28th Mediterranean Conference on Control and Automation

September 16-18, 2020
Congress Center, St Raphaël, France

Final Program and Book of Abstracts

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Message from the President of the Mediterranean Control Association (MCA)

On behalf of the Mediterranean Control Association, I would like to welcome you to MED'20, the 28th Mediterranean Conference on Control and Automation and the first virtual MED conference!

MED'20 was supposed to take place in Saint-Raphael in the South of France in 16-19 June 2020. Due to the COVID-19 pandemic, the date for MED'20 was moved to 16-18 September in case we would still be able to physically attend the conference, but it soon became clear that this would be impossible and so MED'20 became the first ever virtual MED conference. I was looking forward, as I am sure you were, to visiting the South of France, meeting new colleagues and renewing friendships. Unfortunately, this is not to happen in 2020 and so we have to plan for a MED in the South of France some-time in the future.

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!

The Mediterranean Control Association (MCA) is the sponsoring, parent organization of all the MED conferences. MCA selects the organizers and venues, and oversees all the 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 went to 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 where you may also find Book of Abstracts and conference reports of previous MED that have appeared in the IEEE Control Systems Magazine).

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

Looking ahead, MED'21 goes to Italy, to the Puglia region (June 2021) and am looking forward to seeing you all there!

Thank you for your participation and contributions to MED'20! Be Well and Prosper!

Panos Antsaklis, President
Mediterranean Control Association

Welcome to MED 2020

On behalf of the Organizing Committee and International Program Committee of the 28th Mediterranean Conference on Control and Automation, MED 2020, I am pleased to welcome all the participants of the conference. This edition is very particular. Let me, in this welcome message, retrace the history of the events.

I was very honoured to be selected at the meeting in Zadar, Croatia, as the General Chair of this edition. I was particularly happy and motivated to welcome you to France on the French Riviera. The venue had been carefully chosen: St Raphaël, which is clearly a Mediterranean site *par excellence*. The conference was planned, as is often the case, in mid-June. The global health crisis due to the COVID-19 pandemic has decided otherwise. Submissions went smoothly and the organizing team was pleased to have been able to attract a total of 257 papers at the end of January. The health situation has worsened in France and throughout the world. I waited long enough to assess the possibility of organizing the conference in June, but on March 26, while France was on lockdown, I decided to postpone the conference and to hold it from September 16 to 18, still in St Raphaël. On the basis of these submissions, the Program Chairs built a thoughtful and exciting technical program. I thank them very warmly for the hard work they have done. This program was published mid-June. After lengthy discussions with the Congress Center in St Raphaël and the restrictions imposed by the French government, particularly on gatherings of people, I decided, on July 1st, with great sadness, to transform the conference into a completely virtual event like, unfortunately, many other conferences. It is a very great disappointment to have been forced to make this decision. I would have been really happy to be able to welcome the community to the South of France. A virtual event cannot replace the informal human contacts which are so rich and which constitute the essence of such a scientific gathering.

This is only the second edition taking place in France. I had already taken part in the organisation of the 2008 edition, which took place in Ajaccio in Corsica and I had excellent memories of it. Taking into account the situation, the 2020 edition will therefore be managed from Nancy, the city where I teach at the Université de Lorraine with some of my colleagues within the organizing committee. The conference is sponsored by the Mediterranean Control Association. It is technically co-sponsored by IEEE Control System Society, the IEEE Robotics and Automation Society and the Research Center for Automatic Control and supported by Université de Lorraine.

The program of MED 2020 includes 26 regular sessions and 6 invited sessions in 5 parallel tracks. Moreover, the program contains 3 plenary talks prepared by outstanding academic and industrial experts. We hope that those talks will give the participants the opportunity to share in the knowledge and experience of world-renowned scientists and experts in exciting topics. Despite the situation, we hope that you will find your participation in MED 2020 very stimulating and rewarding. Unfortunately, you won't be able to discover St Raphaël and its surroundings; I hope it's only a postponement!

I would like to thank all members of the International Program Committee for their excellent work in ensuring a high quality of the conference program. Special thanks go to members of the Organizing Committee for their work that made it possible to organize this international scientific event.

I wish all participants to enjoy the 28th Mediterranean Conference on Control and Automation.

Didier Maquin
General Chair of MED 2020

About St Raphaël

Seaside and tourist resort on the Mediterranean, beautifully situated at the foot of the Estérel, Saint-Raphaël is a highly-prized vacation destination. It is divided into different zones of great diversity, the old town, the town centre, the ports, Valescure, Boulouris, Le Dramont, Agay, Anthéor, Le Trayas, which since the 19th century have attracted artists, writers and a well-off and elegant society.

But its biggest attraction is the sea and its beaches. Saint-Raphaël stretches over 36 kilometres of coast from the town centre to the edge of the Alpes-Maritimes and offers you thirty sand or shingle beaches. And there are all the pleasures that go with it – aquatic activities such as sailing, swimming, fishing and diving, hikes along the water, a marine archaeological museum...

The monks of the Lérins Islands occupied the site until the 11th century when it was ceded to the bishops of Fréjus. Napoleon Bonaparte had his turn here in 1799 following his Egyptian campaign, successfully escaping pursuit by the English squadrons. An obelisk on the northeast corner of the port commemorates this event. In May 1814, tail between his legs, the dethroned emperor left from Saint-Raphaël to regain his little kingdom on the island of Elba.

Once a fishing port, with the arrival of the railway in the 19th century the town transformed itself into a vacation spot and many luxurious villas in Palladian style sprung up. With its geography and history, Saint-Raphaël is interesting in many ways.

PROGRAM AT A GLANCE

MED 2020 Technical Program Wednesday September 16, 2020

Track 1	Track 2	Track 3	Track 4	Track 5
09:00-10:00 WePL1 ROOM SR1 **Passivity Theory in Cooperative Control: A Network Optimization Perspective Dr. Daniel Zelazo**				
10:20-12:20 WeA01 ROOM SR1 **Recent Works on Automotive Control Systems I**	10:20-12:20 WeA02 ROOM SR2 **Aerospace Control I**	10:20-12:20 WeA03 ROOM SR3 **Nonlinear Control**	10:20-12:20 WeA04 ROOM SR4 **Advanced Control Systems Including Fault-Tolerance, Robustness and Cooperation**	10:20-12:20 WeA05 ROOM SR5 **Nonlinear Estimation**
14:00-16:00 WeB01 ROOM SR1 **Recent Works on Automotive Control Systems II**	14:00-16:00 WeB02 ROOM SR2 **Aerospace Control II**	14:00-16:00 WeB03 ROOM SR3 **Robust Control**	14:00-16:00 WeB04 ROOM SR4 **Fault Tolerant and Resilient Control Systems**	14:00-16:00 WeB05 ROOM SR5 **System Identification**
16:20-18:00 WeC01 ROOM SR1 **Automotive Control**	16:20-18:00 WeC02 ROOM SR2 **Disturbance Rejection**	16:20-18:00 WeC03 ROOM SR3 **Fuzzy Control**	16:20-18:00 WeC04 ROOM SR4 **State Estimation and Environment Perception: Application to Mobile Vehicle**	16:20-18:00 WeC05 ROOM SR5 **System Identification and Estimation**

MED 2020 Technical Program Wednesday September 17, 2020

Track 1	Track 2	Track 3	Track 4	Track 5
09:00-11:00 ThA01 ROOM SR1 **Autonomous System**	09:00-11:00 ThA02 ROOM SR2 **Fault Diagnosis and Prognosis**	09:00-11:00 ThA03 ROOM SR3 **Multi-Agent Systems**	09:00-11:00 ThA04 ROOM SR4 **Time-Delay Systems**	09:00-11:00 ThA05 ROOM SR5 **Predictive Control**
11:20-12:20 ThPL2 ROOM SR1 **Modeling, Estimation, and Control in Deep Brain Stimulation Prof. Alexander Medvedev**				
14:00-16:00 ThB01 ROOM SR1 **Unmanned Aerial Vehicles: Modeling and Control**	14:00-16:00 ThB02 ROOM SR2 **Renewable Energy and Sustainability**	14:00-16:00 ThB03 ROOM SR3 **Machine Learning**	14:00-16:00 ThB04 ROOM SR4 **Signal Processing**	14:00-16:00 ThB05 ROOM SR5 **Power Systems and Industrial Automation**
16:20-17:20 ThRT Room T1 **Round Table**				

MED 2020 Technical Program Wednesday September 18, 2020

Track 1	Track 2	Track 3	Track 4
09:00-10:40 FrA01 ROOM SR1 **Biology and Biologically Inspired Systems**	09:00-10:40 FrA02 ROOM SR2 **Integrating Wireless Sensor Networks in Distributed Control Systems**	09:00-10:40 FrA03 ROOM SR3 **Adaptive Control**	09:00-10:40 FrA04 ROOM SR4 **Robotics**

11:00-12:00 FrPL3
ROOM SR1

Civil Aircraft Reduced Order Modelling, Control and Validation: Numerical and Experimental Challenges
Dr. Charles Poussot-Vassal

14:00-16:00 FrB01 ROOM SR1 **Unmanned Systems**	14:00-16:00 FrB02 ROOM SR2 **Linear System**	14:00-16:00 FrB03 ROOM SR3 **Applications**

16:00-16:30 FrCC
Room T1

Closing Ceremony

BOOK OF ABSTRACTS

Plenary Talks

Passivity theory in cooperative control: A network optimization perspective

Speaker: **Daniel Zelazo**
Tecnion – Israel Institute of Technology
Director of the Philadelphia Flight Control Laboratory
Israel

Plenary session WePL1 – Wednesday September 16, 9h00-10h00

Daniel Zelazo is an Associate Professor of Aerospace Engineering at the Technion - Israel Institute of Technology and the director of the Philadelphia Flight Control Laboratory. He received his BSc. (’99) and M.Eng (’01) degrees in Electrical Engineering & Computer Science from the Massachusetts Institute of Technology. Before beginning his doctoral studies, he worked for two years on audio compression algorithms as a research engineer at Texas Instruments, Japan. In 2009, he completed his Ph.D. from the University of Washington in Aeronautics and Astronautics. From 2010-2012 he served as a post-doctoral research associate and lecturer at the Institute for Systems Theory & Automatic Control in the University of Stuttgart, and he joined the Technion in 2012. Daniel serves as an associate editor for the IEEE Control Systems Letters, and a subject editor of the International Journal on Robust and Nonlinear Control

Abstract:
Passivity theory is one of the cornerstones of control theory, providing a rich framework for analyzing properties of dynamical systems. The compositional properties of passive systems make them especially powerful in the study of multi-agent systems and cooperative control. In this talk we will explore necessary and sufficient conditions for a network of passive dynamical systems to reach an output agreement, i.e., the trajectories of each system will synchronize. The leads to a refinement of classical passivity theory that we term maximal equilibrium passivity. We then show that the steady-state behavior of these systems are in fact solutions to a family of classic network optimization problems, and as a result we draw connections between notions of duality in static optimization to cooperative control. This network optimization perspective also leads to synthesis methods for controllers to guarantee the desired behavior of the network and provides new insights to classical problems such as feedback passivation.

Modeling, estimation, and control in deep brain stimulation

Speaker: **Alexander Medvedev**
Department of Information Technology
Director of Program in Automatic Control
Uppsala University, Sweden

Plenary session ThPL2 – Thursday September 17, 11h20-12h20

Alexander Medvedev is a Professor of Control Engineering at Uppsala University, Sweden. He is also the Director of Program in Automatic Control since 2013. Prof. Medvedev has received his MSc (honors, 1981) and PhD (1987) in automatic control from Leningrad Electrical Engineering Institute (LEEI), USSR. He was promoted to Associate Professor (docent) at LEEI in 1991. After a research visit to Åbo Akademi, Finland, (1990-1991), Prof. Medvedev joined Luleå University of Technology, Sweden, and served there as Lecturer, Acting Professor, and Full Professor from 1991 until 2003. In 2002 he moved to Uppsala, where he was appointed Full Professor and started a research group in Biomedical Systems and Control. The current research interests of Prof. Medvedev are mathematical modeling in life sciences and medicine, feedback control of therapies, and quantification of symptoms in neurological diseases. He is Chair of the IEEE Technical Committee on Healthcare and Medical Systems.

Abstract:
Collaborative Deep brain stimulation (DBS) is an invasive therapy broadly used to treat the symptoms of neurological and mental diseases. DBS is currently performed by means of surgically implanted multi-contact electrodes delivering electrical stimulation to well-defined targets in the brain of the patient. The therapeutical effect is much dependent on the individual and can be improved by selecting suitable stimulation settings such as amplitude, frequency, and the signal form of the stimuli pulse train. Insufficient stimulation of the target area does not properly alleviate the symptoms of the treated disease, while overstimulation is prone to undesirable side effects.
A major complication on the way of the individualization and optimization of the DBS therapy is the fact that the biological mechanism behind its therapeutical effect is basically unknown. Selecting the stimulation parameters by medical personnel in a trial-and-error procedure takes up to several months and numerous visits to the clinic.
A significant progress in the computer-assisted individualization and optimization of DBS has been recently made. The talk reviews the mathematical models that describe how the electrical pulses emitted by the electrode propagate through the brain tissue and interact with neural populations. Provided measurements of the local potential are available from the electrode, model-based estimation of the electrical properties of the tissue around the electrode can be performed. The problem of target coverage and stimuli spill minimization is cast as a spatial control problem and solved by optimization. The technology for symptoms quantification in neurological diseases is also reviewed. Finally, an outlook on the prospects of of the individualized DBS therapies is offered.

Civil aircraft reduced order modelling, control and validation: numerical and experimental challenges

Speaker: **Charles Poussot-Vassal**
Onera, Department of Systems and Signal Processing
Toulouse, France

Plenary session FrPL3 – Friday September 18, 11h-12h

Charles Poussot-Vassal is senior researcher at ONERA, the French aerospace lab (Toulouse, France). His research area covers the model-based (and data-driven) approximation of large-scale and infinite dimensional dynamical models, with emphasis on the numerical issues, connections with input-output stability and with industrial-oriented applications in civil aircrafts.
He was born in Grenoble, France, in 1982. In 2005, he completed his Engineering degree and M.Sc. in control and embedded systems from Grenoble INP-ESISAR (Valence, France) and Lund University of Technology (Lund, Sweden), respectively. In 2008, he completed his Ph.D. degree in control systems theory, within the GIPSA-lab's (Grenoble, France). He obtained his French habilitation in 2019 from Toulouse INP (Toulouse, France). At the beginning of 2009, he worked as a research assistant with the Politecnico di Milano (Milan, Italy). From mid-2009, he joined ONERA, as a full-time researcher.

