. Then, the sub-optimal control law is derived by employing the discrete-time generating functions representing the canonical transformation in the discrete-time Hamilton-Jacobi theory. The proposed approach allows us to derive the control law as an algebraic form of the states of spacecraft, reference solution, and obstacles without any iterative process and initial guess. The numerical simulations validate the proposed approach by showing that spacecraft can reach the target point while avoiding obstacles with constrained control.

15:00-15:20 ThuB01.4

Aircraft Motion Decoupling of Roll and Yaw Dynamics Using Generalized Dynamic Inversion Control, pp. 570-574

Bajodah, Abdulrahman H. King Abdulaziz Univ
Mibar, Hassen Coll. Jeddah of Tech
Ansari, Uzair King Abdulaziz Univ

In this paper, Generalized Dynamic Inversion (GDI) control methodology for linear state equality constraints is proposed for independent motion control of an aircraft along the roll and the yaw axes. In GDI control, dynamic constraints are defined based on the roll and yaw attitude deviation functions and are inverted using Moore Penrose Generalized Inverse (MPGI) to realize the control law. In the particular part of GDI control, constraint differential equation is formulated for the yaw channel, where as the constraint dynamics for the roll axis is constructed by using the involved null control in the auxiliary control part of GDI. The two noninterference control actions is a key advantage of GDI control, and it provides extra degree of design freedom. Numerical simulations are conducted on the lateral dynamics of a transport aircraft to demonstrate the motion decoupled tracking performance of the proposed control strategy.

15:20-15:40 ThuB01.5

Distributed State Feedback Control for Aeroelastic Morphing Wing Flutter Supression, pp. 575-580

Svoboda, Filip Czech Tech. Univ. in Prague
Hromcik, Martin Czech Tech. Univ. in Prague, FEE
Hengster-Movric, Kristian Katedra ř ídicí Tech. FEL Č VUT

This paper offers a novel approach at flutter suppression problem on morphing wing and relates to current research of morphing aircraft. The active flutter suppression task is formulated as a state synchronization in a network of identical Linear Time-Invariant (LTI) systems. These systems consist of wing segments which can be actuated separately. Finite Element Method (FEM) approach and unsteady aerodynamics represented by Theodorsen function are used for flexible morphing wing modeling. An example of distributed Linear-Quadratic Regulator (LQR) state synchronization is shown in this paper. Comparison in time-domain, frequency-domain, and flutter speeds has been done for the system with distributed LQR and the original system.

ThuB02 Meeting Room 1
Marine Control (Regular Session)

Chair: Arrichiello, Filippo — Univ. Di Cassino E Del Lazio Meridionale
Co-Chair: Miskovic, Nikola — Faculty of Electrical Engineering and Computing, Univ. of Zagreb

14:00-14:20 ThuB02.1

Human Interactions Framework for Remote Ship Operations, pp. 581-587

Kari, Raheleh Norwegian Univ. of Science and Tech. (NTNU)

Gaspar, Henrique — NorwegianUniversityofScienceandTechnology
Haugen Gausdal, Anne — Univ. Coll. of Southeast Norway
Morshedi, Maghsoud — Univ. of Oslo

The concept of unmanned ships capable of being controlled remotely is now beyond the idea and will start a revolution in maritime industry. In this context, remote ship operations refer to processes of controlling the vessels from distance such that operators obtain information from sensors. Thus, assessment and improvement of human interactions can enhance the overall performance of remote ship operations. However, there are unknown i human-human and ii human-machine relationships in remote ship operations, which increase the complexity of ship operations and therefore affect the overall system performance. This paper introduces a human interaction framework in remote ship operations domain in order to maximize system performance by minimizing conflicting operations. Hence, the proposed framework identifies the human interactions in remote control centers as well as the main differences between remote and non-remote ship operations. The current paper employed human system integration (HSI) approach in order to consider human as a sub-system. In this respect, literature review and human factor engineering technique (HFE) named similar system analysis were utilized to collect data and accordingly coding process was performed to analyze collected data. The proposed framework updated the earlier models of human-automated interactions and tailored to fit in the context of remote control centers. Besides, differences between remote and non-remote operations provide insight into human interactions in remote ship operations and consequently facilitates performance improvement actions. As a result, the proposed framework provides a solid understanding of human as a critical sub-system in remote ship domain so that gained knowledge could be used by designers and engineers.

14:20-14:40 ThuB02.2

Adaptive Generalized Dynamic Inversion Based Trajectory Tracking Control of Autonomous Underwater Vehicle, pp. 588-594

Ansari, Uzair — King Abdulaziz Univ
Bajodah, Abdulrahman H. — King Abdulaziz Univ
Alam, Saqib — NED Univ. of Engineering and Tech

This paper presents the two-loops structured control system based on Adaptive Generalized Dynamic Inversion (AGDI) for the position and attitude control of Autonomous Underwater Vehicle (AUV). The outer-loop is responsible to provide the pitch and yaw tilting commands to the inner-loop, which in turns generates the tilting angles that are required to control its position in depth and east directions respectively. In AGDI control, the particular part is formulated by prescribing the constraint differential equations based on the deviation functions of the position coordinates and attitude angles. The control law is realized by inverting the constraint dynamics using Moore-Penrose Generalized Inverse (MPGI). The involved null control vector in the auxiliary part of AGDI is constructed to guarantee global closed loop stability of the linear and angular velocities. The singularity problem is addressed by incorporating a dynamic scaling factor in the expression of MPGI. The integration of an additional term based on Sliding Mode Control with adaptive modulation gain provides robustness against system nonlinearities, uncertainties and tracking performance deterioration due to dynamic scaling, such that semi-global practically stable position and attitude tracking is guaranteed. To demonstrate the tracking performance of the AGDI control, numerical simulations are conducted on six degrees of freedom simulator of the Monterey Bay Aquarium Research Institute (MBARI) AUV, under nominal and perturbed marine conditions.

14:40-15:00 ThuB02.3

Information Gain-Guided Online Coverage Path Planning for Side-Scan Sonar Survey Missions, pp. 595-600

Kapetanović, Nadir — Univ. of Zagreb, Faculty of Electrical Engineering and Comp
Miskovic, Nikola — Faculty of Electrical Engineering and Computing, Univ. of Z
Tahirovic, Adnan — Faculty of Electrical Engineering Sarajevo

Mapping an unknown large-scale marine area by a side-scan sonar onboard a marine vehicle as quickly as possible is often of great importance. It is also important that a-priori unknown interesting parts of the area are scanned in more detail, i.e. with the removal of sonic shadows. In contrast to the standard overlap-all-sonar-ranges lawnmower pattern, which is an offline static coverage problem solution for side-scan sonar missions, here a novel online side-scan sonar data-driven coverage solution is proposed. The proposed coverage algorithm provides a coverage solution based on local information gain from side-scan sonar data. At the same time, the solution is generated in such a way that coverage path length is minimized while covering the same area as the standard lawnmower. Upper and lower bounds of the proposed algorithm's improvement compared to the overlap-all-sonar-ranges lawnmower method are estimated analytically and validated through extensive mission parameters variation simulations. Simulation results show that our approach can cut down coverage path length significantly compared to the standard lawnmower method in most application cases.

15:00-15:20 ThuB02.4

Localization of an Array of Hydrophones Towed by an Autonomous Underwater Vehicle, pp. 601-606

Arrichiello, Filippo — Univ. Di Cassino E Del Lazio Meridionale
Sarkar, Soumic — Indian Inst. of Tech. Delhi
Chiaverini, Stefano — Univ. Di Cassino
Antonelli, Gianluca — Univ. of Cassino and Southern Lazio

The paper addresses the localization problem of an array of hydrophones mounted on a streamer towed by an Autonomous Underwater Vehicle (AUV). The considered system has been developed in the framework of the H2020 European project WiMUST and it is finally aimed at performing seismic surveys by acoustic means to explore the sea bottom subsurface. In particular, in the project's scenario, the acoustic seismic survey is performed having two autonomous surface vessels, carrying acoustic sources named sparkers, and a team of AUVs, towing a streamer each. The time of flight with which the waves generated from the sparkers reflect in the sea sub-bottom layers and return to the hydrophones provides valuable information about the properties of the ocean subsurface. However, for a proper processing of the acoustic data, there is the need to estimate hydrophones' positioning. Here, we present a localization strategy for the described system based on an Extended Kalman Filter (EKF) that uses the dynamic model of the AUV-streamer system and the range measurements from sparkers to hydrophones as extracted from the seismic acoustic signals. The proposed approach has been tested in numerical case studies built using data extracted from the experimental tests performed in the framework of the WiMUST project.

15:20-15:40 ThuB02.5

3D Autonomous Underwater Navigation Using Seabed Acoustic Sensing, pp. 607-612

Miller, Boris — Inst. for Information Transmission Problems RAS and Monash U
Miller, Alexander — Inst. for Information Transmission Problems, RAS

Autonomous Underwater Vehicle (AUV) being a powerful tool for exploring and investigating ocean resources can be used in a large variety of oceanographic, industry and defense applications. Underwater navigation for AUV is still a challenging task and is one of the fundamental elements in modern robotics because the ability of AUV to correctly understand its position and attitude within the underwater environment is determinant

for the success in the different applications. AUV navigation usually is based only on information obtained from Doppler Velocity Loggers, Inertial Navigation Systems, etc. due to the absence of an external reference sources. But this type of navigation is subjected to a continuously growing error due to the absence of the absolute position measurement (for example, received from GPS or GLONASS) which is typical for the majority of UAV applications. These measurements might be provided by observation of so-called feature points like in Unmanned Aerial Vehicles (UAV) case, but the big difference between acoustical and optical images makes it a rather difficult problem which solution needs detailed preliminary mapping of the operational seabed area. The new generation of acoustic imaging gives rise to the new approaches to AUV navigation based on the absolute velocity measurements. By analogy with the optical flow approach coming from the area of UAV the evolution of the seabed map produces the information related to the absolute motion of the AUV. The principal advantage of the proposed algorithm is that the fusion of the acoustic mapping and the Inertial Navigation System (INS) gives the absolute velocity of the vehicle.

ThuB03 Meeting Room 2

Biomedical Engineering (Regular Session)

Chair: Precup, Radu-Emil	Pol. Univ. of Timisoara
Co-Chair: Yen, Jia-Yush	National Taiwan Univ

14:00-14:20 ThuB03.1

A Novel Method to Identify Relevant Features for Automatic Detection of Atrial Fibrillation, pp. 613-618

Trardi, Youssef	Aix Marseille Univ. , CNRS, LIS UMR 7020
Ananou, Bouchra	Univ. Paul Cézanne
Haddi, Zouhair	2016
Ouladsine, Mustapha	Univ. D'aix Marseille III

The selection of an appropriate subset of predictors from a large set of features is a major concern in clinical diagnosis research. The purpose of this study is to demonstrate that the Multiple Kernel Learning (MKL) approach could be successfully applied as a feature selection process for machine learning pipelines. Furthermore, we suggest a multi-dynamic analysis of heartbeat signal to characterize the most common sustained arrhythmia, Atrial Fibrillation (AF). Indeed, we have targeted six different dynamics of QRS time series, where each one will be associated with 12 linear and nonlinear functions to yield a set of 72 features. Afterward, a feature selection process is implemented using the MKL to evaluate the relevant features allowing AF diagnosis. Hence, a subset of only 13 features has been selected. To demonstrate the effectiveness of the proposed approach, Support Vector Classification (SVC) model has been conducted, first, on all features, and then on the features issued from the MKL selection feature process. The obtained results showed that the SVC model trained by 13 features outperformed the one trained by 72 features. This approach has reached 99.77% of success rate in the discrimination between Normal Sinus Rhythm (NSR) and AF. The proposed selection feature method holds several interesting properties in dimensionality reduction which makes it a suitable choice for several applications.

14:20-14:40 ThuB03.2

Input-Output Feedback Linearization Control (IOFLC) for Muscle Force Control by Functional Electrical Stimulation, pp. 619-624

BEN HMED, Abdennacer	Lab. Le2i, Univ. De Bourgogne
Bakir, Toufik	Univ. De Bourgogne
Sakly, Anis	The National School of Engineers of Monastir
Binczak, Stephane	Lab. Le2i UMR 6306, CNRS, Arts Et Métiers, Univ. Bourgogne

Functional Electrical Stimulation (FES) is mainly used to help paralyzed individuals to restore functional movements. The efficiency of FES-systems is technically limited by the imprecise control of movements and also by the rapid appearing of the fatigue. Therefore, there is a need to include control strategies into FES-systems to modulate stimulation parameters (frequency, pulse amplitude and pulse duration). We aimed in this work to compute the required stimulation pulse duration using the Input-Output Feedback Linearization Control (IOFLC) in order to perform electrical stimulation by tracking a given desired force reference. The IOFLC approach is validated in this study through different simulation scenarios. The illustrated results showed promise in application of IOFLC into closed loop control in FES rehabilitation systems.

14:40-15:00 ThuB03.3

Structure and Evolving Fuzzy Models for Prosthetic Hand Myoelectric-Based Control Systems, pp. 625-630

Precup, Radu-Emil	Pol. Univ. of Timisoara
Teban, Teodor-Adrian	Pol. Univ. of Timisoara
Petriu, Emil	Univ. of Ottawa
ALBU, Adriana	Pol. Univ. Timisoara
Mituletu, Ion-Cornel	Pol. Univ. of Timisoara

This paper suggests a structure for prosthetic hand myoelectric-based control systems and a set of evolving Takagi-Sugeno-Kang (TSK) fuzzy models to characterize mathematically the finger dynamics of the human hand for the myoelectric control of prosthetic hands. The fuzzy models represent the reference models in myoelectric-based control systems, the model outputs are the flexion percentages that correspond to the midcarpal joint angles, and the model inputs are the myoelectric signals obtained from eight myoelectric sensors. Different numbers of additional model inputs obtained from past inputs and/or outputs are considered. The structure and parameters of the fuzzy models are evolved by an incremental online identification algorithm (IOIA). The evolving TSK fuzzy models for one finger are tested against the experimental data, and a comparison with similar TSK fuzzy models evolved by another IOIA and a neural network model with similar number of parameters is included.

15:00-15:20 ThuB03.4

Comparison of the Control Designs of an Human Co-Working Endoscope Holder, pp. 631-636

Liao, You-Ting	National Taiwan Univ
Chen, Chin-Yuan	National Taiwan Univ
Yen, Jia-Yush	National Taiwan Univ
Ho, Ming-Chih	National Taiwan Univ
Chen, Yung-Yaw	National Taiwan Univ

The research addresses the design of an endoscope holding robot. The minimally invasive surgery (MIS) usually takes many doctors to work together; only one surgeon is actually performing the operation. One of the doctors is required to hold the endoscope and to point the camera at the surgical area. This research aims to design a robot to fulfill the function of this doctor to hold the endoscope in place. This paper demonstrates how to achieve the two main functions of the endoscope holders namely: to maintain the entry point into the body and to actively move away from blocking the doctor in their operation. This paper describes how to achieve these goals based on a regular six degree-of-freedom industrial robots. The control could be implemented at different levels of control. The experimental results show that the implementation at the different level of controls each has its advantages and disadvantages.

15:20-15:40 ThuB03.5

System for Compensating for Leg Length Discrepancy Based on the Estimation of the Centre of Mass of a Human Body, pp. 637-642

Vrhovski, Zoran	Bjelovar Univ. of Applied Sciences
Benkek, Goran	Bjelovar Univ. of Applied Sciences

Mutka, Alan — Bjelovar Univ. of Applied Sciences
Obrovac, Karlo — Cognitus Ltd
Bogdan, Stjepan — Univ. of Zagreb

This paper presents a system for compensating for leg length discrepancy (LLD) based on the estimation of the centre of mass of a human body. The system consists of two 3-RPS parallel manipulators with a moving force plate, control and measuring electronics and a graphical user interface (GUI). Force plates are equipped with force sensors that estimate the centre of mass (CoM) of a human body. Patients with LLD have a displaced CoM. By increasing the height of the force plate that measures a greater load, the CoM of a human body returns into the correct position. The height of the force plate is regulated by means of the 3-RPS parallel manipulator. LLD is compensated for by the difference in heights of the force plates. This paper presents the preliminary experimental results of the system for compensating for LLD.

ThuB04 — Meeting Room 3

Robust Control 2 (Regular Session)

Chair: Hure, Nikola — FER Zagreb
Co-Chair: Dritsas, Leonidas — ASPETE

14:00-14:20 — ThuB04.1

A Case Study on Determining Stability Boundaries of Parameter Uncertain Systems, pp. 643-648

mutlu, ilhan — Istanbul Tech. Univ
Schrödel, Frank — IAV GmbH
Mihailescu-Stoica, Dinu — TU Darmstadt
Mustafa, Khaled Alaaeldin Abdelfattah — Univ. of Twente
Söylemez, Mehmet Turan — Istanbul Tech. Univ

Guaranteeing the stability is one of the fundamental problems of control engineering. In most of the dynamical systems, parameter uncertainties can not be avoided. Thus, it is crucial from a practical point of view to propose generic methods for analyzing the stability of uncertain parameter systems. In this study, the extension of previously proposed Lyapunov Equation based stability mapping approach to the case of parameter uncertain systems is presented. Using the present method, it becomes possible to determine the explicit stability boundaries of the uncertain parameters along with the free controller parameters. Unlike most of the conventional approaches, the current method does not include any restrictions related with the number of the uncertain parameters and the way that the uncertain parameter(s) show themselves in the problem formulation. In order to demonstrate the efficiency of the proposed method, two benchmark case studies are discussed in detail. It is shown that the proposed approach is capable of increasing the accuracy of the previous results in specific cases while ensuring a flexible and easily applicable stability analysis environment for such systems.