Abstract:
Despite Aircraft mobility plays an important role in our life style and societal organisation. While this transportation mean is faced to severe environmental changes and safety constraints, research must provides answers applicable in an industrial context. Since some decades, civil aircraft industry did rely - among others - on dynamical systems and control theory advances to address these issues. Indeed, recent developments in these communities did play a important role in the aircraft efficiency and safety improvement, as well as footprint reduction.
This talk aims at illustrating how three "control-oriented" aspects impact this field and led to great improvements. More specifically, (i) the linear large-scale dynamical model approximation, (ii) the linear control design, and (iii) the uncertain modelling robustness analysis will be presented. The talk will illustrate how these developments benefit to the - constrained - industrial civil aircraft environment and fit to practitioners needs. Numerical, practical and experimental aspects will stand as the cornerstone of the presentation.

TECHNICAL PROGRAM

WeA01 ROOM SR1

Recent Works on Automotive Control Systems I (Invited Session)

Organizer: Sename, Olivier — Grenoble INP / GIPSA-Lab

Organizer: Gaspar, Peter — SZTAKI

10:20-10:40 WeA01.1

Frequency-Shaping Observer-Based Controller Design for Actuator Degradation : Application to Suspension System (I)

Do, Manh-Hung — GIPSA-Lab

Koenig, Damien — Grenoble - Inp

Theilliol, Didier — University of Lorraine

Gaspar, Peter — SZTAKI

The main contribution of this paper is a methodology, derived from H2 cost functional, Parseval's Theorem in controller design and the principle of unknown input observer, for the estimation and accommodation of polynomial actuator degradation. In this design, the observer-based controller, integrated with a frequency-shaping filter and a state-feedback compensator, attenuates the disturbance influence on observer estimation and maintains the system stability. Furthermore, due to its simplicity, industrial engineers and readers can easily apply the proposed method to health maintenance system. Finally, an application to suspension system is illustrated to highlight the performance of the proposed method.

10:40-11:00 WeA01.2

Fault-Tolerant Distributed and Switchable PI Slip Control Architecture in Four In-Wheel Motor Drive Electric Vehicles (I)

Amato, Gerardo — University of Rome Tor Vergata

Marino, Riccardo — University of Rome Tor Vergata

A fault-tolerant feedback architecture is presented and simulated for chassis motion control of both longitudinal and lateral dynamics in Four In-Wheel Motors (4-IWMs) drive Electric Vehicles (EVs), in the presence of mechanical failures. The control architecture is capable of a quick Fault Detection and Isolation (FDI) by making a sensor fusion between the measured chassis-acceleration vector angle and its estimate determined by distributed torque loads estimation. The fault is isolated by comparing online left and right torque load estimates. The proposed architecture can switch smoothly from 4-IWMs to 2-IWMs configuration, by excluding the whole faulted axle to preserve the torque balancing.

11:00-11:20 WeA01.3

Trajectory Reference Generation and Guidance Control for Autonomous Vehicle Lane Change Maneuver (I)

Ammour, Manel — Université de Haute-Alsace

Orjuela, Rodolfo — Université de Haute-Alsace

Basset, Michel — Université de Haute Alsace

One of the expected tasks that autonomous vehicle may do is driving on highway which makes performing lane change maneuvers inevitable. In order to ensure the safety of the lane change, the contingency planning approach must generate smooth and feasible local trajectory adequate for overtaking or collision avoidance applications. This paper presents a method to carry out a lane change maneuver based on a sigmoid function trajectory. The main contribution of this paper is to provide an envelope of the set of the feasible parameterized sigmoid functions based on vehicle dynamics and geometric constraints. The few parameters used in the trajectory adjustment make the lane change maneuver safe, comfortable laterally and applicable in real-time. The proposed lateral controller switches between attenuating the lateral error and the orientation error to better track the desired reference trajectory. CarMaker simulation results show the applicability of the proposed approach.

11:20-11:40 WeA01.4

Vehicle Odometry Model Identification Considering Dynamic Load Transfers (I)

Fazekas, Máté — SZTAKI

Nemeth, Balazs — SZTAKI

Gaspar, Peter — SZTAKI

Sename, Olivier — Grenoble INP / GIPSA-Lab

The paper proposes a parameter identification method for a vehicle model using real measurements of onboard sensors. The motivation of the paper is to improve the localization of the vehicle when the accuracy of the regular methods is poor, e.g. in the case of unavailable GNSS signals, no enough feature for vision, or low acceleration for IMU-based techniques. In these situations the wheel encoder based odometry may be an appropriate choice for pose estimation, however, this method suffers from parameter uncertainty and unmodelled effects. The utilized vehicle model operates with dynamic wheel radius. The proposed identification method combines the Kalman-filter and least square techniques in an iterative loop for estimating the parameters. The estimation process is verified by real test of a compact car. The results are compared with the nominal setting, in which there is no estimation.

11:40-12:00 WeA01.5

Integrated Multi-Criteria Velocity and Semi-Active Suspension Control Based on Look-Ahead Road Information (I)

Basargan, Hakan — Budapest University of Technology and Economics

Mihaly, Andras — SZTAKI

Gaspar, Peter — SZTAKI

Sename, Olivier — Grenoble INP / GIPSA-Lab

Semi-active suspension control and vehicle cruise control systems have already been developed by researchers and adapted by automotive companies. Most of these systems react on actual road irregularities and terrain characteristics, and the control for each subsystem is designed separately. However, since oncoming road conditions can be known by using historic road information and GPS navigation system, the paper introduces a method to build in look-ahead road data in the control of the adaptive semi-active suspension, moreover, design the vehicle velocity for the cruise controller considering comfort and energy efficiency at the same time. The operation of the presented integrated suspension and velocity control system is validated by a real data simulation in TruckSim environment.

12:00-12:20 WeA01.6

Fault Tolerant Velocity Control of an Urban Autonomous Vehicle Based on a Switching Strategy (I)

Ruhnke, Mélodie — University of Bordeaux

Moreau, Xavier — University of Bordeaux

Benine-Neto, André — University of Bordeaux

Moze, Mathieu — University of Bordeaux

Aioun, François — PSA Peugeot Citroën

Guillemard, Franck — PSA Peugeot Citroën

Rizzo, Audrey — DRIA PSA Peugeot Citroën

This paper presents a methodology of switching control law following a fault detection of a controller on a longitudinal speed regulation. This method consists on designing a dynamic parity space to detect a fault on a CRONE controller. Then a supervisor is put in place in order to calculate a residue, analyze it and generate a signal to switch from the CRONE controller to the PI and so ensuring the speed regulation despite the fault. Results show that the proposed method ensures a safe functioning of the cruise control despite control faults.

WeA02 ROOM SR2

Aerospace Control I (Regular Session)

10:20-10:40 WeA02.1

Attitude Control of a Fin-Stabilized Projectile on a Three-Axis Gimbal in Wind Tunnel

Riss, Valentin — French-German Research Institute of Saint-Louis

Roussel, Emmanuel — French-German Research Institute of Saint-Louis

Laroche, Edouard — Strasbourg University

In this paper, a three-axis autopilot has been developed for a guided projectile steered in a wind tunnel. A linear model based on the equations of motion is identified using parameter estimation methods. Then, a fixed-order controller is synthesized in a multi-objective framework and implemented on a dual-loop structure. The reference tracking performance and disturbance rejection capabilities of the closed-loop plant are evaluated by dedicated experiments and compared to the model predictions.

10:40-11:00 WeA02.2

Trajectory Generation and Tracking for Phugoid Maneuvers Using a Mini-Airplane

Delbene, Andrea — University of Genova
De Souza Jr., Cristino — Heudiasyc, UTC
Castillo, Pedro — Heudiasyc, UTC
Vidolov, Boris — Heudiasyc, UTC
Baglietto, Marco — University of Genova

In this work, the problem for trajectory generation and tracking for phugoid maneuvers using a fixed-wing aerial vehicle is studied. The goal of using this kind of trajectories is to reduce the kinetic energy produced by the aerial vehicle during forward flight. In our study, the phugoid trajectory contains a recovery phase for safely continue to fly the aerial vehicle. In order to track the phugoid trajectory, separate controllers generated by using Lyapunov Analysis are proposed. Several simulations are carried out to validate experimentally the proposed theory, using several tools such as Gazebo, QGroundControl, PX4, and ROS (Robot Operating System).

11:00-11:20 WeA02.3

Nonlinear Model and Control Validation of a Tilting Quadcopter

Offermann, Alexis — Heudiasyc, UTC
Castillo, Pedro — Heudiasyc, UTC
De Miras, Jérôme — Heudiasyc, UTC

In this paper, a deep analysis of a quadcopter with tilting rotors is proposed. An exhaustive mechanical study is provided for several configurations of the aerial vehicle, allowing nonlinear mathematical equations that are obtained using the Newton-Euler approach, resulting in over actuated systems. A control scheme is proposed and validated numerically and in real time to stabilize the system. Some ROS nodes are developed, to convert the SimulinkTM control diagrams into C++ code, in order to implement the control algorithms easily into the embedded system of the developed quadcopter prototype with tilting rotors.

11:20-11:40 WeA02.4

Artificial Time Delay Based Adaptive Robust Fault Tolerant Control for RLV During Re-Entry Phase

Sarkar, Rajasree — Indian Institute of Technology Delhi
Mukherjee, Joyjit — Indian Institute of Technology Delhi
Patil, Deepak — Indian Institute of Technology Delhi
Kar, Indra Narayan — Indian Institute of Technology Delhi

This paper considers attitude tracking problem of a reusable launch vehicle (RLV) in its re-entry phase. The complex environmental conditions and highly nonlinear coupled dynamics impose a challenging task to regulate the spacecraft to follow a desired trajectory. In this paper, an artificial time-delay based control (TDC) scheme is implemented to incorporate robustness against system uncertainties, external disturbances and actuator faults. The time-delay approach uses input and output measurements from the past instant to estimate uncertainties effecting the system. Lyapunov stability is conducted to show that with the proposed control scheme uniformly ultimately bounded (UUB) convergence of system states under bounded estimation error is ensured. To further improve the performance, a switching law is augmented with the TDC. Additionally, a dual-rate adaption law for switching gain has also been exploited to prevent over and under estimation. The effectiveness of the proposed control scheme is verified through simulation results which shows robust tracking of the desired trajectory.

11:40-12:00 WeA02.5

A New Path Planning Algorithm for Forced Landing of UAVs in Emergency Using Velocity Prediction Method

Kim, Young-Won — Korea Advanced Institute of Science and Technology
Lee, Dong-Yeon — Korea Advanced Institute of Science and Technology
Tahk, Min-Jea — Korea Advanced Institute of Science and Technology
Lee, Chang-Hun — Korea Advanced Institute of Science and Technology

This paper aims to propose a waypoint path planning for the forced landing of an unmanned aerial vehicle in an emergency based on the terminal velocity prediction method, in order to satisfy the approach conditions. In the proposed path planning method, a flight path is represented by a set of waypoints and a combination of rectilinear path and curvilinear path. Based on this representation with some approximations, the terminal velocity prediction method is analytically derived. By using the terminal velocity prediction method, the path planning problem can be converted into a problem finding appropriate positions of the waypoints in order to satisfy the approach conditions for a safe landing. Since the problem is given by a nonlinear system of equations, it can be readily solved using a simple numerical method. Compared to other methods, the proposed method can allow to satisfying the approach conditions with a low computational load. Numerical simulation is performed to conduct the performance of the proposed method.

12:00-12:20 WeA02.6

Robust Design for Highly Agile Missile Autopilots

Theodoulis, Spilios — French-German Research Institute of Saint-Louis (ISL)
Proff, Michael — French-German Research Institute of Saint-Louis (ISL)
Marchand, Charlotte — Institut des Systèmes Intelligents et de Robotique (ISIR)

This article presents the design of a gain-scheduled 4-loop autopilot for the nonlinear pitch dynamics of a tail-controlled highly agile missile. The missile's nonlinear flight dynamics and the procedure for obtaining an accurate linearized model across the system's flight envelope are dully explained. Autopilot design specifications are systematically translated into hard and soft tuning goals and the resulting multi-model/multi-objective problem is solved using commercially available non-smooth optimization tools. The performance and robustness of the flight control laws are then studied in simulation both in a linear and nonlinear context.

WeA03 — ROOM SR3

Nonlinear Control (Regular Session)

10:20-10:40 WeA03.1

Hybrid Position/Force Control for Hydraulic Actuators

Pasolli, Philipp — UIA
Ruderman, Michael — University of Agder

In this paper a novel hybrid position/force control with autonomous switching between both control modes is introduced for hydraulic actuators. A hybrid position/force control structure with feed-forwarding, full-state feedback including integral control error, pre-compensator of the deadzone nonlinearity and low-pass filtering of the control value is designed. Controller gains are obtained via local linearization and pole placement accomplished separately for the position and force control. A hysteresis-based autonomous switching is integrated into the closed control loop, while multiple Lyapunov function based approach is applied for stability analysis of the entire hybrid control system. Experimental evaluation is shown on the developed test setup with the standard industrial hydraulic cylinders, and that for different motion and load profiles.at for different motion and load profiles.

10:40-11:00 WeA03.2

Stability of Periodically Switched Systems: Illustrative Examples

Lunze, Jan — Ruhr-Universität Bochum

The paper presents an example to illustrate the fact that specific

switched systems can be stabilized by using a sufficiently short switching period. A necessary and sufficient condition is proved, which poses requirements on the operation modes under which switched systems are asymptotically stable for fast switching. Emphasis is laid on an intuitive explanation why this phenomenon occurs.

11:00-11:20 WeA03.3

Non-Linear Control Algorithms for De-Oiling Hydrocyclones

K G, Mishiga Vallabhan — Norwegian University of Science and Technology

Holden, Christian — Norwegian University of Science and Technology

Reduction in environmental footprint has become one of the key performance indicators in the oil and gas industry. As per the OSPAR commission, produced water containing more than 30 ppm of oil cannot be discharged to sea. This clearly indicates the importance of advanced control systems in produced-water system equipment like hydrocyclones and compact flotation units. It is expected that the control algorithms handle all the plant disturbances and meet the performance specifications. This paper investigates non-linear control algorithms for controlling the efficiency of hydrocyclones. Here, two well-known non-linear control design techniques-- feedback linearization control and sliding mode control are used for the control of a hydrocyclone.