14:20-14:40 — ThuB04.2

On Robustly Stabilizing PID Controllers for Systems with a Certain Class of Multilinear Parameter Dependency, pp. 649-654

Mihailescu-Stoica, Dinu — TU Darmstadt
Schrödel, Frank — IAV GmbH
Vosswinkel, Rick — Tech. Univ. Dresden
Adamy, Juergen — Tech. Univ. Darmstadt

PID controllers are the most common controller type in industry. However, methods for optimal controller parameter tuning are still under development, especially in the case of robust control. One starting point for controller tuning is the usage of D-decomposition techniques, in order to identify the space of stabilizing controller parameters. In this paper, a novel approach for exact calculation of all stabilizing controller parameters which explicitly considers parameter uncertainties is introduced. Based on previous studies, the focus is expanded to multilinear parameter uncertainties. The usage of the proposed method is demonstrated in the prominent case study of robust control.

14:40-15:00 — ThuB04.3

Discrete Robust Controller for Ball and Plate System, pp. 655-660

Dobriborsci, Dmitrii — ITMO Univ
Margun, Alexey — ITMO Univ
Kolyubin, Sergey — NTNU

In this paper we present recent results on designing the discrete output robust controller called "'consecutive compensator"' suitable for multiple-input multiple- output discrete systems. It is an extension of the previous results where the continuous version was considered for uncertain Single- input single-output plants. The proposed algorithm provides convergence of the tracking error to the bounded area. Lyapunov function method for stability analysis was used. The experimental validation was performed using well-known Ball and Plate System.

15:00-15:20 — ThuB04.4

On Optimal Anisotropy-Based Control Problem for Discrete-Time Descriptor Systems, pp. 661-666

Andrianova, Olga — Ics Ras
Belov, Alexey — ITMO Univ

This paper is dedicated to optimal state-feedback control problem for discrete-time descriptor systems in presence of "colored" noise with known mean anisotropy level. Here "colored" noise stands for a stationary Gaussian sequence, generated by a linear shaping filter from the Gaussian white noise sequence. The control goal is to find a state feedback control law which makes the closed-loop system admissible and minimizes its a-anisotropic norm (mean anisotropy level a is known).

15:20-15:40 — ThuB04.5

Aggressive Control Design for Electric Power Generation Plants, pp. 667-672

Dritsas, Leonidas — ASPETE
Kontouras, Efstathios — Univ. of Patras
Kitsios, Ioannis — Hellenic Air Force Electronics & Telecoms Depot
Tzes, Anthony — New York Univ. Abu Dhabi

This article addresses the design problem of an aggressive load/frequency feedback controller against load disturbances for an electric power generation plant. The controller is comprised of two components. The primary aggressive component, whose design is based on LMI techniques, places the closed loop poles in a predefined region while providing fast attenuation and disturbance rejection. The resulting control action provides control commands with large amplitudes that trigger the plant's input saturator especially in case of large load disturbances. To account for this, an anti-windup compensator is provided assuring stability of the closed--lop system in all cases. The overall controller provides a fast response for small load disturbances and a rather conservative response owing to the anti-windup action for large loads. Simulation studies are offered to illustrate the efficiency of the control design.

ThuB05 — Meeting Room 4

Fault Diagnosis and Fault Tolerant Control 1 (Regular Session)

Chair: Ivanjko, Edouard — Univ. of Zagreb, Faculty of Transport and Traffic Sciences
Co-Chair: Maquin, Didier — Univ. De Lorraine

14:00-14:20 — ThuB05.1

Development and Experimental Testing of a Health Monitoring System of Electro-Mechanical Actuators for Small Airplanes, pp. 673-678

Previdi, Fabio — Univ. Degli Studi Di Bergamo
Maccarana, Yamuna — Univ. of Bergamo
Mazzoleni, Mirko — Univ. Degli Studi Di Bergamo
Scandella, Matteo — Univ. of Bergamo
Pispola, Giulio — Umbra Cuscinetti
Porzi, Nicola — Umbra Cuscinetti

This paper reports the preliminary results of the REPRISE (Reliable Electromechanical actuator for PRImary SurfacE with health monitoring) project, which aims to design a novel Electro-Mechanical Actuator (EMA) to be used on primary flight surfaces of small aircrafts. An important element of the actuator control system is a Health Monitoring (HM) module. This component is an algorithm able to detect anomalies in the device even if there is no evident loss of ability in pursuing its main function (position tracking). In particular, the project aim is to identify any degradation in the mechanical transmission elements, the ballscrew and other components such as bearings. Moreover, it is strongly advisable that the HM algorithm is based on a feature whose value can be easily computed and monitored during the actuator life. In this work, a large experimental activity has been carried out with the purpose of bringing the actuator close to failure, by progressive fault injection in overload operating conditions. A feature named Σ, that is, the mean of the RMS of the three phase currents (the input to the electric motor), is proposed as a parameter for HM. The effectiveness of this parameter in detecting the mechanical transmission degradation is experimentally proven. The degradation has been confirmed by visual inspection and screw thread profile measurements. In spite of this, the actuator is still able to perform position tracking in an effective way.

14:20-14:40 — ThuB05.2

Robust Time-Varying Sensor Bias Estimation for Bounded-Error Systems: Application to the Wind Turbine Benchmark, pp. 679-684

Witczak, Marcin — Univ. of Zielona Gora
Pazera, Marcin — Univ. of Zielona Gora
Puig, Vicenç — Univ. Pol. De Catalunya (UPC)
Mrugalski, Marcin — Univ. of Zielona Gora

The objective of this paper is to propose a novel approach for simultaneous state and time-varying sensor bias estimation of dynamic systems. The main advantage of the presented strategy is its simplicity along with robustness to exogenous bounded disturbances. The proposed approach belongs to the wide class of the so-called bounded-error approaches. It constitutes an attractive alternative to the stochastic Kalman-filer-based framework as no knowledge about disturbances/noise distribution is required. The only preliminary requirement is the knowledge about their upper and lower bounds. In this paper, it is assumed that their belong the the ellipsoidal set. Under such an assumption, a novel estimator is proposed along with a comprehensive convergence analysis. It is worth to note that, the convergence analysis is realised with the so-called quadratic boundedness approach. The final part of the paper concerns application of the proposed approach to the wind turbine benchmark.

14:40-15:00 — ThuB05.3

Fault-Tolerant Disturbance Observer Based Control for Altitude and Attitude Tracking of a Quadrotor, pp. 685-690

Baldini, Alessandro — Univ. Pol. Delle Marche
Felicetti, Riccardo — Univ. Pol. Delle Marche
Freddi, Alessandro — Univ. Pol. Delle Marche
Longhi, Sauro — Univ. Pol. Delle Marche
Monteriù, Andrea — Univ. Pol. Delle Marche

This paper presents an attitude and altitude fault-tolerant tracking control for a quadrotor using the Disturbance Observer Based Control (DOBC). A Newton-Euler model of the quadrotor is described and the fault-tolerant control problem is treated for small angles. An appropriate estimation gain is proposed for the considered system, which allows to impose desired closed loop performances. These closed loop performances are analysed, showing the boundedness properties, and highlighting the trade off between fault estimation and control effort. Numerical simulations are provided for testing the effectiveness of the proposed DOBC solution, which is compared with the classical backstepping controller in case of multiple actuation faults.

15:00-15:20 — ThuB05.4

Sparse Reconstruction-Based Contribution for Multiple Fault Isolation by KPCA, pp. 691-696

Mourot, Gilles — Univ. De Lorraine
Kallas, Maya — Univ. De Lorraine / CRAN UMR 7039
Anani, Kwami Dodzivi — Univ. De Lorraine
Maquin, Didier — Univ. De Lorraine

This paper addresses the problem of multiple fault isolation based on kernel principal component analysis and proposes a sparse fault estimation method to evaluate the reconstruction-based contribution. The fault magnitude estimation is here formulated as an optimization problem under nonnegativity and sum-to-one constraints. A multiplicative iterative scheme and its initialization procedure are proposed to solve it. The effectiveness of the proposed method is demonstrated on the simulated continuous stirred tank reactor (CSTR) process.

15:20-15:40 — ThuB05.5

Learning Observer-Based Robust H∞ Fault-Tolerant Control for T-S Fuzzy Descriptor Systems with Time-Delay, pp. 697-702

Kharrat, Dhouha — Univ. of Picardie Jules Verne
Gassara, Hamdi — Univ. of Picardie Jules Verne
El Hajjaji, Ahmed — Univ. De Picardie-Jules Verne
Chaabane, Mohamed — National Engineering School of Sfax, Tunisia

This brief is concerned with the problem of learning observer-based robust H∞ fault-tolerant Control (FTC) for Takagi-Sugeno (T-S) fuzzy descriptor systems with time-delay affected by both actuator faults and external disturbances. The learning observer allows simultaneous the estimation of system states and actuator faults. Based on the state estimation and the actuator fault reconstruction, a FTC is designed to maintain the performance of the faulty system. Using the H∞ optimization technique, the analysis and design conditions of the fuzzy learning observer-based FTC are provided and then formulated into a set of delay dependent linear matrix inequalities (LMIs) which can be solved in a single step. An example is finally presented to validate our findings.

FriA01 Kolovare

Fault Diagnosis and Fault Tolerant Control 2 (Regular Session)

Chair: Boutalis, Yiannis — Democritus Univ. of Thrace
Co-Chair: Marx, Benoit — Univ. De Lorraine

09:00-09:20 FriA01.1

State Estimation and Fault Detection for 2-D Discrete-Time Systems, pp. 703-708

Ichalal, Dalil — IBISC Lab, Univ. Evry
Marx, Benoit — Univ. De Lorraine
Ragot, Jose — Univ. De Lorraine

This paper presents an observer based sensor fault diagnosis for 2-D systems. Firstly, a state observer is designed by taking into account the measurements in a fixed length sliding window. Secondly, structured residual signals are generated by a bench of finite memory state observers which allow to detect and isolate sensor faults affecting the system. Finally, simulation results are given to illustrate the proposed approach.

09:20-09:40 FriA01.2

Motor Fault Detection and Diagnosis Using Fuzzy Cognitive Networks with Functional Weights, pp. 709-714

Karatzinis, Georgios — Democritus Univ. of Thrace
Boutalis, Yiannis — Democritus Univ. of Thrace
KARNAVAS, YANNIS — Democritus Univ. of Thrace

A Fuzzy Cognitive Network (FCN) is an operational extension of a Fuzzy Cognitive Map (FCM) which incorporates proven stability and guaranteed exponentially-fast error convergence to zero during its training and supports at the same time the continuous interaction with the system it describes. FCN is a suitable, reliable and very powerful FCM structure for system identification, control applications and adaptive decision making because of its convergence based operational architecture. In this paper we introduce the FCN based classifier and apply it on a motor fault detection problem. We use also an alternative form of the network that assumes functional interconnection weights which improves its performance. A benchmark data set is used for condition monitoring of rolling bearings, consisting of motor current and vibration signals. Statistical features are extracted from both current and vibration signals and are combined together to enhance the diagnosis performance of the model. The classification accuracy of the proposed approach shows that the FCN based classifier can be used as a very reliable diagnostic tool for motor fault detection and diagnosis.

09:40-10:00 FriA01.3

Positive Unknown Input Observer for Fault Detection of Positive Distributed Systems, pp. 715-720

Nazari, Sam — Northeastern Univ
Shafai, Bahram — Northeastern Univ

We consider robust fault detection in distributed systems with first and second order agent models. In such systems, we show that a ubiquitous class of consensus protocols leads to collective dynamics that lie in a nonnegative invariant set. Based on this, we derive LMI conditions for residual generators to sense faults in the nonnegative invariant set. An illustrative example is provided to highlight our approach and to show that it can reduce the time interval between fault occurrence and fault detection.

10:00-10:20 FriA01.4

Distributed Multi-Equilibria Consensus in the Presence of Byzantine Adversaries and Time Delays, pp. 721-726

Oksuz, Halil Yigit — Bogazici Univ
Akar, Mehmet — Bogazici Univ

In this paper, fault tolerant multi-equilibria consensus computation is studied when the thread model is considered as structured Byzantine (StrBYZ). First, a brief review on graph theoretic concepts that we use throughout this paper is provided. Then, the structured Byzantine fault model is presented by considering the general Byzantine misbehaviour. It is shown that non-faulty nodes achieve consensus on K equilibria if there are K number of primary and secondary layers with non-faulty root nodes, each of which contains StrBYZ agents having at least one in-neighbor in the network. The analysis is extended to the case where the network has bounded uniform/non-uniform time delays on its communication links. The results are verified by numerical examples.

FriA02 Meeting Room 1

Disturbance Rejection (Regular Session)

Chair: Kouvakas, Nikolaos — Sterea Ellada Inst. of Tech
Co-Chair: Aitouche, Abdel — CRISTAL/HEI

09:00-09:20 FriA02.1

An MPC with Disturbance Forecasting for the Control of the Level of a Tank with Limited Buffer Capacity, pp. 727-734

Borghesan, Francesco — Imperial Coll. London
Chioua, Moncef — Abb Ag
Thornhill, Nina — Imperial Coll. London

The paper deals with the behavior of an MPC for the control of a level of a tank, whose inflow is subject to persistent plantwide disturbances. It is shown that the response of an industrial MPC can be aggressive and oscillatory in such situations. The result is that the disturbance propagates further. The reason is the assumption made by the industrial MPCs regarding the future evolution of the disturbance. To improve the response in presence of plantwide disturbances, an MPC with disturbance forecasting is proposed. Such MPC is able to handle tight constraints and still reduce the movement of the outflow of the tank, therefore reducing the disturbance propagation. To compare the MPC with prediction forecasting with other two strategies used in industrial practice to handle measured disturbances, the paper uses sinusoidal disturbances and real disturbances coming from a refinery.

09:20-09:40 FriA02.2

Sideslip Angle Estimation of Ground Vehicles in a Finite Frequency Domain through H∞ Approach, pp. 735-740

El Hellani, Doha — MIS, Upjv
El Hajjaji, Ahmed — Univ. De Picardie-Jules Verne
Ceschi, Roger — F'sati, Cput
Aitouche, Abdel — CRISTAL/HEI

This paper studies the sideslip angle estimation problem of a ground vehicle in a finite frequency (FF) domain. The main objective is to estimate the sideslip angle using the yaw rate measurements. Filter design conditions are developed based on the uncertain lateral dynamics model, and time domain interpretations of the kalman Yakubovich Popov lemma (GKYP lemma). The designed filter ensures that the estimation error system is stable and has a prescribed H∞ attenuation level, over a specified FF domain of the vehicle steering angle. Simulation results are presented to demonstrate the effectiveness of the proposed approach.

09:40-10:00 FriA02.3

Delayless Controllers for Triangular Decoupling with Simultaneous Disturbance Rejection of General Neutral Time Delay Systems, pp. 741-746

KOUMBOULIS, FOTIOS — Sterea Ellada Inst. of Tech
Kouvakas, Nikolaos — Sterea Ellada Inst. of Tech

The problem of Triangular decoupling with simultaneous Disturbance Rejection (TDDR) is studied for the class of general neutral multi delay systems with measurable disturbances via delayless controllers. The delayless controllers are of the measurement output feedback type with compensation of the measurable disturbances. The cases of dynamic and static

controllers are studied separately. For both cases, the necessary and sufficient conditions for the problem to have a solution are established and the general form of the delayless controller matrices solving the problem are derived.

10:00-10:20 FriA02.4

Discrete-Time IDA-PBC for Underactuated Mechanical Systems with Input-Delay and Matched Disturbances, pp. 747-752

Franco, Enrico Imperial Coll. London

This work investigates the control problem of discrete-time underactuated mechanical systems with fixed input-delay and matched disturbances. A new control strategy is proposed, which builds upon a discrete-time implementation of the interconnection-and-damping-assignment passivity-based control (IDA-PBC) and extends it in two ways: the disturbances are estimated adaptively; the input-delay is compensated with a recursive algorithm. The resulting control law is constructed from IDA-PBC without solving any additional partial-differential-equation (PDE). Stability conditions are discussed and compared to alternative designs. Numerical simulations for the ball-on-beam system and for the Acrobot system demonstrate the effectiveness of the proposed approach.

10:20-10:40 FriA02.5

Combined Design of Adaptive Sliding Mode Control and Disturbance Observer with Friction Compensation for a Feed Drive System, pp. 753-758

Farrage, Abdallah Assiut Univ
Uchiyama, Naoki Toyohashi Univ. of Tech

Mechanical friction and disturbance are the key issues in precision control of mechanical systems especially in computer numerical controlled (CNC) feed drives. The friction does not only deteriorate the motion accuracy but also increases consumed energy of machining process. Feed drives have diverse applications and operate for a long time over the world, and therefore energy saving is highly expected. This paper proposes a combined design of adaptive sliding mode control and disturbance observer with a nonlinear static friction compensation to improve the motion accuracy and save consumed energy of a biaxial feed drive system. The friction compensator is designed based on a nonlinear friction model. Contour error, which is defined as the shortest distance between the actual position and the reference trajectory, is more important on the machining accuracy than the tracking error in each axis, and therefore contouring controllers are designed by feeding back contour errors. The disturbance observer and friction compensator are integrated into sliding mode contouring control and adaptive sliding mode contouring control. In order to verify the effectiveness of the combined design, comparative experiment was carried out with a biaxial feed drive system. The proposed approach effectively improved the contouring performance and achieved a significant reduction of the consumed energy.