11:20-11:40 WeA03.4

Gain Scheduled Subspace Predictive Control of a Pressurized Water-Type Nuclear Reactor

Vajpayee, Vineet — University of Portsmouth

Becerra, Victor M. — University of Portsmouth

Bausch, Nils — University of Portsmouth

Banerjee, Shohan — Leeds Beckett University

Deng, Jiamei — Leeds Beckett University

Shimjith, S.R. — Bhabha Atomic Research Centre

Arul, John — Indira Gandhi Centre for Atomic Research

This work presents a methodology for designing subspace-based gain scheduled predictive controller for nuclear reactor power control. The main idea is to design a family of predictive controllers directly from measurements and integrate them without employing any explicit process model. The developed controller incorporates the robustness feature of subspace identification with the adaptive capability of gain scheduling in a predictive control set up. The controller is designed to handle process variations effectively. The efficacy of the proposed controller is demonstrated for load-following transients using a simulated model of a PWR-type nuclear reactor. Simulation results show that the proposed strategy is effective in addressing the load-following control problem of a non-linear parameter-varying PWR nuclear reactor system.

11:40-12:00 WeA03.5

Decentralized Suboptimal Control Synthesis for Interconnected Bilinear Systems Using 2 Types of Orthogonal Functions

Mohamed Sadok, Attia — LSA-EPT

Bouafoura, Mohamed Karim — LSA-EPT

Benhadj Braiek, Naceur — LSA-EPT

A new technique for synthesizing an optimal decentralized controller for interconnected bilinear systems is proposed by using Legendre polynomials and Block Pulse Functions properties. The use of these interesting tools allows the conversion of differential state equations into a set of algebraic ones by expanding the system input and output variables into an orthogonal function basis and using the operational properties of these functions. The main objective of the proposed method is to simplify the determination of the controller gain parameters so that the performance of each controlled subsystem of the global system can be matched to a chosen reference model.

12:00-12:20 WeA03.6

Singular Solution in Optimal Control for Two Input Dynamics: The Case of a SIRC Epidemic Model

Di Giamberardino, Paolo — Sapienza, University of Rome

Iacoviello, Daniela — Sapienza, University of Rome

The analysis of singular solutions in optimal control problems is addressed. The case of systems with two inputs is investigated characterizing all the possible combination of singular arcs and constant boundary values. It is described the extension to a two input system of a previously proposed procedure for computing the control along the singular arcs in a state feedback form for one input dynamics. The procedure makes use of the possibility of computation in an analytical form of the costate as a function of the state. The example of a SIRC epidemic model is used to verify the effectiveness of the result.

WeA04 ROOM SR4

Advanced Control Systems Including Fault-Tolerance, Robustness and Cooperation (Invited Session)

Organizer: Puig, Vicenç — Universitat Politècnica De Catalunya (UPC)

Organizer: Ahmed Ali, Sofiane — IRSEEM Rouen

10:20-10:40 WeA04.1

LPV MPC Control of an Autonomous Aerial Vehicle (I)

Misin, Mark — UPC

Puig, Vicenç — Universitat Politècnica De Catalunya (UPC)

This work proposes the use of the LPV MPC approach for the position-heading control problem of a small quadrotor. The use of a LPV representation of the attitude subsystem allows to consider it as independent from the position one, allowing the use of cascade control structure. For the inner attitude control loop, the proposed LPV MPC controller is solved efficently using quadratic programming. The proposed solutions are applied to an AscTec Hummingbird UAV in simulation.

10:40-11:00 WeA04.2

Image Based Visual Servoing for Multi Aerial Robots Formation (I)

Bastourous, Mark — Université du Havre, LITIS

Al-Tuwayyij, Jaafar — OneVisage

Guerin, François — Université du Havre, LITIS

Guinand, Frédéric — Université du Havre, LITIS

There are numerous advantages of flying in group over using single robot in mission execution. However this implies solving a crucial issue: the coordination between drones. Moreover, according to the targeted application, it may be necessary or desirable that drones fly following a given geometric shape (line, diamond, etc.), a problem known as formation control. Building and maintaining a spatial geometric shape while evolving within the environment usually requires extensive communications between the robots for coordinating their movements. In this work we focus on the use of an Image Based Visual Servoing (IBVS) technique for building and maintaining a Leader-Follower (LF) configuration of multi aerial vehicles (UAVs) without communication. While most IBVS techniques either require rigor camera calibration or can not regulate the error according to the three robot axes, our approach avoids the calibration phase by relying image moments features to provide a vision-based predictive compensation method. The follower robot's solution works in GNSS-denied conditions and can run using only on-board sensors. The method is validated through simulations for a group of three quadrotors.

11:00-11:20 WeA04.3

Robust Economic Model Predictive Control of Water Transport Networks (I)

Boutros, Khoury — Universitat Politècnica De Catalunya

Puig, Vicenç — Universitat Politècnica De Catalunya

Nejjari, Fatiha — Universitat Politècnica De Catalunya

In this paper, a robust economic model predictive controller is proposed for a water transport network. Considering that forecast of demand is required in the drinking water network for future predictions of states in the MPC formulation, robustification of the proposed controller is undertaken considering demand uncertainties as unknown but bounded in a zonotopic set. Based on this uncertainty description, a robust MPC controller is designed that ensures that robust constraint satisfaction, stability and performance under uncertainties is guaranteed. The proposed

approach is satisfactorily tested in a part of the Barcelona water transport network.

11:20-11:40 WeA04.4

Robustness of Model Predictive Control Using a Novel Tuning Approach Based on Artificial Neural Network

Moumouh, Houssam — Normandie Univ
Langlois, Nicolas — Irseem / Esigelec
Haddad, Madjid — SEGULA TECHNOLOGIES

A successful implementation of Model Predictive Control (MPC) requires appropriately tuned parameters. This paper presents a novel tuning approach based on Artificial Neural Network (ANN). To build the data learning base of the ANN, we adopted the Particle Swarm Optimization (PSO) method, and we used the reliable algorithm, Online Sequential Extreme-Learning-Machine (OS-ELM) to learn the ANN. The objective of this work is to show that good tuning of MPC parameters makes it possible to reach closed-loop stability and ensure robustness against disturbances and sensor noises, without using robustification approaches in addition to MPC. The effectiveness of our approach is brought to light by comparing the obtained performances to other MPC tuning approaches without disturbances, and also to a robustified Generalized Predictive Control (GPC) using Youla parameterization in the presence of disturbances.

11:40-12:00 WeA04.5

Robustness Estimation of Large Deviations in Linear Stable Systems with the Sensitivity Analysis

Vunder, Nina — TU Braunschweig
Dudarenko, Natalia — ITMO University

The article deals with robustness estimation of large deviations in free motion of continuous-time systems due to parameter variations in the state matrix. It is assumed that parameters of the system are linearly dependent on the uncertainties. The problem is solved with the state space approach and the sensitivity theory methods. An upper bound estimation of trajectory deviations for continuous-time systems is obtained. The estimation contains the condition number of the eigenvectors matrix of the system state matrix. Therefore, sensitivity functions of singular values of the eigenvectors matrix are used to calculate the robustness estimation of the deviations. Based on the obtained equations, an algorithm for the robustness estimation of large deviations in linear continuous-time systems with parametric uncertainties is proposed. The results are supported with an example.

12:00-12:20 WeA04.6

Controllability and Observability Robustness of Perturbed Linear Time Invariant Systems

Bouazza, Leila — Université de Haute Alsace
Mourllion, Benjamin — Université de Haute-Alsace
Makhlouf, Abdenacer — Université de Haute Alsace
Birouche, Abderazik — Universite de Haute Alsace

The controllability and observability of a continuous linear time-invariant system (LTI) under perturbations are analyzed in this paper. Based on various mathematical tools, sufficient conditions to ensure controllability of LTI systems are presented. Besides, the perturbed system corresponds to a perturbation of the matrices, and the conditions that have been established are intimately linked to the structure of perturbed system. By duality, the robustness of observability is also ensured under suitable conditions.

WeA05 ROOM SR5

Nonlinear Estimation (Regular Session)

10:20-10:40 WeA05.1

Tumor Growth Modeling: State Estimation with Maximum Likelihood and Particle Filtering

Patmanidis, Spyridon — National Technical University of Athens
Charalampidis, Alexandros — CentraleSupélec
Papavassilopoulos, George — Univ. of Southern California

In this study, we combined the Maximum Likelihood Estimator from our previous works with a Sequential Importance Resampling (SIR) particle filter to estimate the states of the stochastic Gompertz tumor growth model. We also implemented a parallel version in CUDA for the SIR filter in order to reduce its execution time. Extensive simulations with synthetic data were run to examine whether the SIR filter can provide more accurate state estimates in respect to the Normalized Mean Squared Deviation compared to those provided by the deterministic Gompertz model. Moreover, we monitored and compared the execution time of the SIR's parallel and sequential implementations for different numbers of particles. The results showed that the SIR filter can estimate the system's states very accurately, even at the early tumor growth stages. Additionally, the parallel implementation that ran on the NVIDIA GPU proved to be way more efficient than the implementation that ran on the CPU. By combining the Maximum Likelihood Estimator (MLE) with an SIR filter, we were able to obtain very accurate estimates of the tumors' volume. Furthermore, the execution time for the SIR filter was significantly decreased by taking advantage of the GPUs ability to perform a very large number of computations in parallel.

10:40-11:00 WeA05.2

A New Approach for Designing Stable Nonlinear Bounded-Lipschitz Observers

Papageorgiou, Panos — University of Patras
Alexandridis, Antonios — University of Patras

Observer synthesis for nonlinear Lipschitz systems is still an open problem mainly due to the heuristic manner of obtaining the observer gain matrix. The design is constrained with hard stability restrictions typically imposed by the Lipschitz constant. In this paper, it is shown that when the Lipschitz terms are bounded the stability restrictions can be significantly relaxed and an easily implemented design is deployed which enables the observer linear part eigenvalues to be assigned with a desirable real part on the left of the system poles. The asymptotic stability of the estimation-error is guaranteed by employing a Lyapunov-type equation, which is absolutely compatible with the bounded conditions assumed for the nonlinear terms. As it is easily seen, the proposed observer can be directly integrated into a closed-loop system structure with any linear feedback controller capable to stabilize the original system. The validity of this method is verified by implementing the proposed design on a fundamental power system example. The simulation results fully support the theoretical analysis by exhibiting the easy way of the design, which allows an enhanced observer-based control performance.

11:00-11:20 WeA05.3

Observer-Based Closed-Loop Estimation of Tunneling Current Parameters with Experimental Application

Besancon, Gildas — University of Grenoble Alpes
Voda, Alina — University of Grenoble Alpes
Popescu, Andrei — University of Grenoble Alpes

This paper proposes an observer-based approach towards parameter estimation for tunneling current modeling. Since getting and using tunneling current strongly rely on feedback control, a first study on possible closed-loop operation without knowing tunneling current parameters is first provided. Then, owing to this possible closed-loop configuration, the proposed estimation approach is presented. Some application results finally illustrate the methodology with experimental data taken from an STM-like prototype

11:20-11:40 WeA05.4

A Comparison Study of Nonlinear State Observer Design: Application to an Intensified Heat-Exchanger/Reactor

Han, Xue — Insa Toulouse
Li, Zetao — Guizhou University
Cabassud, Michel — University Paul Sabatier, Toulouse, France
Dahhou, Boutaieb — LAAS-CNRS

In this paper, five classical nonlinear state observers: extended Luenberger observer (ELO), extended Kalman filter (EKF), high-gain observer (HGO), sliding mode observer (SMO) and adaptive observer (AO), are applied to an intensified chemical heat exchanger/reactor (HEX reactor). In order to choose a suitable observer to develop a new fault diagnosis algorithm for this high nonlinear system, the behaviors of these observers are compared. The maximum overshoot and the settling time, which are the key features of the dynamic of the output estimation error system, are used as the criteria to compare the performances of the observers.

Both cases with and without measurement noise are considered. It is concluded that the AO presents the fastest convergence speed and the minimum oscillation for the application to the HEX reactor. And the information provided by the AO will be further used for its fault diagnosis.

11:40-12:00 WeA05.5

Dissipation in Suspension System Augmented by Piezoelectric Stack: Port-Hamiltonian Approach

Tavares, Rafael — University of Agder
Ruderman, Michael — University of Agder

Analysis of damping in semi-active and active suspension systems is prerequisite for an advanced control and, eventually, energy harvesting functions. This paper addresses the damping in suspension system augmented by the piezoelectric (PE) stack. The Hamiltonian system approach with port-power modeling of single subsystems is used for describing and studying the dissipative properties of piezoelectric stack element, integrated in series with a standard quarter-car suspension. The slightly improved, compared to the underlying passive suspension system, frequency response of the sprung mass acceleration is demonstrated. Moreover, the overall power flow in the system, caused by the disturbing road profile, and the dissipated power due to PE-augmented suspension are analyzed and discussed in detail. The results of dissipation analysis provide helpful tools for further developments towards PE-based energy harvesting.

12:00-12:20 WeA05.6

Non-Linear Measures of Dependence in the MIMO Systems Identification with Applications to NPP Efficiency Evaluation

Chernyshov, Kirill — V.A. Trapeznikov Institute of Control Sciences
Jharko, Elena — V.A. Trapeznikov Institute of Control Sciences
Sakrutina, Ekaterina — V.A. Trapeznikov Institute of Control Sciences

The paper deals with the problem of input/output system identification in the light of selecting representative outputs of the system under study, accompanied with its application to the analysis of the nuclear power plant efficiency. Features of the approach are based on an extension of the Rényi axioms for measures of dependence to the case of the multivariate dependence and applying an information-theoretic measure of dependence originated from a symmetric Tsallis divergence of probabilistic distributions.

WeB01 ROOM SR1

Recent Works on Automotive Control Systems II (Invited Session)

Organizer: Sename, Olivier — Grenoble INP / GIPSA-Lab
Organizer: Gaspar, Peter — SZTAKI

14:00-14:20 WeB01.1

A First Approach for a Passenger-Centered Behavior on Driverless Vehicles (I)

Gonzalez Bautista, David — AKKA
Navas, Francisco — AKKA Technologies
Mahtout, Imane — INRIA Paris
Milanes, Vicente — Renault

Driverless shuttles are becoming one of the most promising applications of automated vehicle technologies in the short term. For a real system deployment, passenger's acceptance on the shuttle performance will play a key role. This paper presents a passenger-centered control algorithm design for increasing passenger's ride quality. Controllers with different performance but keeping the same robustness are developed for lane-level autonomous navigation. The whole solution has been implemented and tested in a real vehicle, using a roundabout as use-case scenario, providing encouraging results.