FriA03 Meeting Room 2

Nonlinear Systems and Control 1 (Regular Session)

Chair: Ramp, Michalis National Tech. Univ. of Athens (NTUA)
Co-Chair: Katayama, Hitoshi Shizuoka Univ

09:00-09:20 FriA03.1

On Negotiating Aggressive Quadrotor Attitude Tracking Maneuvers under Actuator Constraints, pp. 759-764

Ramp, Michalis National Tech. Univ. of Athens (NTUA)
Papadopoulos, Evangelos National Tech. Univ. of Athens

The quadrotor task of negotiating aggressive attitude maneuvers while adhering to motor constraints is addressed here. The majority of high level quadrotor Nonlinear Control Systems (NCS) ignore motor control authority limitations, especially important during aggressive attitude maneuvers, generating unrealizable thrusts and negating the validity of the accompanying stability proofs. Here, an attitude control framework is developed, comprised by a thrust allocation strategy and a specially designed geometric attitude tracking controller, allowing the quadrotor to achieve aggressive attitude maneuvers, while complying to actuator constraints and simultaneously staying ”close” to a desired position command in a computationally inexpensive way. This is a novel contribution resulting in thrusts realizable by available quadrotors during aggressive attitude maneuvers, and enhanced performance guaranteed by valid stability proofs. Also, it is shown that the developed controller can be combined with a collective thrust expression in producing a position/yaw tracking controller. Through rigorous stability proofs, both the position and attitude frameworks are shown to have desirable closed loop properties that are almost global. This establishes a quadrotor control solution allowing the vehicle to negotiate aggressive maneuvers position/attitude on SE(3). Simulations validate the effectiveness/capabilities of the developed solution.

09:20-09:40 FriA03.2

Effect of Delay of Immune System Response in Cancer Dynamics: Bifurcation and Chaos Analysis, pp. 765-770

Naseri Soufiani, Babak Gazi Univ
SALAMCI, Metin U. Gazi Univ

The mathematical models of cancer dynamics consider interactions between different cells and give a deep understanding the progress of the tumor growth. In most of the cases, the proposed models are formed by assuming that the interactions occur in the exact times, i.e., no delay is incorporated into the models. On the other hand, this assumption may not be valid as the interactions could have possible delays. The purpose of this paper is to determine the effect of delay interactions between tumor cells and immune system cells. By adding delay time to the cancer model, behavior of the new model is analyzed. In this paper, we investigate the stability of equilibria points, Hopf bifurcation and chaotic behavior of the system. The critical value of time delay is computed by an analytical method. Finally, we show that increasing the delay time will lead series of bifurcations to chaos.

09:40-10:00 FriA03.3

$mathcal{H}_infty$ Observer-Based Controller for Lipschitz Nonlinear Discrete-Time Systems, pp. 771-775

GASMI, Noussaiba Univ. of LORRAINE
Boutayeb, M. Lorraine Univ
THABET, ASSEM Univ. OF GABES
Aoun, Mohamed National Engineering School of Gabes, Tunisia. Res. Unit Of

Within the paper, a relevant $mathcal{H}_infty$ observer-based controller design for a class of Lipschitz nonlinear discrete-time systems is proposed. Usually, Bilinear Matrix Inequaities (BMIs) are obtained from the resolution of the observer-based stabilization design problem for this class of systems. Since, the resolution of a BMI is a hard task, then it is interesting to search for a convenient way to linearize the obtained conditions. Therefore, the objective of this paper is to present new Linear Matrix Inequality (LMI) conditions ensuring the convergence of the observer-based controller in a noisy context. Thanks to the introduction of a slack variable the presented LMI conditions are more general and less conservative than the existence ones. Indeed, reformulations of the Lipschitz property and Young's relation in a convenient way lead to a more relaxed new LMI. A numerical example is implemented to show high performances of the proposed design methodology with respect to some existing results.

10:00-10:20 FriA03.4

Output Feedback Stabilization and Asymptotic Performance Recovery for Input-Affine Sampled-Data Strict-Feedback Systems, pp. 776-781

Katayama, Hitoshi — Shizuoka Univ

In this paper output feedback stabilization and asymptotic performance recovery are considered for input-affine sampled-data strict-feedback systems. It is shown that output feedback stabilization and asymptotic performance recovery can be achieved by combining an emulation of continuous-time globally asymptotically stabilizing state feedback controllers with reduced-order observers that are semiglobal and practical in a sampling period. A numerical example is also given to illustrate the efficiency of the proposed output feedback controllers.

10:20-10:40 — FriA03.5

Geometric Surface-Based Tracking Control of a Quadrotor UAV for Aggressive Maneuvers, pp. 782-787

Ramp, Michalis — National Tech. Univ. of Athens (NTUA)

Papadopoulos, Evangelos — National Tech. Univ. of Athens

New quadrotor UAV control algorithms are developed, based on nonlinear surfaces composed of tracking errors that evolve directly on the nonlinear configuration manifold, thus inherently including in the control design the nonlinear characteristics of the SE(3) configuration space. In particular, geometric surface-based controllers are developed and are shown, through rigorous stability proofs, to have desirable almost global closed loop properties. For the first time in regards to the geometric literature, a region of attraction independent of the position error is identified and its effects are analyzed. The effectiveness of the proposed 'surface based' controllers are illustrated by simulations of aggressive maneuvers in the presence of disturbances and motor saturation.

FriA04 — Meeting Room 3

Signal and Image Processing (Regular Session)

Chair: Manesis, Stamatios — Univ. of Patras

Co-Chair: Kapetanović, Nadir — Univ. of Zagreb, Faculty of Electrical Engineering and Computing

09:00-09:20 — FriA04.1

Position Tracking and Control of Lightweight Flexible Joint Manipulator Robolink Using Kinect Sensor, pp. 788-793

Stathopoulos, Ioannis — Univ. of Patras

Papandreou, Foivos — Univ. of Patras

Manesis, Stamatios — Univ. of Patras

In this article, a method of feedback data acquisition and target recognition using Kinect sensor is proposed, in order to perform position trucking and control of Robolink® articulated arm. Robolink is a lightweight flexible joint robotic manipulator, the rotational joints of which are driven by step motors through Dyneema wires. The goal of the presented experimental work was to investigate the possibility to use Robolink in fruit picking systems and other similar works. At an early stage, Lidar sensors were also used for Robolink indoor behavior experimentation. Feedback data management and control law, based on the kinematics of this lightweight flexible robotic arm are also analyzed and presented from the efficiency point of view.

09:20-09:40 — FriA04.2

Desensitized Filtering for Systems with Uncertain Parameters and Noise Correlation, pp. 794-799

Tabacek, Jaroslav — Czech Tech. Univ. in Prague

Havlena, Vladimir — Honeywell ACS AT Lab

This paper introduces estimation algorithms for systems with uncertain parameters and correlated noises. The algorithms are derived using the standard Kalman filter for correlated noises and the desensitized filtering technique for systems with uncertain parameters. A general algorithm and its special case are proposed. The latter updates statistics with explicit expressions, which makes it simpler and faster. The extended forms of the algorithms, which can be used for nonlinear systems, are also introduced. The developed algorithm is tested on an example, where the importance of the noise correlation information is shown.

09:40-10:00 — FriA04.3

Attitude and Rate Sensor Bias Estimation for Underwater Vehicles, pp. 800-806

Jørgensen, Erlend Kvinge — Norwegian Univ. of Science and Tech. (NTNU)

Schjølberg, Ingrid — Norwegian Univ. of Science and Tech. (NTNU)

This paper considers the problem of estimating attitude and rate sensor bias for underwater vehicles, having both proven stability and close-to-optimal performance with respect to noise. Accurate and stable attitude estimates are necessary when performing autonomous underwater operations, and in this paper a novel filter is proposed for estimating attitude and rate sensor bias, using only acoustic and rate sensor measurements. This can provide more robust attitude estimation, as well as enable more accurate accelerometer bias estimation. The suggested filter is proven to be globally exponentially stable except for known singular points, and is based on the eXogenous Kalman Filter principle, in which an estimator with proven stability provides a linearization point for a Linearized Kalman Filter. Experimental validation is provided, and the suggested filter converges and stays close to the true states. The suggested filter is also compared to the conventional Extended Kalman Filter, and a non implementable Linearized Kalman Filter using the true state as linearization point.