14:20-14:40 WeB01.2

Recent Research on Automotive Control at DLR Institute of System Dynamics and Control - an Overview (I)

Brembeck, Jonathan — German Aerospace Center (DLR)
Bals, Johann — German Aerospace Center (DLR)
Baumgartner, Daniel — German Aerospace Center (DLR)
Bellmann, Tobias — German Aerospace Center (DLR)
Bieri, Caspar — German Aerospace Center (DLR)
Bünte, Tilman — German Aerospace Center (DLR)
Mirwald, Jonas — German Aerospace Center (DLR)
Pfeiffer, Andreas — German Aerospace Center (DLR)
de Castro, Ricardo — German Aerospace Center (DLR)
Otter, Martin — German Aerospace Center (DLR)
Ruggaber, Julian — German Aerospace Center (DLR)
Schreppel, Christina — German Aerospace Center (DLR)
Tobolar, Jakub — German Aerospace Center (DLR)
Ultsch, Johannes — German Aerospace Center (DLR)
Winter, Christoph — German Aerospace Center (DLR)

Safety, comfort, and responsible use of natural resources are motivating the work regarding road vehicles in the automotive research group at the DLR (German Aerospace Center) Institute of System Dynamics and Control. The present article presents an overview of the research activities of this group, including recent results on energy management, vehicle dynamics and intelligence. Most of this research has been experimentally validated in the ROboMObil, a modular robotic electric vehicle with a highly integrated mechatronic chassis, developed by DLR. These activities are in particular taking advantage of the opportunities offered by digitalization, automation, and electrification in order to decrease the conflict between mobility demands and its harmful collateral effects.

14:40-15:00 WeB01.3

Improvement of Low-Frequency Comfort through the Design of CRONE-SkyHook Suspension Systems (I)

Hamrouni, Emna — Groupe PSA
Bel Haj Frej, Ghazi — University of Bordeaux
Moreau, Xavier — University of Bordeaux
Benine-Neto, André — University of Bordeaux
Hernette, Vincent — Groupe PSA

This paper deals with vehicle dynamics and focuses on Global Suspension Control. The aim is to improve low-frequency comfort, defined in the frequency range [0; 5] Hz, of an active suspension system. Therefore, an analysis and design approach is proposed on a functional scale. A target behavior of the equivalent open-loop, seen from the angle of low-frequency comfort, is generalized using CRONE-SkyHook (CSH) approach. The controller implemented on the validation model is therefore deduced. Simulation results show that requirements in terms of body handling under road solicitations and filtering are reached.

15:00-15:20 WeB01.4

A Multi-Modes Semi-Active Suspension Control Strategy for Peugeot 308 RCZ Vehicle

Bel Haj Frej, Ghazi — University of Bordeaux
Moreau, Xavier — University of Bordeaux
Hamrouni, Emna — Groupe PSA
Benine-Neto, André — University of Bordeaux
Hernette, Vincent — Groupe PSA

In this paper, a new semi-active suspension control strategy is proposed for the Peugeot 308 RCZ vehicle. The aim of this study is to automate transition between the two modes of suspension based on nonlinear damping laws and using a variable damper. By minimizing a quadratic gap between a control target and the control actuation force issued from each mode, a decision strategy is defined and a suspension mode is selected, so that the variable damper can achieve it by controlling the actuation force. The used control target is synthesized using CRONE-Skyhook approach. Simulation results show that the requirements in terms of passenger comfort and vehicle stability are reached applying the proposed control strategy.

15:20-15:40 WeB01.5

Optimal LPV-Based Control and Estimation for Autonomous Vehicles (I)

Alcala, Eugenio — Universitat Politècnica De Catalunya
Facerias, Marc — Universitat Politècnica De Catalunya
Puig, Vicenç — Universitat Politècnica De Catalunya

This article presents a proposal to the problem of designing advanced control and estimation techniques to give solution to the autonomous driving guidance. In particular, this work takes advantage of the properties of polytopic LPV systems and predictive optimal control to guide the vehicle along a planned trajectory. Linear Parameter Varying (LPV) theory is used to model the dynamics of the vehicle and implement an LPV- Model Predictive Controller (LPV-MPC) that can be computed online with reduced computational cost. Furthermore, the LPV framework is used to design an optimal observer that estimates vehicle variables that cannot be measured. The control and estimation scheme is validated in simulation using the Robotic Operating System (ROS) framework where its effectiveness is demonstrated.

15:40-16:00 WeB01.6

LPV Control for Autonomous Vehicles Using a Machine Learning Based Tire Pressure Estimation (I)

Fényes, Dániel — SZTAKI
Hegedus, Tamas — Budapest University of Technology and Economics
Nemeth, Balazs — SZTAKI
Gaspar, Peter — SZTAKI
Koenig, Damien — Grenoble INP / GIPSA-Lab
Sename, Olivier — Grenoble INP / GIPSA-Lab

The paper presents a data-driven method for tire pressure estimation and an LPV-based control design for autonomous vehicles. The motivation of the research is that the pressures of the tires have high impacts on the lateral dynamics of the vehicle, because the loss of tire pressure may result in degradation in the lateral vehicle motion. First, a machine learning-based estimation algorithm, which uses only signals of on-board sensors, is proposed. Second, an LPV-based lateral control design is proposed, which uses the estimated tire pressure as a scheduling variable. The control is able to handle situations, in which the tire pressure decreases. The efficiency and the operation of the control system is illustrated through a comprehensive simulation example using the high fidelity simulation software CarMaker.

WeB02 ROOM SR2

Aerospace Control II (Regular Session)

14:00-14:20 WeB02.1

Policy Gradient-Based Integral Reinforcement Learning for Optimal Control Design of Non-Affine Morphing Aircraft Systems

Lee, Hanna — Seoul National University
Kim, Seong-hun — Seoul National University
Kim, Youdan — Seoul National University

An online model-free optimal control design strategy is proposed for general continuous-time nonlinear non-affine systems using policy gradient-based integral reinforcement learning. In the case of the non-affine system such as a morphing wing aircraft considering the morphing parameters as control effectors, general nonlinear control design method cannot be applied and solving the Hamilton-Jacobi-Bellman equation analytically is difficult. The proposed online optimal control algorithm is constructed based on the actor-critic structure using Q-function and policy gradient scheme and the integral reinforcement learning approach is used to develop the actor-critic parameter estimation for the continuous-time system. The closed-loop stability analysis for the designed method is presented. Through the proposed method, the optimal controller can be designed for the general non-affine system, which has an advantage in terms of a computational issue for the complex system. Note that the entire dynamic model is not required. Simulation results demonstrate the effectiveness of the proposed scheme.

14:20-14:40 WeB02.2

Continuous-Time Deterministic Policy Gradient-Based Controller for Morphing Aircraft without Exploration

Kim, Seong-hun — Seoul National University
Lee, Hanna — Seoul National University
Kim, Youdan — Seoul National University

A controller is optimized using limited flight data of morphing aircraft without dynamic model. Due to the nonlinear and non affine in control nature of the morphing aircraft dynamics, the integral reinforcement learning scheme and the deterministic policy gradient-based learning method are incorporated to develop to train the parameterized control input. The stability of the learnt control input is analyzed when the corresponding action-value function is converged. Unlike online algorithms, the parameters in the control input are hard to converge, and therefore a constrained learning strategy is implemented. The performance of the proposed method is demonstrated through numerical simulation for a longitudinal morphing aircraft system.

14:40-15:00 WeB02.3

Time-Energy Efficient Path Tracking for Spacecraft in Finite-Time under Input Saturation

Amrr, Syed Muhammad — Indian Institute of Technology, Delhi
Banerjee, Arunava — Indian Institute of Technology, Delhi
Nabi, Mashuq-un- — Indian Institute of Technology, Delhi

This paper develops a robust controller for the attitude tracking of time-energy near-optimal angular velocity obtained by the Legendre Pseudo-spectral method (LPSM). The information of near-optimal reference trajectory is realized offline by employing the LPSM for the nominal spacecraft model, which is without any uncertainties. Then, the proposed robust controller is employed online to track that near-optimal path while compensating for the inertial uncertainties, external disturbances, and noises under input saturation. The robust scheme is developed by combining the finite-time robust nonlinear disturbance observer (RNDO) and the adaptive non-singular fast terminal sliding mode control (NSFTSMC). The estimated output of RNDO directly attenuates lumped disturbance of moderate frequency and thus significantly helps in alleviating the chattering problem. Whereas NSFTSMC ensures the finite-time convergence of relative system states, and adaptive law solves the overestimation problem of controller gains while rejecting high-frequency disturbances. The simulation analysis is carried out to validate the proposed strategy.

15:00-15:20 WeB02.4

On Optimal Spacecraft Trajectory Planning for Asteroid Visual Coverage

Satpute, Sumeet — Lulea University of Technology
Sharif Mansouri, Sina — Lulea University of Technology
Bodin, Per — OHB Sweden
Nikolakopoulos, George — Lulea University of Technology

In this article, an optimization based spacecraft trajectory planner for asteroid proximity missions is presented. In asteroid missions, it is of a specific interest to determine the surface and material properties of the target asteroid by obtaining high-resolution measurements from multiple sites over the asteroid surface. During this mission, an important problem to solve is the trajectory planning for the spacecraft that results into a visual coverage problem for the asteroid surface. However, asteroids provide a challenging target for such missions since they are partially illuminated, rotating, irregular shaped bodies with a low (micro) but irregular gravity field. For addressing this challenging problem, this article will propose a novel optimization approach for the visual coverage of an asteroid. Thus, the proposed trajectory planner's objective is to determine the sequence of the areas to cover and the associated trajectories to achieve this coverage, while considering the motion of the spacecraft, the rotation dynamics of the asteroid, the illumination to each asteroid site and the irregular gravity constraints of the asteroid. The efficacy of the proposed optimal trajectory planner is evaluated through multiple simulation results, where it demonstrates successful optimal coverage of all the desired asteroid areas.

15:20-15:40 WeB02.5

Feasible Initial Conditions for Bias Proportional Navigation Guidance Laws under Look Angle Constraints

Cho, Namhoon — Agency for Defense Development
Kim, Jinrae — Seoul National University
Lee, Seokwon — Seoul National University

This study examines the conditions for guaranteeing stationary target interception without violating the impact angle and the look angle limit constraints during flight. Two types of new guidance laws are proposed for the constrained guidance problem in the form of a bias proportional navigation based on linear and nonlinear impact angle error feedback. Unlike the relevant previous study, both the range and the look angle are considered as the scheduling variables of the shaping functions, assuming that a constant stream of reliable range information is available. Also, the proposed guidance laws does not involve any explicit command switching. The set of feasible initial conditions are determined by the sufficient condition for guaranteeing constraint satisfaction during the entire time interval. The proposed sufficient condition can be thought of as the quantification of the set of feasible launch conditions with the desired final impact angle fixed, or vice versa.

15:40-16:00 WeB02.6

Singularity-Free Analytic Solution of Ballistic Trajectory with Quadratic Drag

Lee, Dong-Yeon — Korea Advanced Institute of Science and Technology
Tahk, Min-Jea — Korea Advanced Institute of Science and Technology
Lee, Chang-Hun — Korea Advanced Institute of Science and Technology
Kim, Young-Won — Korea Advanced Institute of Science and Technology

In this study, an analysis of the approximate analytic solution that represents the ballistic trajectory under the quadratic drag is performed. The analytic solution of the dynamics has the following assumptions. Gravity is a constant and there are no lift. Drag has a quadratic drag polar that is proportional to the square of velocity. In this case, using the flight path angle as an independent variable, an analytic solution for time, downrange and altitude can be calculated. This solution has a singularity where the denominator is zero under certain conditions. In this study, the derivation process is re-confirmed to analyze the physical meaning of each singularity condition. The analysis shows an analytic solution derivation based on the altitude axis, so that the singularity conditions on the altitude axis affect the time and downrange domains. New substitution variables are introduced to avoid these singularity conditions. All equations are re-derived based on the downrange axis, resulting in an analytic solution of downrange and time from which singularities are finally removed. Numerical simulations are performed to compare and verify the new solution with the existing solution, showing that singularities are removed under the same conditions.

WeB03 ROOM SR3

Robust Control (Regular Session)

14:00-14:20 WeB03.1

Hamiltonian Monte Carlo Based Path Integral for Stochastic Optimal Control

Patil, Akshay Kumar — Veermata Jijabai Technical Institute, Mumbai
Donge, Vrushabh — Veermata Jijabai Technical Institute, Mumbai
Kharade, Sonam — Veermata Jijabai Technical Institute, Mumbai
Wagh, Sushama — Veermata Jijabai Technical Institute, Mumbai
Singh, Navdeep — Veermata Jijabai Technical Institute, Mumbai

This paper develops a path integral based model predictive control using the Hamiltonian Monte Carlo (HMC) sampling to address the stochastic optimal control (SOC) problem. The proposed control framework provides an analytically sound method for building an algorithm of optimal control based on stochastic trajectory sampling. This is achieved by using Feynman-Kac (F-K) lemma, which transforms the value function of SOC problem into an expectation over all probable trajectories. The various sampling methods used in statistical analysis are bound to fail in high dimensional spaces where there is a presence of a large number of directions in which to guess. More specifically, just a singular set of directions is available that remain within the typical collection and pass the test. The HMC sampling is the Markov Chain Monte Carlo (MCMC) method that uses derivatives of density function, which is being sampled to generate efficient transitions spanning the posterior. Specifically, transitions that can follow high-dimension probability mass contours and glide coherently through the typical set of the desired exploration obtained by exploiting derivatives of target distributions. As a consequence, these Hamiltonian Markov transitions provide optimal control law for the SOC problem. Finally, the model predictive path integral control using HMC sampling is efficiently implemented for a Cart-pole system.

14:20-14:40 WeB03.2

Compensation of Mismatched Disturbances in Nonlinear Systems

Vrazhevsky, Sergey — ITMO University
Konovalov, Dmitry — ITMO University
Furtat, Igor — Institute of Problems of Mechanical Engineering Russian Academy
Kremlev, Artem — ITMO University

The paper deals with the problem of state feedback control with compensation of mismatched unknown disturbances in nonlinear systems. The proposed control law is based on two control methods: backstepping method and auxiliary loop method. The backstepping method allows control under mismatched disturbances with guarantying the input-to-state stability. The additional use of a new auxiliary loop method allows to significantly reduce the influence of disturbances in the closed-loop system. The simulations illustrate the advantages of the proposed method with some existing ones.

14:40-15:00 WeB03.3

Tracking Output Robust Control of Unmanned Surface Vessel with Disturbance Cancellation and Anti-Windup

Kakanov, Mikhail — ITMO University
Karashaeva, Fatimat — ITMO University
Borisov, Oleg — ITMO University
Pyrkin, Anton — ITMO University

This paper shows an explicit application example of the robust output high-gain control framework augmented with the internal model and back-calculation anti-windup technique. The application in question concerns station-keeping and tracking of an unmanned surface vessel modeled as MIMO systems with cross-couplings. The framework is illustrated by a set of simulation runs under different conditions.

15:00-15:20 WeB03.4

H-/H∞ Reference Model-Based Fault Detection and Isolation for Discrete-Time Systems

Schons, Silvane — Univ. Libre de Bruxelles
Coutinho, Daniel — Universidade Federal De Santa Catarina
Kinnaert, Michel — Univ. Libre de Bruxelles

This paper deals with the design of an *H-/H∞* observer-like filter for linear discrete-time systems. The goal is to guarantee fault detection and isolation taking into account the desired behavior given by a reference model despite the presence of disturbances. The filter design is cast as a convex optimization problem involving a set of linear matrix inequalities constraints. The effectiveness of the proposed design is illustrated by a numerical example.

15:20-15:40 WeB03.5

Static Output Feedback Controller for Uncertain Systems Subject to Actuators Limitations

Mesquine, Fouad — Cadi Ayyad University
Khallouk, Hamza — LAEPT, Cadi Ayyad University

This paper deals with the static output feedback problem for uncertain systems with restricted controls. Two uncertainty aspects are considered: polytopic and norm-bounded. New robust stability characterizations are firstly obtained, thanks to a system augmentation approach. Then, an iterative cone complementarity LMI algorithm is derived enabling one to design static output feedback maintaining both, linear behavior and the robustness of the controlled system. The effectiveness of the proposed design approach is illustrated through examples confirming the merit of the design method.

15:40-16:00 WeB03.6

A Robust Output Feedback Input Constrained Design for a Class of LPV Systems

Regaieg, Mohamed Amin — Lab-STA, National School of Engineers of Sfax
Bosche, Jerome — University of Picardie Jules Verne of Amiens
El Hajjaji, Ahmed — University of Picardie Jules Verne of Amiens

This work deals with the robust output feedback control design for a class of uncertain systems with input saturations. A sufficient condition for static output feedback stabilizability is proposed and the corresponding design method is based on solving an optimization problem expressed in terms of LMI. The technique is validated by a numerical illustration considering a photovoltaic energy conversion system.

WeB04 ROOM SR4

Fault Tolerant and Resilient Control Systems (Regular Session)

14:00-14:20 WeB04.1

User-Aware Centralized Resource Allocation in Heterogeneous Networks

Ornatelli, Antonio — La Sapienza, Rome
Giuseppi, Alessandro — La Sapienza, Rome
Suraci, Vincenzo — Università Degli Studi E-Campus
Tortorelli, Andrea — La Sapienza, Rome

In the last two years, in Europe, 5G networks and services proliferated. The integration of 5G networks with other radio access networks is considered one of the key enablers for matching the challenging 5G Quality of Service requirements. In particular, the integration with high throughput satellites promises to increase the network performances in terms of resilience and Quality of Service. The present work addresses this problem and presents a user-aware resource allocation methodology for heterogeneous networks. Said methodology is articulated in two-steps: at first, the Analytical Hierarchy Process is used for deciding the network over which traffic is steered and, then, a Cooperative Game for allocating resources within the network is set up. Simulations are presented to validate the proposed approach.

14:20-14:40 WeB04.2

Model-Free Control As a Service in the Industrial Internet of Things: Packet Loss and Latency Issues Via Preliminary Computer Experiments

Join, Cédric — Université de Lorraine, CRAN
Fliess, Michel — Ecole Polytechnique
Chaxel, Frédéric — Université de Lorraine

Model-Free Control (MFC), which is easy to implement both from software and hardware viewpoints, permits the introduction of a high level control synthesis for Industrial Internet of Things (IIoT) and for Industry 4.0. The choice of the User Diagram Protocol (UDP) as the Internet Protocol permits to neglect the latency. In spite of a most severe packet loss, convincing computer experiments show that MFC exhibits a good Quality of Service (QoS) and behaves better than a classic PI regulator.

14:40-15:00 WeB04.3

Attack Resilient Heterogeneous Vehicle Platooning Using Secure Distributed Nonlinear Model Predictive Control

Basiri, Mohammad Hossein — University of Waterloo
Azad, Nasser L. — University of Waterloo
Fischmeister, Sebastian — University of Waterloo

Recently, vehicle platoons have offered significant enhancements in traffic management, energy consumption and safety in intelligent transportation systems. Despite the benefits brought by the platoons, they potentially suffer from insecure networks which provide the connectivity among the vehicles participating in the platoon. This paper deals with the secure control of vehicle platoons under the risk of a common cyber attack, namely Denial of Service (DoS) attack. A DoS intruder can endanger the security of platoon by jamming the communication network among the vehicles, which is responsible to transmit inter-vehicular data throughout the platoon. This can potentially result in huge performance degradation or even hazardous collisions. We propose a secure distributed nonlinear model predictive control algorithm consisting of i) detection and ii) mitigation phases. The algorithm is capable of handling DoS attack performed on a platoon equipped by different communication topologies and at the same time it guarantees the desired formation control performance. Stability analysis of the attacked platoon running the given algorithm is also presented. Simulation results on a sample heterogeneous attacked platoon exploiting two-predecessor follower communication environment demonstrate the effectiveness of the method.

15:00-15:20 WeB04.4

Fault-Tolerant Task Allocation in Networked Control Systems

Schenk, Kai — Ruhr-Universität Bochum
Lunze, Jan — Ruhr-Universität Bochum

Networked control systems are made fault tolerant in this paper by redistributing the control tasks of the subsystems in case of faults. Active fault tolerance is brought into the overall system by a cooperation of the faulty subsystems and the healthy subsystems rather than by trying to recover the nominal performance of the faulty subsystems. This paper states conditions under which reconfigurable tasks exist and provides a description of the design process of the fault-tolerant task allocation unit that determines the new tasks in dependency upon the fault case.

15:20-15:40 WeB04.5

Compositional Verification of Passivity for Cascade Interconnected Nonlinear Systems

Agarwal, Etika — University of Notre Dame
Sivaranjani, S — University of Notre Dame
Gupta, Vijay — University of Notre Dame
Antsaklis, Panos J. — University of Notre Dame

We consider the problem of verifying passivity of a networked system comprised of dynamically coupled nonlinear subsystems affine in the control input, connected in a cascade architecture. We propose a novel verification approach, wherein the verification is carried out locally at each subsystem using only the dynamics of the particular subsystem and limited information about its coupling with the immediately preceding subsystem in the cascade. The proposed verification is compositional, that is, the addition of new subsystems does not require re-verification of the passivity of the existing network. When a new subsystem is added to the network, only the dynamics of the new subsystem and limited information about its interconnection to the existing network are used to verify passivity of the entire networked system.

15:40-16:00 WeB04.6

Distributed Time-Varying Kalman Filter Design and Estimation Over Wireless Sensor Networks Using OWA Sensor Fusion Technique

Basiri, Mohammad Hossein — University of Waterloo
Azad, Nasser L. — University of Waterloo
Fischmeister, Sebastian — University of Waterloo

In this paper, a novel estimation procedure is proposed, which consists of designing a distributed class of time-varying Kalman filter based on wireless sensor networks topology along with a new sensor fusion method. The proposed technique is employed to estimate the states and outputs of a linear time-varying system with a high level of accuracy. Both the dynamics of the system and the measurements are assumed to be contaminated by external noises. The notion of Orness and Ordered Weighted Averaging (OWA) operator technique are utilized to fuse the estimation of the sensors. O'Hagan method, along with the gradient descent method, is

employed to find the optimal weights. In the introduced approach, OWA weights are learned for each observation such that they efficiently minimize the estimation error for that particular observation. This will result in an outstanding high accurate sensor fusion outcome. In addition, two optimistic and pessimistic exponential OWA operators are used and compared together to achieve a pre-specified level of Orness. The simulation results are shown on a given linear time-varying system to verify the effectiveness of the proposed sensor fusion distributed filtering design method.

WeB05 ROOM SR5

System Identification (Regular Session)

14:00-14:20 WeB05.1

Comparison of Algorithms for Real-Time Identification of FIR Systems from Binary Measurements on the Output

Oualla, Hicham — Sultan Moulay Slimane University
Pouliquen, Mathieu — University of Caen
Frikel, Miloud — University of Caen
Safi, Said — Sultan Moulay Slimane University

There are six main algorithms for real-time identification of FIR systems from binary measurements on the output. The objective of this paper is to propose a first short comparison of these methods based on the description of each method and on some numerical simulations. This comparison should help the user in choosing an algorithm if necessary.

14:20-14:40 WeB05.2

Filtration Duration and Errors in Finite-Frequency Identification

Shatov, Dmitrii — V. A. Trapeznikov Institute of Control Sciences

The paper is devoted to analysis of filtration errors in finite-frequency identification. We consider a linear control plant subject to action of an external disturbance, which is assumed to be a bounded function. The finite-frequency identification allows us to find estimates of this plant's parameters. It uses special integral filters (Fourier filters), that find estimates of the plant frequency response at specific frequencies. There are known estimates of convergence rate of Fourier filters errors, which we use as a basis to propose a new approach to determine the duration of identification. The proposed method is based on a special linear programming problem, the solution of which gives us two parameters: an estimate of the filter value and a parameter that describes the rate of the filter error convergence. The last one is used for duration determination. We develop corresponding filtration algorithm and give certain consideration to its accuracy. An illustrative example is presented.

14:40-15:00 WeB05.3

A Relaxed Model Selection Method for Duffing Oscillator Identification

Khatiry Goharoodi, Saeideh — Ghent University
Dekemele, Kevin — Ghent University
Loccufier, Mia — Ghent University
Dupré, Luc — Ghent University
Crevecoeur, Guillaume — Ghent University

This study presents a relaxed model selection procedure based on the sparse regression system identification method for Duffing oscillator identification. A two-stage relaxation procedure is presented. In a first stage an elastic net optimizer underpins the sparse regression that enables to explore the possible models. The subsequent stage employs the Akaike information criteria that employs the one standard error rule (1-SE) to select the appropriate model. We study the effect of relaxation in both stages, i.e. providing more exploration capabilities in the regression and the selection, by applying the two-stage methodology on experimental data collected on a mechanical Duffing oscillator setup. Our analysis shows that relaxation is advantageous when dealing with noisy experimental data and allows to find model structures and associated parameter values in the mechatronic Duffing oscillator. Results show that relaxation is pivotal when dealing with noisy experimental data and that the methodology possesses the capability to find model structures and associated parameter values of a Duffing oscillator. The presented results can be of benefit when identifying the system behavior of other mechatronic systems that exhibit complex, chaotic behavior that is difficult to model starting from first principles.

15:00-15:20 WeB05.4

PEM-Identification of a Block-Oriented Nonlinear Stochastic Model with Application to Room Temperature Modeling

Paschke, Fabian — Fraunhofer Institute for Integrated Circuits (IIS)

This contribution proposes a block-oriented nonlinear stochastic model that can be identified by prediction error minimization (PEM) method. The model consists of a linear time invariant (LTI) stochastic block and a static nonlinear output feedback. Using measured data of a conference and an office room, it is demonstrated that this approach can be used for the identification of models suitable for short term room-temperature prediction.

15:20-15:40 WeB05.5

Identification of Single Flexible-Joint Robot Dynamics: A Nonparametric Approach

Boukhebouz, Bassem — CEA LIST, Strasbourg University
Mercère, Guillaume — Poitiers University
Grossard, Mathieu — CEA List
Lamy, Xavier — French Atomic Energy Commission (CEA)
Laroche, Edouard — Strasbourg University

In this paper, a nonparametric identification method is used to identify the dynamic model of a flexible joint robot (FJR) that includes friction and transmission nonlinearities. More precisely, the Best Linear Approximation (BLA) approach has been considered in a closed-loop setup to provide the frequency response of the system and an evaluation of the nonlinearities. Based on simulated data, the paper investigates the tuning of an adequate multisine excitation signal that enables good identification results. First, an algorithm is adapted in order to shape the spectrum of the control signal adequately. Second, based on an evaluation of the effects on the Coulomb friction and transmission nonlinearity, it is showed that an optimal amplitude can be found.

15:40-16:00 WeB05.6

Identification of the Quadcopter Vertical Translation Dynamics

Alexandrov, Vadim — V.A. Trapeznikov Institute of Control Sciences
Rezkov, Ilya — V.A. Trapeznikov Institute of Control Sciences
Shatov, Dmitrii — V.A. Trapeznikov Institute of Control Sciences

The paper deals with the quadcopter dynamics model identification. The vertical translation is separated as the SISO control loop. The transfer functions from the throttle to vertical velocity and to altitude are studied. The finite-frequency identification is exploited to estimate the transfer function coefficients. This approach includes the feature of the closed loop identification, that is, a controller operates to stabilize the system and to provide performance during the identification test. However, the controller formulae and parameters are not needed for identification. It is important for a quadcopter controlled by standard autopilot software. A standard quadcopter is used as the experimental setup. The identification results from the experimental flight data are considered.

WeC01 ROOM SR1

Automotive Control (Regular Session)

16:20-16:40 WeC01.1

Preview Control of Engine Intake Manifold Pressure

Shulga, Evgeny — Groupe PSA, Université De Bordeaux
Lanusse, Patrick — Université of Bordeaux, IPB
Airimitoaie, Tudor-Bogdan — Université de Bordeaux
Maurel, Stéphane — Groupe PSA
Trutet, Arnaud — Groupe PSA

This paper proposes a control design method for the intake manifold pressure of an internal combustion engine. It is based on a feedback

controller that ensures the robustness to model uncertainties and a preview feed-forward filter. The latter has an anticipating effect with respect to known future values of the reference signal, while at the same time taking into account the model dynamics and mitigating the control effort. The proposed approach is evaluated using the Matlab Simulink model of a spark ignition internal combustion engine in which parametric uncertainties and saturation are added. A nonlinear model predictive controller is implemented on the same model for comparison purposes.