10:00-10:20 — FriA04.4

Robust 𝓗 ∞ Filter for Uncertain Continuous-Time Systems with Finite Frequency Ranges, pp. 807-812

El Amrani, Abderrahim — Univ. Sidi Mohamed Ben Abdellah

BOUKILI, Bensalem — Sidi Mohamed Benabdellah Faculte Des Sciences Dharelmahrazfes

El Hajjaji, Ahmed — Univ. De Picardie-Jules Verne

This paper examines the 𝓗∞ robust filtering problem for uncertain continuous-time systems with finite frequency (FF) specifications. Our goal is to design a new filter that ensures 𝓗∞ performance in specific finite frequency ranges. By virtue of the generalized Kalman-Yakubovich-Popov lemma (gKYP), the Finsler's lemma, the polynomially parameterdependent Lyapunov function and a decoupling technique, sufficient conditions to characterize this problem in terms of linear matrix inequalities (LMIs) are established. Finally, we demonstrate by numerical example that our method can achieve a much smaller approximation error than the existing results.

FriA05 — Meeting Room 4

Control in Smart Cities (Invited Session)

Chair: Lesic, Vinko — Univ. of Zagreb

Co-Chair: Stamatescu, Grigore — Univ. Pol. of Bucharest

Organizer: Lesic, Vinko — Univ. of Zagreb

Organizer: Stamatescu, Grigore — Univ. Pol. of Bucharest

09:00-09:20 — FriA05.1

Data Center Server Energy Consumption Optimization Algorithm (I), pp. 813-818

Stamatescu, Iulia — Pol. Univ. of Bucharest

Ploix, Stephane — Inst. National Pol. De Grenoble

FAGARASAN, IOANA — Univ. Pol. of Bucharest

Stamatescu, Grigore — Univ. Pol. of Bucharest

Understanding, modelling and reducing data center power consumption is a complicated undertaking. Individual data centers are highly complex systems, with a number of interacting mechanical, electrical and computational subsystems. The paper presents an optimization algorithm which reduces the energy consumed by the informational systems by assign virtual machines to physical servers. This action is achieved taking into account the different degrees of freedom of the used resources. The considered problem is formulated as a mixed integer linear programming problem where all transfer functions, constraint functions and objective function are expressed under a linear form.

09:20-09:40 FriA05.2

Energy-Efficient Train Traction Control on Complex Rail Configurations (I), pp. 819-824

Novak, Hrvoje	Univ. of Zagreb, Faculty of Electrical Engineering and Comp
Vašak, Mario	Univ. of Zagreb

In the presented work, control system for energy-efficient train operation with inclusion of a detailed train motion model and a varying rail path configuration is developed. Piecewise affine train model is constructed with the parameters obtained for the electromotive train manufactured by Croatian train producer company Končar - Electric Vehicles Inc. The model encompasses intrinsic features of the train system such as linearized resistance force, various traction and braking force limitations and passengers comfort constraints. Curves and slopes are introduced as rail path segments with different resistance forces and incorporated in the optimization procedure. The resulting quadratic optimization problem is solved parametrically through dynamic programming with the off-line precomputed optimal control law obtained as a function of train speed and traversed path. Control system is evaluated on a simulation scenario with Končar's electromotive train and a rail path configuration with a varying slope.

09:40-10:00 FriA05.3

Price-Optimal Energy Flow Control of a Building Microgrid Connected to a Smart Grid (I), pp. 825-830

Marušić, Danko	Univ. of Zagreb, Faculty of Electrical Engineering and Comp
Lesic, Vinko	Univ. of Zagreb
Capuder, Tomislav	Univ. of Zagreb, Faculty of Electrical Engineering and Comp
Vašak, Mario	Univ. of Zagreb

This paper discusses model predictive control for energy flows in a microgrid as a part of the overall hierarchical organization of energy management in a building. The control is performed in the presence of time-varying building and grid conditions: weather-dependent production, energy prices and consumption. Detailed analysis of microgrid energy and operation cost is presented with real weather data and energy prices, building dynamics and optimal building consumption. Cost-optimal interaction between the building-side energy management system and the grid in conditions of volatile energy price and possibility of building's active participation in the energy market is proposed. Model predictive controller for optimizing total economic cost of energy and microgrid operation is implemented and verified on a model of a building belonging to University of Zagreb, Faculty of Electrical Engineering and Computing, using actual test site data for 2014. Reduction of maximum power, minimization of energy consumption, storage degradation during operation, day-ahead energy profile following and intra-day deviations as energy market incentives are included in the cost function for ensuring building ancillary services as a prosumer in the smart grid.

10:00-10:20 FriA05.4

Energy Management Strategy in a Residential Battery Energy Storage System, pp. 831-836

Galatsopoulos, Charalampos	Centre for Res. and Tech. Hellas (CERTH)
Papadopoulou, Simira	Alexander Tech. Educational Inst
Ziogou, Chrysovalantou	Centre for Res. and Tech. Hellas (CERTH)
Voutetakis, Spyridon	Centre for Res. and Tech. Hellas (CERTH)

Abstract—This paper examines the issue of energy management in a residential Battery Energy Storage System (BESS). The development of the energy management strategy (EMS) involves the modeling of the BESS and the modeling of a prediction aging mechanism for the Lithium Ion battery stack. In addition, EMS comprises the identification of the needs and requirements for energy management in a dynamic pricing environment where the Power Supplier (GRID) is the monadic source of power to the resident and to the BESS. The main objective of the proposed EMS is to prevent the fast aging of the Lithium-Ion batteries with respect to the maximum financial benefits for the consumer. Moreover, due to the dynamic pricing environment and the uncertainty that the forecast energy demand will match the actual energy demand, the ability of the EMS to update the proposed strategy during the day on hourly basis can be deemed vital. Indicative results of the proposed method are presented in order to demonstrate the ability of the BESS's to provide an optimal solution for covering the maximum energy demand with the minimum degradation effects for the batteries.

10:20-10:40 FriA05.5

Distributed Optimal Batteries Charging Control for Heterogenous Electric Vehicles Fleet (I), pp. 837-842

Bucić, Petra	Univ. of Zagreb, Faculty of Electrical Engineering and Comp
Lesic, Vinko	Univ. of Zagreb
Vašak, Mario	Univ. of Zagreb

Road vehicles are big consumers of energy and their transition to electricity supply rises a need for optimal charging control. We consider the case of electric vehicles fleet battery management process that utilizes the battery for supporting smart building operation. The paper presents a centralised and a distributed control method for cost-optimal battery management that include the electric vehicle battery model. Distributed control is used to achieve privacy and transparent charging costs for each vehicle while still achieving the same level of revenue as the centralised control. Here, the central operator acts only as a middle point in communication between various heterogeneous agents and coordinates them to respect global constraints. Charging stations themselves are entrusted to satisfy the local constraints. In this way, the privacy of the information related to specifications of charging station, users demands and behaviour pattern are kept. Most of all, the independence of vehicles and central operator is achieved. Distributed optimal batteries charging control for electric vehicles fleet is implemented by using an asymmetric projection algorithm. Management of electric vehicles fleet charging is considered as a part of hierarchical building energy management where prices and constraints on cumulative fleet charging profiles are obtained from a higher-level instance. Given results show high matching with an equivalent centralised problem based on quadratic programming.

FriB01 Kolovare

Automotive Control (Regular Session)

Chair: Aitouche, Abdel	CRISTAL/HEI
Co-Chair: Vašak, Mario	Univ. of Zagreb

13:30-13:50 FriB01.1

Air-Path Control for a Prototype PCCI Diesel Engine, pp. 843-848

Malan, Stefano Alberto	Pol. Di Torino

Ventura, Loris Pol. Di Torino

The tightening in diesel engines regulations for emissions control forced the automotive industry to face the challenge coming from these constraints. This led to an increase in the overall engine complexity, in both, mechanical and software domains. For what concerns this paper the increased complexity means to deal with and to manage the cross coupled and nonlinear behavior of the engine air-path. Here we propose a control system able to manage under steady-state conditions the airflow through the engine with the purpose of ensuring a smooth Premixed Charge Compression Ignition combustion behavior using the most simple and economical structure possible. The objective was to design a controller capable to handle the three air-path devices of Exhaust Gas Recirculation, Variable Geometry Turbochargers and flap valve all together. Modeling of the system and control design are the two main areas on which we focused our attention in order to retrieve simplicity and system economy. All the trials needed to design the air-path controller were carried out on the mono-dimensional simulation software GT-Power by Gamma Technologies that has proven to be very effective in the simulation domain. The model was created by FPT Industrial and provided to us together with the engine. Based on that model we derived all our computations, in terms of system identification and validation, that lead us to a feed-forward plus feedback control structure capable to cover the whole engine operating area. Simulations show very encouraging results also in presence of high disturbances in the outputs.

13:50-14:10 FriB01.2

Side-Slip Angle Estimation of Autonomous Road Vehicles Based on Big Data Analysis, pp. 849-854

Fényes, Dániel MTA SZTAKI Inst. for Computer Science and Control
Nemeth, Balazs Hungarian Acad. of Sciences
Asszonyi, Máté HUNGARIAN Acad. OF SCIENCES Inst. FOR COMPUTER SCIENCE AND
Gaspar, Peter Mta Sztaki

The paper proposes a side-slip angle estimation method for autonomous road vehicles using a big data approach. The core of the solution is that on-board signals of numerous autonomous vehicles are available, which can be used to generate the side-slip estimator. The estimation is based on the ordinary linear regression method with OLS subset selection using large amount of data collected from the car sensors. The advantage of the proposed solution is that the numerically complex data mining operations are performed off-line, while the side-slip angle estimation of the vehicle using only its own on-board signals requires low computation effort. The efficiency of the estimation is presented through several CarSim simulations, in which the parameters of the vehicle and the road are varied. Moreover, the method is compared to the simulation results of a sensor fusion based Kalman filtering method.