16:40-17:00 WeC01.2

Trajectory Tracking Control for an AutoNOMO Vehicle Using a Decoupling Approach

Rosas-Vilchis, Adonai	Instituto Politecnico Nacional
Ferreira de Loza, Alejandra	Instituto Politecnico Nacional
Aguilar, Luis T.	Instituto Politecnico Nacional
Cieslak, Jérôme	Université de Bordeaux
Henry, David	Université de Bordeaux
Montiel-Ross, Oscar	Instituto Politecnico Nacional

The paper deals with the tracking problem of an AutoNOMO vehicle. The problem statement is similar to the tracking control of a non holonomic car-like robot. To this aim, the kinematic model of the vehicle is considered. Thus, a local transformation takes the system into a chained-form. Later, the error tracking dynamics is transformed into a triangular-like form. In this way, the system may be divided into two inter- connected sub-systems. A homogeneous finite-time controller is proposed to stabilize the Cartesian coordinate x. In consequence, the effects x are decoupled from the remained dynamics. Then, a recursive backstepping-like methodology stabilizes the remaining coordinates. The stability of the closed-loop system is analyzed using the Lyapunov theory. Simulations and experiments illustrate the feasibility of the approach.

17:00-17:20 WeC01.3

Slip Estimation with Receding-Horizon Strategy for Off-Road Vehicles with Nonlinear Tire Interactions

Sousa, Lucas Castro	Pontifical Catholic University of Rio De Janeiro
Hultmann Ayala, Helon Vicente	Pontifical Catholic University of Rio De Janeiro

In the present paper we show the application of moving horizon state estimation approach to longitudinal slip estimation of an off-road vehicle. The tire slip is related to important vehicle dynamics control systems, such as anti-lock braking system or traction control system that prevent the tires from spinning out during traction or locking up during braking. The single-corner model featuring Bekker tire model are applied in a vehicle considering two different terrains, a medium soil and a clayey soil using information about brake torque, longitudinal and angular wheel speed. Simulation results show a good estimation of the longitudinal slip considering longitudinal and angular wheel measurements. It has been shown that even for the case when the longitudinal speed is not measured, it is possible to accurately estimate the vehicle slip by increasing the window size. This highlights the importance of using advanced receding-horizon strategies for vehicle estimation and control.

17:20-17:40 WeC01.4

Model Predictive Control for Agricultural Machines with Implements

Lukassek, Markus	Friedrich-Alexander-Universität Erlangen-Nürnberg
Völz, Andreas	Friedrich-Alexander-Universität Erlangen-Nürnberg
Szabo, Tomas	ZF Friedrichshafen AG
Graichen, Knut	Friedrich-Alexander-Universität Erlangen-Nürnberg

This paper presents a method to stabilize a specific point on a vehicle along a given reference path or trajectory. To this end, based on the classical kinematic single-track model, the rear axle midpoint is transformed to any point that is rigidly coupled to the vehicle, e.g., an agricultural implement. An invariant tracking error is formed which is required for trajectory tracking and path-following using a nonlinear model predictive control. This provides the possibility to react to kinematic restrictions and actuator dynamics as well as to delay times in the actuator system. The underlying optimization problem is solved using a gradient-based augmented Lagrangian approach in order to achieve real-time feasibility. The algorithms are validated in simulations. A hardware-in-the-loop simulation is performed on an embedded electronic control unit to prove real-time capability.

17:40-18:00 WeC01.5

Development of a ROS Controlled Chassis Dynamometer for Lightweight, Single Seater EVs

Piperidis, Savvas	Technical University of Crete
Chrysomallis, Iason	Technical University of Crete
Georgakopoulos, Stavros	Technical University of Crete
Stefanoulis, Theodoros	Technical University of Crete
Ghionis, Nikolaos	Technical University of Crete
Katsifas, Vasileios	Technical University of Crete
Tsourveloudis, Nikos	Technical University of Crete

TUCer team developed a prototype, portable chassis dynamometer capable of carrying out experimentation with alternate scenarios of acceleration, constant speed and deceleration, in a fully automated way. A controller scheme based on Robot Operating System was programmed, using open source tools. The testing scenarios are implemented using a motor/generator and an electronically controlled load, embedded on the dynamometer. Extensive testing during TUCer systems' development and real race conditions proved the dynamometer's reliability and functionality.

WeC02 ROOM SR2

Disturbance Rejection (Regular Session)

16:20-16:40 WeC02.1

Mismatched Disturbance Attenuation of a Spatially Developing Free Shear Flow

Collewet, Christophe	Inrae / Inria
Carlier, Johan	IRSTEA

This paper deals with the closed-loop control of a free shear flow subjected to mismatched disturbances. The goal is to maintain it in a desired state whatever the disturbances. Our approach consists of linearizing the Navier-Stokes equations around the desired state and next to perform a discretization step to obtain a linear state formulation. The components of the state vectors are the stream function evaluated at different points of the space assumed to be estimated via image techniques. The proposed control law writes as the sum of two terms. The first one allows to impose a behavior in regulation while the second one describes a behavior in attenuation. We show that this second term writes simply as a feedback gain that has to apply to the perturbation vector. However, since we consider that the disturbance is unknown, we propose a disturbance observer to derive the control law. Next, we prove the input-to-state stability of our control scheme. Simulations results on the DNS (direct numerical simulation) solver Incompact3d validate our approach.

16:40-17:00 WeC02.2

Tracking Control of Nonlinear Systems under Input and Output Disturbances with Applications

Furtat, Igor	Institute of Problems of Mechanical Engineering Russian Academy
Gushchin, Pavel	Gubkin Russian State University of Oil and Gas

The paper describes the novel tracking control algorithm for nonlinear systems under external bounded output and input disturbances. The dimension of the output disturbance can be equal to the state vector dimension and the input disturbance can be presented in any equation of the plant model. The conditions in terms of linear matrix inequalities are obtained. The experiments in laboratory platforms "Twin Rotor MIMO System" and "KOMEKS-1" show the efficiency of the proposed algorithm.

17:00-17:20 WeC02.3

Disturbance Attenuation in Synchronised Systems

Wissing, Marc	IAV GmbH
Oehlschlägel, Thimo	IAV GmbH
Lunze, Jan	Ruhr-Universität Bochum

This paper investigates the disturbance-attenuation properties of

synchronised systems. An internal-model principle for multi-agent systems is elaborated that describes the necessary dynamics of the extended agents for disturbance attenuation. Accordingly, the extended agents consisting of the agents and the local controllers have to include the dynamics of the disturbance generators. Furthermore, a necessary and sufficient synchronisation condition of disturbed systems is proved. The results are illustrated by a numerical example.

17:20-17:40 WeC02.4

Synthesizing Observers and Controllers Based on Ellipsoidal Reachable Sets of LTV Discrete Systems

Balandin, Dmitry — Nizhny Novgorod State University
Biryukov, Ruslan — Nizhny Novgorod State University
Kogan, Mark M. — Nizhny Novgorod State University

The paper is devoted to reachable sets of linear time-varying discrete systems under uncertain initial states and disturbances with a bounded uncertainty measure. The uncertainty measure is the sum of a quadratic form of the initial state and the sum over the finite-time interval from a quadratic form of the disturbance. It is shown that the reachable set of the system under this assumption is an evolving ellipsoid with a matrix being a solution to the linear matrix difference equation. This result is used to synthesize optimal observers and estimators providing the minimal ellipsoidal sets as the estimates of the system state and unknown parameters, respectively, as well as optimal controllers steering the system state into a final target ellipsoidal set or keeping the entire system trajectory in a prescribed ellipsoidal tube under all admissible initial states and disturbances. The relationships between the optimal ellipsoidal observer and the Kalman filter as well as between the optimal ellipsoidal estimator and the recursive least weighted squares algorithm are established. Numerical modeling with the Mathieu equation for parametric vibrations of a linear oscillator illustrates the results.

17:40-18:00 WeC02.5

Stabilization of Continuous-Time Bilinear Control Systems Subjected to Exogenous Disturbances

Khlebnikov, Mikhail — V. A. Trapeznikov Institute of Control Sciences

We consider new results related to control design problem for continuous-time bilinear systems subjected to arbitrary bounded exogenous disturbances. A simple procedure for the construction of the ellipsoid of stabilizability and the domain of stabilizability for bilinear control systems is proposed and its efficiency is proved. The main tools are the quadratic Lyapunov functions and the linear matrix inequality technique. This simple but general approach has great potential and can be widely generalized; for instance, to various robust statements of the problem.

WeC03 ROOM SR3

Fuzzy Control (Regular Session)

16:20-16:40 WeC03.1

Robust L_2 Control for Uncertain T-S Descriptor Model with Input Saturation

Righi, Ines — Souk Ahras University
Aouaouda, Sabrina — Souk Ahras University
Chadli, M. — University Paris-Saclay
Khelil, Khaled — Souk Ahras University

This paper concerned with the stabilization of uncertain discrete-time descriptor models subject to input saturation and external disturbances. The design control strategy is based on Takagi-Sugeno (T-S) approach and a nonparallel distributed compensation control law. To synthesis the fuzzy controller, the stability conditions are derived using non-quadratic Lyapunov functions with respect to the given saturation constraint on the control input and achieving a guaranteed L_2-gain performance. The optimization problem is formulated in terms of linear matrix inequalities (LMIs). Numerical example illustrates the efficiency of the proposed approaches.

16:40-17:00 WeC03.2

Robust Fuzzy Tracking Control for an Activated Sludge Process

Khallouq, Abdelmounaim — Cadi Ayyad University
Karama, Asma — Cadi Ayyad University
Abyad, Mohamed — Cadi Ayyad University

In this work we are interested in a tracking problem with reference model. A robust fuzzy controller is designed for the regulation of the pollutant substrate and the dissolved oxygen concentrations inside an activated sludge process. The process is described by Takagi-Sugeno fuzzy model obtained from the nonlinear mass-balance model. An observer is considered for the on-line estimation of the unavailable biological states using the dissolved oxygen concentration as unique measurable. The control law is based on the Parallel Distributed Compensation formulation and is combined with a robust Takagi-Sugeno fuzzy observer. The stability of the entire system for both the observer and the controller is then discussed using Lyapunov theory to guarantee tracking performance of the closed loop system. Using the H infinite norm, new sufficient conditions to develop the fuzzy controller is obtained and given in terms of linear matrix inequalities. The efficiency and the robustness of the control scheme is demonstrated via simulations.

17:00-17:20 WeC03.3

Whale Optimization Algorithm-Based Tuning of Low-Cost Fuzzy Controllers with Reduced Parametric Sensitivity

David, Radu-Codrut — Politehnica University of Timisoara
Precup, Radu-Emil — Politehnica University of Timisoara
Preitl, Stefan — Politehnica University of Timisoara
Petriu, Emil — University of Ottawa
Stinean, Alexandra-Iulia — Politehnica University of Timisoara
Roman, Raul-Cristian — Politehnica University of Timisoara

This paper proposes a novel application of Whale Optimization Algorithm (WOA) as solution for solving a complex control design and tuning problem concerning fuzzy control systems that control processes modeled as second-order servo systems with an integral component and variable parameters. The minimization of objective functions containing the error of the controlled process and the output sensitivity functions of the sensitivity models defined with respect to the parametric variations of the controlled process (the servo system) defines the optimization problem. WOA is integrated with the aim of obtaining optimal controller parameters therefore obtaining a new generation of Takagi-Sugeno-Kang proportional-integral fuzzy controllers. For this, a design method is defined and experimentally validated with the aid of a laboratory nonlinear servo system.

17:20-17:40 WeC03.4

State Feedback Control for Intelligent Traffic Light Systems

Tunc, Ilhan — Istanbul Technical University
Söylemez, Mehmet Turan — Istanbul Technical University

Traffic is an important factor affecting human life quality in crowded cities. Increasing population and increasing individual vehicle ownership lead to an increase in traffic density. This leads to an increase in the time lost for travelers and pollution. Intersections are areas that cause more traffic density because of design making hurdles. Traffic jam can be reduced by adapting the traffic light control to the traffic density change at the junctions. In this study, the State Feedback Controller is proposed for the traffic light system control at the four-leg intersection. Simulation of this control system is made and handled using Simulation of Urban Mobility (SUMO). Results are compared for the proposed types of Traffic Light Control Systems. It was observed that the State Feedback traffic light controller, which is the recommended method from the simulation results, gives better results than both the Fuzzy Logic Control (FLC) and the Fixed Time traffic light controller.

17:40-18:00 WeC03.5

Using Genetic Algorithm for Optimizing Fuzzy Logic Controller for Mode-Based Control Algorithms of Building Automation Systems

Cai, Xiaoye — RWTH-Aachen University
Cen, Yue — RWTH-Aachen University
Baranski, Marc — RWTH-Aachen University
Müller, Dirk — RWTH-Aachen University

The integration of renewable forms of energy into building energy systems causes increasing complexity of energy conversion and

distribution systems. This development creates the need for appropriate control algorithms implemented in building automation systems. We previously introduced the MODI-method to support structured development of mode-based control algorithms and allow simulation-based testing in early phases of the planning process. However, the control design concerns different aspects, such as efficiency and system lifetime. It is therefore challenging to determine the conditions of the transitions between operating modes. Furthermore, the control design process lacks an optimization approach for the generated control algorithms. In this paper, we investigate the application of a fuzzy logic controller to generate conditions for mode transition of control algorithms and transfer approximate human knowledge into the control design. We perform optimization based on genetic algorithm to improve the performance of the control system, considering several aspects. The case study presents structured development of a mode-based control algorithm for a cooling supply system and the functionality of a fuzzy logic controller implemented into the control algorithm. The optimization of the fuzzy logic controller is performed using genetic algorithm. As a result, the optimized parameters of the fuzzy logic controller are gathered, leading to improvement of the performance of the system.

WeC04 ROOM SR4

State Estimation and Environment Perception: Application to Mobile Vehicle (Invited Session)

Organizer: Chadli, M.	University Paris-Saclay
Organizer: Bouchafa-Bruneau, Samia	University of Paris-Saclay, IBISC Lab-UEVE
Organizer: Stefanovic, Margareta	University of Denver
Organizer: Vasseur, Pascal	University of Rouen

16:20-16:40 WeC04.1

Passivity-Based Adaptive Controller for Dynamic Self-Leveling of a Custom-Built Landing Platform on Top of a UGV (I)

Alghanim, Mohammed	University of Denver
Qasim, Mohammed	Ninevah University
Valavanis, Kimon P.	University of Denver
Rutherford, Matthew	University of Denver
Stefanovic, Margareta	University of Denver

A Passivity-Based Adaptive Controller (PBAC) is derived and tested for the integrated Argo J5 Skid Steering Mobile Robot (SSMR) and custom-built landing platform. The twofold aim is to demonstrate landing platform dynamic self leveling accuracy, coupled with accurate Argo J5 trajectory tracking in rough and uneven terrains. The overall system dynamic model based on Euler-Lagrange and Terramechanics theory is summarized, followed by derivation of the PBAC. Performance is first tested/evaluated in a MATLAB/Simulink environment using actual/experimentally identified Argo J5- landing platform physical parameter values and constraints. Results are, then, verified/validated using the V-REP Simulation Package. Different terrain slope angles, different platform initial angles, and different realistic Argo J5 velocities are used in all studies. It is observed that dynamic self-leveling is achievable for Argo J5 slow velocities and small slope terrain angles. Results also reveal current design limitations that need to be overcome before actual testing.

16:40-17:00 WeC04.2

Indoor Localization and Mapping: Towards Tracking Resilience through a Multi-SLAM Approach (I)

Alliez, Pierre	Université Cote d'Azur, INRIA
Bonardi, Fabien	Université Paris-Saclay
Bouchafa, Samia	Université Paris-Saclay
Didier, Jean-Yves	Université Paris-Saclay
Hadj-Abdelkader, Hicham	Université Paris-Saclay
Ireta Munoz, Fernando	INRIA
Kachurka, Viachaslau	Universite Evry Val-d'Essonne
Rault, Bastien	Innodura TB
Robin, Maxime	Innodura TB
Roussel, David	Universite Evry Val-d'Essonne

This paper presents a use case for SLAM techniques applied to real time localization and detailed mapping for emergency response personnel in non cooperative environments. Such environments tend to defeat conventional localization approaches, therefore we must ensure continuous operation of our localization and mapping regardless of the difficulties encountered (lack of GPS signals, lighting conditions, smoke, etc.). The proposed system fuses two SLAM algorithms, a LiDAR-based and a camera-based. Since LiDAR-based SLAM uses dense 3D measurements, it is well suited to the construction of a detailed map, while the visual SLAM allows to quickly recognize already visited places in order to apply loop closure corrections, by using a key frames graph. The currently proposed system allows collaboration between these two SLAMs through pose sharing and relocalization.

17:00-17:20 WeC04.3

Comparison of Controller Performance for UGV-Landing Platform Self-Leveling (I)

Alghanim, Mohammed	University of Denver
Qasim, Mohammed	Ninevah University
Valavanis, Kimon P.	University of Denver
Rutherford, Matthew	University of Denver
Stefanovic, Margareta	University of Denver

This paper focuses on a comparative study of linear, nonlinear and adaptive controller performance to level within one degree of the horizon - regardless of terrain configuration, i.e., rough, asphalt, off-road - a custom-built landing platform for quadrotors and small-scale helicopters to take-off and land. The landing platform is built on top of the commercially available Argo J5 Unmanned Ground Vehicle (UGV). A detailed and accurate landing platform model is first derived based on the Euler-Lagrange formulation. Then, PD, PID, LQR, feedback linearization and a Passivity Based Adaptive Controller (PBAC) are designed, tested and compared via extensive MATLAB/ Simulink simulations and by using the V-REP Simulation Environment for further validation and evaluation of leveling capabilities under disturbance and disturbance-free conditions, where the disturbance torque is added to the controllers. The comparative study considers real Argo J5 and platform physical and functional constraints and limitations. Results show that the PD and PBAC achieve faster platform settling time under disturbance-free conditions while the PBAC and LQR achieve leveling under external disturbances. Thus, it is concluded that the PBAC is the best candidate controller configuration. Obtained results also reveal platform design limitations that lead to improved UGV - platform configuration before actual experimentation and use.

17:20-17:40 WeC04.4

H∞ Memory Observer Design for Vehicle Suspension State Estimation and Unknown Road Reconstruction (I)

Wang, Gang	Guizhou Institute of Technology
Chadli, M.	Université Paris-Saclay
Mammar, Said	Université Paris-Saclay

This brief is concerned with the state estimation problem for a vehicle suspension subjected to unknown road input. Limited by installation space and number of sensors, the measurable states are limited. To estimate the entire suspension states and road profile simultaneously, an H∞ memory observer (HMO) is developed. Unlike the traditional unknown input observer (UIO) designed to the suspension system, the proposed HMO takes advantage of the memory outputs. Disturbance decoupling and H∞ attenuation techniques are used in the design. Furthermore, a sufficient condition based on LMI framework is provided to find the observer gains. The simulation results show that the HMO is efficient and the estimated values are very close to the real ones.

WeC05 ROOM SR5

System Identification and Estimation (Regular Session)

16:20-16:40 WeC05.1

A New Measles Epidemic Model: Analysis, Identification and Prediction

Di Giamberardino, Paolo	Sapienza, University of Rome
Iacoviello, Daniela	Sapienza, University of Rome

A new measles epidemic model is proposed and identified by using real data relative to the number of confirmed infected patients in

Italy in the period 1970 - 2018. The possibility of predicting the number of new infection is important for an efficient resource scheduling. Only in the last years great attention has been devoted to reliable data collection; therefore, in general, the model parameters identification is not an easy task. Moreover, the available data are ”corrupted” by human intervention, such as prevention campaign, or, whenever possible, vaccination. In this paper, the measles model parameters are identified referring to the data of the period in which there wasn't a significant vaccination coverage; successively, the vaccination action has been identified. The results obtained appear encouraging, confirming the importance of available consistent data.

16:40-17:00 WeC05.2

Modeling Soft Robotic Actuators Using Data-Driven Model Reduction

Das, Apurba	Indian Institute of Technology Delhi
Nabi, Mashuq-un-	Indian Institute of Technology-Delhi
Chinesta, Francisco	ESI Group Chair, PIMM Lab, Arts et Metiers

Soft robotics is a emerging research area in the field of robotics with promising application areas where traditional robots fails to perform efficiently. However obtaining a nearly accurate mathematical model of the soft robot is challenging due to its high flexibility and non-linear material properties. The limited information of the system in terms of its parameters have led to alternative modeling approaches. With large scale data collection in terms of evolution of states and system identification, data-driven techniques are favorable alternative to obtain nearly accurate models. Considering the large scale dimensional problem of the resulting model, model reduction technique have been applied to obtain optimal reduced set of governing equations. In this work, the dynamic mode decomposition based system identification technique have been implemented in the soft robot model. This technique does not need any information regarding the parameters of the system and is solely dependent on the measurement of the system states. The obtained dynamic model is a linear approximation of the full-order system. The paper describes the model reduction technique aligned with the soft robotic actuator application.

17:20-17:40 WeC05.4

A Data-Driven Slip Estimation Approach for Effective Braking Control under Varying Road Conditions

Crocetti, Francesco	University of Perugia
Costante, Gabriele	University of Perugia
Fravolini, Mario Luca	University of Perugia
Valigi, Paolo	Universita' Di Perugia

The performances of braking control systems for robotic platforms, e.g., assisted and autonomous vehicles, airplanes and drones, are deeply influenced by the road-tire friction experienced during the maneuver. Therefore, the availability of accurate estimation algorithms is of major importance in the development of advanced control schemes. The focus of this paper is on the estimation problem. In particular, a novel estimation algorithm is proposed, based on a multi-layer neural network. The training is based on a synthetic data set, derived from a widely used friction model. The open loop performances of the proposed algorithm are evaluated in a number of simulated scenarios. Moreover, different control schemes are used to test the closed loop scenario, where the estimated optimal slip is used as the set-point. The experimental results and the comparison with a model based baseline show that the proposed approach can provide an effective best slip estimation.

17:40-18:00 WeC05.5

State and Parameter Estimation for Spark Ignition Engine with Parameter Uncertainty

Singh, Vyoma	IIT Mandi, India
Pal, Birupaksha	Robert Bosch Engineering and Business Solutions Private Limited
Jain, Tushar	IIT Mandi, India

Engines are complex and their control is very important in the automotive industry. One of the main objectives while designing the control strategies is to maintain the air-fuel ratio to a specific value. This has increased the inspection of engine dynamical models and their parameter estimation. Some of the main parameters affecting the air-fuel ratio are the throttle discharge coefficient, thermal efficiency, and volumetric efficiency. These parameters are usually constant under steady-state but due to the long run of the engine and various uncertainties, their value may change. The main challenges are how to obtain the information of parameters and the states under the influence of process noise, measurement noise, and parameter uncertainty, which are required for designing an effective control strategy. In this work, the problem of physical parameter estimation of the nonlinear mean value engine system model comprising a throttle, intake manifold, engine speed dynamics, and fuel system altogether with unknown states is considered. A method with a unique combination of Unscented Kalman Filter and Recursive Least Squares with forgetting factor for estimation of parameters and states of spark-ignition engines is proposed. Simulation results are provided for state and parameter estimation for the spark ignition engine model with parameter uncertainties.

ThA01 ROOM SR1

Autonomous System (Regular Session)

09:00-09:20 ThA01.1

Single Filter Lead Vehicle Distance and Velocity Estimation with Multiple Hypothesis Testing

Bauer, Peter — Institute for Computer Science and Control

Hiba, Antal — Hungarian Academy of Sciences Institute for Computer Science And

Zarándy, Ákos — Computer and Automation Research Institute

This paper presents a monocular camera-based lead vehicle distance and velocity estimation algorithm for automotive application. With an initial guess of real width of the lead vehicle, a Kalman Filter gives estimates for relative distance, velocity and acceleration. The still unknown scale factor to the real size is then statistically estimated from multiple hypothesis using vertical triangulation measurements. Camera pitching motion effects are compensated through the estimation of the vanishing point. The real relative distance, velocity and acceleration can be obtained with the estimated scale factor. The developed method is evaluated in simulations considering the Euro NCAP forward collision warning and emergency braking test procedures, the braking dynamics of vehicles, multiple lead vehicle sizes, periodic camera pitching disturbance, pixelization and vanishing point estimation errors and a wide range of velocities from 10km/h to 130km/h. The results are promising and so real life evaluation is the goal of future development.

09:20-09:40 ThA01.2

Ethical Considerations for a Decision Making System for Autonomous Vehicles During an Inevitable Collision

Millan-Blanquel, Lalis — University of Sheffield

Veres, Sandor — University of Sheffield

Purshouse, Robin — University of Sheffield

The automotive industry is heading towards the introduction of fully autonomous vehicles. However before these type of vehicles are commercially available at mass scale, some issues need to be solved. A major issue is the ethics involved in the decision-making during an accident; this paper presents an analysis of how to solve this issue. The proposal is a preprogrammed system with different ethical settings based on six formal ethical theories. For the implementation, eight ethical concerns are defined and ordered according to each theory. These concerns are defined in terms of harm to self and harm to others. The ethical concerns are used as a guideline to define the level of importance of each person or object in an accident scenario. With the proposed system, the vehicle will be partially tailored to the preferences of different users while still being bounded by legal requirements to avoid any misuse.

09:40-10:00 ThA01.3

Dynamic Configuration for an Autonomous Underwater Robot

Dang, Tho — LIRMM, Montpellier University

Lapierre, Lionel — LIRMM, Montpellier University

Zapata, René — LIRMM, Montpellier University

Ropars, Benoit — Ciscrea - LIRMM

Lepinay, Pascal — LIRMM, Montpellier University

This paper presents an Autonomous Underwater Vehicle (AUV) with a dynamic configuration of its actuation. The AUV is able to modify its configuration online (at each sampling time) during its missions. A procedure to optimize the dynamic configuration with respect to energy-like criteria is introduced. The simulation results are shown to prove the efficiency of a dynamic management of the actuation configuration.

10:00-10:20 ThA01.4

Trajectory Tracking Control for a Kinematic Bicycle Model

Ailon, Amit — Ben Gurion University of the Negev

Arogeti, Shai — Ben-Gurion University of the Negev

This paper deals with the trajectory tracking control problem in the kinematic bicycle model. To solve the control problem when there are several inherent constraints in the system we apply a sigmoid function (hyperbolic tangent) in the feedback loop. We present an error function between the real and virtual vehicles (when the latter moves along the required trajectory) and introduce a control law that ensures that the zero error is an asymptotic equilibrium point. A number of examples demonstrate the characteristics of the control law and its performance.

10:20-10:40 ThA01.5

A Multi ROSbot Laboratory Setup for Experimenting Autonomous Driving Maneuvers

de Leeuw, Wouter — Delft Univ. Tech

Ricke, Mats — Delft Univ. Tech

Rosier, Cas — Delft Univ. Tech

Thijs, Wielenga — Delft Univ. Tech

Grammatico, Sergio — Delft Univ. Tech

In this paper, we describe a laboratory setup made with three wheeled mobile robots, the Husarion ROSbots, for implementing and testing autonomous driving maneuvers. First, we implement a lane detection algorithm and an adaptive cruise control to enable the ROSbots to follow lanes and adapt their longitudinal speed. Then, we set up a wireless communication scheme to enable the ROSbots to perform safe overtaking maneuvers. Finally, we demonstrate the developed algorithms via laboratory experiments in the DCSC Lab at TU Delft.

10:40-11:00 ThA01.6

Collision Free Path Planning Based on Local 2D Point-Clouds for MAV Navigation

Lindqvist, Björn — Luleå University of Technology

Sharif Mansouri, Sina — Luleå University of Technology

Kanellakis, Christoforos — Luleå University of Technology

Nikolakopoulos, George — Luleå University of Technology

The usage of Micro Aerial Vehicles (MAVs) in different applications is gaining attention, however one of the main challenges is to provide collision-free paths, despite the uncertainties in localization, mapping, or path planning. This article proposes a novel collision free path planner for MAVs navigation in confined environments, while not being dependent on the information of the localization and only relying on 2D local point-cloud data. The proposed backup path planner generates velocity commands for a trajectory follower controller, while guaranteeing a safety distance from all points in the local-point-cloud. The proposed method considers the kinematics of the MAV and can be extended to any robotics application, such as ground vehicles. The proposed method is evaluated in a Gazebo simulation environment and successfully provides a collision-free navigation.