14:10-14:30 FriB01.3

Complete Odometry Estimation of a Vehicle Using Single Automotive Radar and a Gyroscope, pp. 855-860

Ghabcheloo, Reza Tampere Univ. of Tech
Siddiqui, Shadman Razzaq U-Blox

In this paper, we propose an algorithm for complete odometry of a vehicle on a horizontal plane, that is, estimation of linear velocity vector (forward and sideslip speeds) and angular speed of a vehicle. The vehicle is equipped with an automotive Radar sensor and a vertical gyro. The Radar sensor provides radial speed and azimuth angle of number of objects in the environment. We first derive the kinematic constraints imposed on the vehicle motion and stationary points in the environment. Using the constraints we classify the points detected by the Radar to stationary and non-stationary points. It is known that using data from a single Radar, the above-mentioned constraints are singular. Previous works have thus proposed the use of more than one Radar sensor, or they have neglected the sideslip speed. In our work, we then use the Radar data of the stationary objects and a gyro data to solve an optimization algorithm to calculate vehicle odometry. Experimentation has been performed with a non-road vehicle driven on a straight path and on a circular path. We report our findings and show efficacy of the algorithm in comparison to the state of art [8] as well as wheel odometry and a complete navigation solution (including GNSS) as the reference path.

14:30-14:50 FriB01.4

Fuzzy Sliding-Mode Observer for Lateral Dynamics of Vehicles with Consideration of Roll Motion, pp. 861-866

El Youssfi, Naoufal USMBA
Oudghiri, Mohammed Univ. of Picardie Jules Verne
Aitouche, Abdel CRISTAL/HEI
El Bachtiri, Rachid EST; Univ. Sidi Mohamed Ben Abdellah;

This paper focuses on the methodology of estimating dynamic states of the vehicle, by a sliding-mode observer(SMO). The vehicle is represented by the fuzzy model of Takagi Sugeno (TS). The main contribution of this article is the development of a robust observer with the synthesis of sufficient stability conditions of this observer. This representation is used to take into account the non-linearities of the lateral forces. The stability of the fuzzy observer is given by the Lyapunov approach; the stability conditions of this observer are expressed in terms of linear matrix inequalities (LMI). The simulation results show the effectiveness of the proposed observer in estimating the states ofthe vehicle dynamics.

14:50-15:10 FriB01.5

Modelling and Control of a Self-Balancing Electric Motorcycle: Preliminary Results, pp. 867-872

Del Rosso, Verdiana Univ. of Camerino
Andreucci, Andrea Visionar Srl
Boria, Simonetta Univ. of Camerino
Corradini, Maria Letizia Univ. Di Camerino
Giambo, Roberto Univ. Di Camerino
Ranalli, Antonio Visionar Srl

In four-wheeled vehicles, electronic stability control (ESC) was introduced in the recent past to improve passengers' safety in critical driving conditions. On the other hand, the development of electronic systems for two-wheeled vehicles has started with considerable delay with respect to their four-wheeled counterparts and the design of such a riderless control system has not been thoroughly investigated at low speed and without the use of steering torque. In this paper a riderless self-balancing two wheel drive electric motorcycle mathematical model - based on Lagrange's equations - with a sliding mode control strategy is put forward to cover this deficiency at low speed range. Moreover, the study would find out whether at low speed front wheel torque could help vehicle stabilization when steering handlebar can not be actuated. For these reasons, in the proposed model the steering axis is locked over time and both front and rear wheel driving torques could be chosen as control inputs. The paper also presents a model validation with a multibody software.

FriB02 Meeting Room 1

Identification (Regular Session)

Chair: Bai, Er-Wei Univ. of Iowa
Co-Chair: Petric, Frano Univ. of Zagreb

13:30-13:50 FriB02.1

Ranking Variables Based on Goodness of Fits in Nonlinear Nonparametric System Identification, pp. 873-878

Bai, Er-Wei Univ. of Iowa

Identification of a high dimensional nonlinear nonparametric system is costly. On the other hand for many real-world

problems, they are sparse in the sense that not all variables contribute or contribute significantly. If these variables that do not contribute or contribute little can be identified and removed prior to system identification, the identification problem is of lower dimension. In this paper, methods to rank variables based on the Goodness of Fits are proposed without full scale identification.

13:50-14:10 FriB02.2

Wind Estimation for Fixed-Wing Aircraft Using Command Tracking Approach, pp. 879-884

Hong, Haichao	Beijing Inst. of Tech
Wang, Mengmeng	Beihang Univ
Holzapfel, Florian	Tech. Univ. München
Tang, Shengjing	Beijing Inst. of Tech

This paper addresses a three-dimensional wind estimation problem for fixed-wing aircraft based on the tracking model predictive static programming which was originally proposed for trajectory tracking control. Without relying on any airflow measurement, the wind velocity is estimated by considering the wind vector as a virtual control input. The wind vector is corrected in real time so that the model output tracks the measured kinematic velocity states in a command-tracking manner. The proposed method features a closed-form solution and a fast indication of wind variations. The effectiveness of the proposed method is illustrated by numerical simulations in the presence of measurement noises.

14:10-14:30 FriB02.3

H^∞ Model Reduction for Two-Dimensional Discrete Systems in Finite Frequency Ranges, pp. 885-890

El Amrani, Abderrahim	Univ. Sidi Mohamed Ben Abdellah
El Hajjaji, Ahmed	Univ. De Picardie-Jules Verne
BOUKILI, Bensalem	Sidi Mohamed Benabdellah Faculte Des Sciences Dharelmahrazfes
hmamed, abdelaziz	Faculty of Sciences Dhar Elmehraz Fes

This paper examines the H^∞ design problem of the reduced order model for two-dimensional (2D) discrete systems described by the Roesser model with a control input assumed to operate in a finite frequency (FF) domain. Given an asymptotically stable system; our goal is to find a stable reduced order system so that the error of the transfer functions between the original system and the reduced order is limited to a range FF. Using the well-known generalized lemma of Kalman Yakubovich Popov (gKYP) and the Finsler's lemma, sufficient conditions for the existence of the reduction of the H^∞ model for different FF ranges are proposed and then unified in terms of solving a set of linear matrix inequalities (LMIs). An illustrative example is provided to show the utility and potential of the proposed results.

14:30-14:50 FriB02.4

System Identification of a CNC Machining Center with Support Vector Machines, pp. 891-896

Ay, Muzaffer	RWTH Aachen Univ
Stemmler, Sebastian	RWTH Aachen Univ. Aachen
Abel, Dirk	RWTH Aachen Univ
Schwenzer, Max	RWTH Aachen Univ
Klocke, Fritz	RWTH Aachen Univ

Support Vector Machines (SVM) is a machine learning algorithm with inherent generalization ability and a convex optimization problem. This paper studies the application of the SVM method for the online identification of the nonlinear dynamic behavior of the feed velocity in a CNC machining center. Both blackbox and greybox modeling approaches are tested for this purpose. Within the German Cluster of Excellence ”Integrative Production Technology for High-Wage Countries”, a modelbased predictive control (MPC) strategy with a linear state-space model is already implemented for the feed velocity of the CNC machining center. Due to nonlinearities, the model of the controlled system has to be identified and updated during the process. Therefore, the SVM method should be used to recurrently identify a model in every time-step. Additionally, the identified models should be capable of being formulated in a linear state-space model. The methodology is validated with measured data from the CNC machining center. The gained results for the blackbox and greybox approaches show only small deviations from the measured behavior of the system.

FriB03 Meeting Room 2

Nonlinear Systems and Control 2 (Regular Session)

Chair: Ailon, Amit	Ben Gurion Univ. of the Negev
Co-Chair: Konstantopoulos, George	The Univ. of Sheffield

13:30-13:50 FriB03.1

Steering-Based Controllers for Stabilizing Lean Angles in Two-Wheeled Vehicles, pp. 897-902

Ailon, Amit	Ben Gurion Univ. of the Negev
Arogeti, Shai	Ben-Gurion Univ. of the Negev

This study considers the lean angle stability problems in steering controlled tilting vehicles. Despite the fact that the considered nonlinear nonminimum phase model ignores some dynamic characteristics of the real system (we ignore wheel sleeping and wheel inertia), yet it captures important properties of the vehicle dynamics. We establish a stabilizing control strategy for the lean angle of the vehicle. To eliminate impulse behavior (due to the appearance of the derivative of the steering angle) we propose using Lyapunov stability theory a continuous feedback loop for the steering input signal that ensures exponential stability of a desired lean angle. The process of stabilizing a desired lean angle does not imply trajectory tracking, however the current approach can be extended to yield further results regarding trajectory tracking for the complicated model of a two-wheeled vehicle system like bicycles and motorcycles.

13:50-14:10 FriB03.2

Dichotomy and Stability of Disturbed Systems with Periodic Nonlinearities, pp. 903-908

Smirnova, Vera B.	Saint-Petersburg State Univ
Proskurnikov, Anton	Delft Univ. of Tech
Utina, Natalia	St. Petersburg State Univ. of Architecture and Civil Engine
Titov, Roman	St.Petersburg State Univ. of Architecture and Civil Enginee

Systems that can be decomposed as feedback interconnections of stable linear blocks and periodic nonlinearities arise in many physical and engineering applications. The relevant models e.g. describe oscillations of a viscously damped pendulum, synchronization circuits (phase, frequency and delay locked loops) and networks of coupled power generators. A system with periodic nonlinearities usually has multiple equilibria (some of them being locally unstable). Many tools of classical stability and control theories fail to cope with such systems. One of the efficient methods, elaborated to deal with periodic nonlinearities, stems from the celebrated Popov method of "integral indices", or integral quadratic constraints; this method leads, in particular, to frequency-domain criteria of the solutions' convergence, or, equivalently, global stability of the equilibria set. In this paper, we further develop Popov's method, addressing the problem of robustness of the convergence property against external disturbances that do not oscillate at infinity (allowing the system to have equilibria points). Will the forced solutions also converge to one of the equilibria points of the disturbed system? In this paper, a criterion for this type of robustness is offered.

14:10-14:30 FriB03.3

Optimal Control with Singular Solution for SIR Epidemic Systems, pp. 909-914

Di Giamberardino, Paolo	Sapienza, Univ. of Rome
Iacoviello, Daniela	"Sapienza" Univ. of Rome

Mathematical modeling represents a useful instrument to study the evolution of an epidemic spread and to determine the best control strategy to reduce the number of infected subjects. The computation of the singular solution for a SIR epidemic system with vaccination control is performed; a constructive algorithm for the computation of a bang-singular-bang optimal solution is proposed and, for the specific choice of the parameters typical for a SIR model, the two switching instants, as well as the singular profile, are determined. Numerical simulations are reported to show the results of the described procedure.

14:30-14:50 FriB03.4

Optimal Control of Roll Pitch Seeker with Singularity Avoidance, pp. 915-920

Park, Jaemin	Korea Advanced Inst. of Science and Tech
Hong, Seong-Min	Korea Advanced Inst. of Science and Tech
Roh, Heekun	Korea Advanced Inst. of Science and Tech
Tahk, Min-Jea	KAIST
Kim, Yun young	Korea Advanced Inst. of Science and Tech. Aerospace En
Yun, Joongsup	LIG Nex1

In order to provide guidance information, various types of optics seekers are incorporated in most modern missiles. A seeker moves independently of the missile dynamics to track a target image, providing the target information to the missile. Among them, two-axis seekers are widely used because they can rotate freely toward the target. According to the direction of rotating axes, the two-axis seekers are categorized into yaw-pitch and roll-pitch types. The yaw-pitch gimbal structure has been researched widely since it provides an intuitive way to track the target. On the other hand, due to smaller size with a larger gimbal angle, the roll-pitch structure is actively studied and widely applied to missiles recently. Despite the advantages, the inherent structural characteristic of the roll-pitch seeker has made the research relatively late. When the target is aligned with the missile axial direction, a singularity occurs at which the roll angle of the gimbal becomes indefinite. Furthermore, when the target moves around the singular point, the roll gimbal command angle abruptly changes, dissipating control energy while showing an abrupt oscillation in gimbal response. This paper analyzes the singularity problem in the roll-pitch seeker and introduces an optimal control method to properly relieve the problem.

14:50-15:10 FriB03.5

Bidirectional DC/DC Power Converters with Current Limitation Based on Nonlinear Control Design, pp. 921-925

Konstantopoulos, George	The Univ. of Sheffield
Alexandridis, Antonios	Univ. of Patras

A new nonlinear controller for bidirectional dc/dc power converters that guarantees output voltage regulation with an inherent current limitation is proposed in this paper. In contrast to traditional single or cascaded PI controllers with a saturation unit that can lead to integrator windup and instability, the proposed controller is based on a rigorous nonlinear mathematical analysis and, using Lyapunov stability theory, it is proven that the current of the converter is always limited without the need of additional saturation units or limiters. The proposed concept introduces a virtual resistance at the input of the converter and a controllable voltage that can take both positive and negative values leading to bidirectional power flow capability. The dynamics of this voltage are proven to remain bounded and with a suitable choice of the voltage bound and the virtual resistance, the upper limit for the converter current is guaranteed at all times, even during transients. Simulation results for a bidirectional converter equipped with the proposed controller are presented to verify the current-limiting capability and the desired voltage regulation.

FriB04 Meeting Room 3

Integrating Wireless Sensor Networks in Distributed Control Systems (SENSYS'18) (Invited Session)

Chair: Popescu, Dan	Pol. Univ. of Bucharest
Co-Chair: Ichim, Loretta	Pol. Univ. of Bucharest
Organizer: Popescu, Dan	Pol. Univ. of Bucharest
Organizer: Stoican, Florin	Pol. Univ. of Bucharest
Organizer: Ichim, Loretta	Pol. Univ. of Bucharest

13:30-13:50 FriB04.1

Residual Water Burst Detection Using WSN Measurements and Cloud Analysis (I), pp. 926-931

Enache, Dragos	Pol. Univ. of Bucharest Romania
Chenaru, Oana	Pol. Univ. of Bucharest
Ichim, Loretta	Pol. Univ. of Bucharest
Popescu, Dan	Pol. Univ. of Bucharest

Water leakage and burst detection with increased accuracy represents an open issue in water management systems. Main challenges identified in this sector refer to lack of proper analysis tools and poor system state information. Stating from the water dynamics principles, we defined a model for water system characterization and pipe burst detection. We identified a minimum set of data needed for this information and proposed a WSN architecture for data acquisition. We computed the dynamic characteristics of a water supply shaft system and performed a cloud analysis of the system to determine the localization of the burst.

13:50-14:10 FriB04.2

Connectivity Solutions for Hybrid Air-Ground Sensor Networks (I), pp. 932-937

Militaru, Gabriel	UPB
Popescu, Dan	Pol. Univ. of Bucharest
Ichim, Loretta	Pol. Univ. of Bucharest

The hybrid air-ground sensor networks and the radio technologies used to ensure their interconnectivity will encounter various challenges raised by spectrum availability in non-licensed bands. The interconnectivity of drones and the sensor networks has to find right spectrum resources to allow its safe and secure operation, while the coordination and harmonization of the spectrum is performed according to regulations in place. Satellite or 3G/4G/LTE networks are bringing significant advantages like connection safety and reliability, system scalability and versatility. Since IoT is highly supported by mobile operators, it's worth considering the opportunity that next generation mobile networks might provide simultaneous services to terrestrial and airborne sensor networks to ensure proper performance, reliability and resilience of hybrid air-ground sensor networks. The experiment presented in this article comes to validate the reliability of the connection between a drone and the terrestrial 3G/4G/LTE base station, while trying to identify scenarios in which the signal lost will affect the command and control system of the drone.

14:10-14:30 FriB04.3

Integration of WSN, IoT and Cloud Computing in Distributed Monitoring System for Aging Persons in Active Life (I), pp. 938-943

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The paper presents a multi-level architecture for AAL

applications, separating sensor, fog computing and cloud processing levels and assigning a specific role for each of them. This increases efficiency in data acquisition, integration, response time and long-term analysis. The system was designed scalable, being capable to integrate data from different IoT and WSN networks and provide support for distributed application implementation. The paper details the functionality of each level and tools used in the implementation of a body sensor network and indoor environmental monitoring of a single patient. Indoor comfort and temperature variation are used as examples for the user application stored at the fog computing level. An ARIMA model is used at the cloud level for temperature data prediction.

14:30-14:50 FriB04.4

A Solution for Mobile Computing in a Cloud Environment for Ambient Assisted Living (I), pp. 944-949

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The objectives of this paper is to describe the software architecture and corresponding components for collecting the data from the pilot sites within the NOAH (NOt Alone at Home) AAL European Project, the developing of software services for these locations, and the improvement of the developed software components for these locations, accordingly to the co-creation sessions. The NOAH platform is implemented as a solution for mobile computing in a cloud environment. NOAH system mostly addresses user's needs related to safety, adherence to daily living prescriptions (therapies, physical activity, etc.), motivation and self-esteem, participation in social life. Exploiting accumulated knowledge about user's activity and needs, NOAH provides the user with context-sensitive support.

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