ThA02 ROOM SR2

Fault Diagnosis and Prognosis (Regular Session)

09:00-09:20 ThA02.1

A Cross-Correlation Based Method for Open Phase Fault Detection in Multi-Phase Electric Machines

Mocanu, Razvan — Gheorghe Asachi Technical University of Iasi

Onea, Alexandru — Gheorghe Asachi Technical University of Iasi

In this paper is presented a method for open phase fault detection with applicability in electric drive trains. The strategy is simple and requires only a limited number of hardware components available on most common hardware platforms for power electronics. The method is based on the computation of cross-correlation between each phase current and is simple and robust enough to be used in real-time automotive applications. The algorithm is tested with recorded data acquired from a Permanent Magnet Synchronous Machines (PMSM) motor-load test bench used for high power Hybrid Electrical Vehicles (HEV). The experimental results sustain the applicability of the algorithm to HEVs open phase fault detection.

09:20-09:40 ThA02.2

PCA Methods and Evidence Based Filtering for Robust Aircraft Sensor Fault Diagnosis

Cartocci, Nicholas — University of Perugia
Costante, Gabriele — University of Perugia
Napolitano, Marcello — West Virginia University
Valigi, Paolo — University of Perugia
Crocetti, Francesco — University of Perugia
Fravolini, Mario Luca — University of Perugia

In this paper PCA and D-PCA techniques are applied for the design of a Data Driven diagnostic Fault Isolation (FI) and Fault Estimation (FE) scheme for 18 primary sensors of a semi-autonomous aircraft. Specifically, contributions-based and reconstruction-based contributions approaches have been considered. To improve FI performance an inference mechanism derived from evidence-based decision making theory has been proposed. A detailed FI and FE study is presented for the True Airspeed sensor based on experimental data. Evidence Based Filtering (EBF) showed to be very effective particularly in reducing false alarms.

09:40-10:00 ThA02.3

Input-Output Hidden Markov Model for System Health Diagnostic Considering Missing Data

Shahin, Kamrul Islam — CRAN, Univ. Lorraine, CNRS
Simon, Christophe — CRAN, Univ. Lorraine, CNRS
Weber, Philippe — CRAN, Univ. Lorraine, CNRS
Theilliol, Didier — CRAN, Univ. Lorraine, CNRS

Sensor data can be used to diagnose the system's health. A challenge comes when the data contain missing or invalid data. It is common that sensors misread for various reasons. So, data contain missing measurements and sensor saturation. The main contribution in this paper is to implement a method based on the Input-Output Hidden Markov Model that trains the model using the missing measurements and sensor saturation, then diagnoses the system health at given operating conditions. Usually, if a data set contains some sequences with missing elements then they can be excluded from the analysis. It cleans the data set but reduces its size. This strategy knows as list-wise or case-wise deletion is less suitable for real application cases. The proposed method includes the sequences with missing data into the analysis by generating the missing elements to complete the sequence. The maximum likelihood is applied to estimate IOHMM parameters that offer substantial improvements over list-wise deletion. A numerical application with simulated data sets illustrates the method.

10:00-10:20 ThA02.4

An Output Observer Approach to Actuator Fault Detection in Multi-Agent Systems with Linear Dynamics

Taoufik, Anass — Northumbria University
Busawon, Krishna K. — Northumbria University
Defoort, Michael — Valenciennes University
Djemai, Mohamed — Valenciennes University

This paper deals with the problem of distributed fault detection for a team of multi-agent systems with linear dynamics using output observers. The proposed output observer is employed to estimate the state of virtual models based on relative outputs in order to generate a set of residual signal that are indicative of the presence of a fault. The convergence of the observer is proven for any initial condition and fault detectability conditions are defined. The proposed method ensures distributed actuator fault detection using input-output relations, where each agent is capable of detecting not only its own faults, but also those that occur in its neighbors solely by using exchanged relative outputs. Results of numerical simulations are provided to show the robustness of the proposed approach.

10:20-10:40 ThA02.5

Robust Fault Detection for Switched Systems Based on Interval Observers

Zammali, Chaima — CNAM
Van Gorp, Jeremy — CNAM
Raïssi, Tarek — CNAM

This paper deals with fault detection (FD) for a class of discrete-time switched systems with sensor faults. Under the assumption that disturbances and measurement noise are unknown but bounded, two methods, respectively based on the H∞ and the L∞ formalisms, are introduced to attenuate the effects of the uncertainties and to improve the accuracy of the proposed residual framers. The design conditions of the interval observer are given in terms of Linear Matrix Inequalities (LMIs). Furthermore, a FD decision is developed to indicate the presence of faults. A numerical example is performed to illustrate the effectiveness of the proposed method based on the L∞ performance through a comparison with the results obtained using the H∞ analysis.

10:40-11:00 ThA02.6

Zonotopic Extended Kalman Filter for RUL Forecasting with Unknown Degradation Behaviors

Al-Mohamad, Ahmad — Universitat Politècnica De Catalunya (UPC) and Normandy Universi
Puig, Vicenç — Universitat Politècnica De Catalunya (UPC)
Hoblos, Ghaleb — IRSEEM/ESIGELEC

This paper proposes a novel approach for Remaining Useful Life (RUL) forecasting using interval model-based prognostics techniques based on zonotopes without prior knowledge of the degradation behaviors of the system. Although Kalman filtering techniques have proved their estimation ability with Gaussian noises, an interval approach with zonotopic sets technique has been integrated for optimal estimation of parameters with unknown-but-bounded noises. Moreover, the proposed model-based prognostics technique has been applied to a DC-DC converter described as a nonlinear dynamical system affected by degradation behaviors. Thus, the estimated degraded parameters are adopted in the RUL prediction technique that propagates the zonotopic sets until the End-of-Life (EoL) of the system. In general, the technique is split into estimation and prediction phases using Zonotopic Extended Kalman Filter (ZEKF) to deal with the nonlinearities of the system and compute the optimal observer gain. A DC-DC converter case study in simulation is used to illustrate the utilized techniques and the simulation results prove the effectiveness.

ThA03 ROOM SR3

Multi-Agent Systems (Regular Session)

09:00-09:20 ThA03.1

A Forward-Backward Algorithm for Decomposable Semi-Definite Programs

Fabiani, Filippo — University of Oxford
Grammatico, Sergio — Delft Univ. Tech

We present semi-decentralized and distributed algorithms, designed via a preconditioned forward-backward operator splitting, for solving large-scale, decomposable semidefinite programs (SDPs). We exploit a chordal aggregate sparsity pattern assumption on the original SDP to obtain a set of mutually coupled SDPs defined on positive semidefinite (PSD) cones of reduced dimensions. We show that the proposed algorithms converge to a solution of the original SDP via iterations of reasonable computational cost, numerically comparing their performances with respect to others available in the literature.

09:20-09:40 ThA03.2

Human Intention Recognition for Human Aware Planning in Integrated Warehouse Systems

Petković, Tomislav — University of Zagreb
Jakub, Hvězda — Czech Technical University in Prague
Tomáš, Rybecký — Czech Technical University in Prague
Marković, Ivan — University of Zagreb
Kulich, Miroslav — Czech Technical University in Prague
Preucil, Libor — Czech Technical University
Petrović, Ivan — University of Zagreb

With the substantial growth of logistics businesses the need for larger and more automated warehouses increases, thus giving rise to fully robotized shop-floors with mobile robots in charge of transporting and distributing goods. However, even in fully

automatized warehouse systems the need for human intervention frequently arises, whether because of maintenance or because of fulfilling specific orders, thus bringing mobile robots and humans ever closer in an integrated warehouse environment. In order to ensure smooth and efficient operation of such a warehouse, paths of both robots and humans need to be carefully planned; however, due to the possibility of humans deviating from the assigned path, this becomes an even more challenging task. Given that, the supervising system should be able to recognize human intentions and its alternative paths in real-time. In this paper, we propose a framework for human deviation detection and intention recognition which outputs the most probable paths of the humans workers and the planner that acts accordingly by replanning for robots to move out of the human's path. Experimental results demonstrate that the proposed framework increases total number of deliveries, especially human deliveries, and reduces human-robot encounters.

09:40-10:00 ThA03.3

A Rendezvous Algorithm for Multi-Agent Systems in Disconnected Network Topologies

Ribeiro, Rafael — Instituto Superior Técnico
Silvestre, Daniel — Instituto Superior Técnico
Silvestre, Carlos — University of Macau

This paper addresses the problem of having a multi-agent system converging to a rendezvous location for networks of agents without any type of localization sensor. A central node or tower is able to determine the noisy position of each agent and transmit it using a directional antenna. Given the asynchronous communication setup, the topology will not be connected in general, which precludes the use of set-consensus algorithms available in the literature. By devising a flocking rule with mechanisms to prevent collisions, nodes explore the mission plane while maintaining the current connectivity. The process is followed by a convergence phase using a modified set-consensus algorithm with collision-free guarantees and asymptotic convergence. Results are also presented that, if there is a sufficient density of nodes, convergence occurs to a single cluster. The performance of the proposed algorithm is assessed through simulations, illustrating the cases where convergence occurs to a single or multiple clusters.

10:00-10:20 ThA03.4

Generalized Cyclic Pursuit: An Estimator-Based Model-Reference Adaptive Control Approach

Ansart, Antoine — National Cheng Kung University
Juang, Jyh-Ching — National Cheng Kung University

The paper proposes an estimation and control method about sustaining the motion of a group of autonomous agents under the Generalized Cyclic Pursuit (GCP) laws, where formation patterns can be formed by assigning eigenvalues of the system to be marginally stable. In the present paper, a Linear Quadratic Estimator (LQE), used to estimate the absolute position based on information exchange, is coupled with a Model Reference Adaptive Control (MRAC) to sustain the motion of agents and thus maintain the desired patterns in the presence of uncertainties and noise. Simulation results are provided to verify the proposed approach in area coverage applications.

10:20-10:40 ThA03.5

On Estimation of the Parameters in the Complex Network Via the Adaptive Observer

Lynnyk, Volodymyr — Institute of Information Theory and Automation of the CAS
Rehak, Branislav — The Czech Academy of Sciences, Institute of Information Theory
Celikovsky, Sergej — Academy of Sciences

In this paper, the problem of estimation of the unknown parameters in the complex networks composed of identical nodes being generalized Lorenz chaotic systems will be discussed. The estimation is provided using an adaptive observer. Estimation of the parameters is provided on the complex network with ring topology and bidirectional coupling between nodes. The extra node being an adaptive observer is connected with the permanent node of the analyzed complex network. During the relatively short period, this additional node will be identically synchronized with the analyzed complex network without precise knowledge of the unknown parameters in the permanent nodes. The results are illustrated by numerical simulation as well.

10:40-11:00 ThA03.6

A Dynamic Programming Approach for the Decentralized Control of Discrete Optimizers with Quadratic Utilities and Shared Constraint

Carli, Raffaele — Politecnico Di Bari
Dotoli, Mariagrazia — Politecnico Di Bari

This paper addresses the problem of controlling a large set of agents, each with a quadratic utility function depending on individual combinatorial choices, and all sharing an affine constraint on available resources. Such a problem is formulated as an integer mono-constrained bounded quadratic knapsack problem. Differently from the centralized approaches typically proposed in the related literature, we present a new decentralized algorithm to solve the problem approximately in polynomial time by decomposing it into a finite series of sub-problems. We assume a minimal communication structure through the presence of a central coordinator that ensures the information exchange between agents. The proposed solution relies on a decentralized control algorithm that combines discrete dynamic programming with additive decomposition and value functions approximation. The optimality and complexity of the presented strategy are discussed, highlighting that the algorithm constitutes a fully polynomial approximation scheme. Numerical experiments are presented to show the effectiveness of the approach in the optimal resolution of large-scale instances.

ThA04 ROOM SR4

Time-Delay Systems (Regular Session)

09:00-09:20 ThA04.1

Robust Stabilization of Fractional Positive Systems with Time-Delay and Input Constraints

Mesquine, Fouad — Cadi Ayyad University
Ben Braim, Abdoualaziz — Cadi Ayyad University

This paper deals with the stabilization problem of constrained uncertain fractional order positive systems with time delay. Non symmetrical constraints with polytopic and interval uncertainties are considered. The designed controller is computed using linear programming technique. A numerical example is given to illustrate the usefulness of the proposed results.

09:20-09:40 ThA04.2

Motion Control for Constraint Mobile Robotic Manipulators in Singular Time Delay Form

Kouvakas, Nikolaos — National and Kapodistrian University of Athens
Koumboulis, Fotios — National and Kapodistrian University of Athens

The nonlinear dynamic description of a wheeled platform with active and passive resonators carrying a single link manipulator on an uphill/downhill road path including the road disturbance forces applied to the wheels is presented. The linear approximant of the description is derived to be in a singular neutral time delay system form. The design goal is to control the distance of the load from the road and the speed of the platform despite the presence of the disturbances. The approach is that of exact model matching with simultaneous disturbance rejection for singular neutral time delay systems. The matrices of the general controller are derived. The performance of the proposed control scheme is demonstrated through computational experiments upon the nonlinear description and the linear controller.

09:40-10:00 ThA04.3

Numerical Analysis of Exponential and BIBS Stability for Linear Discrete Time-Variant Systems Using Bohl Exponents

Genser, Simon — Virtual Vehicle Research GmbH
Stettinger, Georg — Virtual Vehicle Research GmbH
Watzenig, Daniel — Virtual Vehicle Research GmbH
Pötzsche, Christian — Alpen-Adria Universität Klagenfurt

This work deals with the stability analysis of linear discrete-time time-variant systems, focusing on the most restrictive stability measures for free respectively forced systems, the exponential

stability respectively BIBS (bounded-input bounded-state) stability. Additionally the connection of these stability concepts with the so-called Bohl exponent is in focus of this work. The Bohl exponent can be seen as a generalization of eigenvalues for the stability analysis of time-variant systems. The contribution of this work is the combination of the exponential and BIBS stability analysis with the numerical computation of the Bohl exponent, leading to a numerical stability analysis for linear discrete-time time-variant systems. This stability analysis is applied at a time-variant drivetrain control loop.

10:00-10:20 ThA04.4

Control Design Method for Obtaining Special Performances in Discrete-Time Linear Switched Systems with Time-Varying Delay Based on the Average Dwell-Time Approach

Ghavami, Mahsa — Isfahan University of Technology
Sheikholeslam, Farid — Isfahan University of Technology
Ghaisari, Jafar — Isfahan University of Technology
Azarmi, Roohallah — Eindhoven University of Technology

This paper devotes to propose control design methods imposing general quadratic and bounded peak to peak gain performances on discrete-time linear switched positive systems with time-varying delay. General quadratic constraints are limitations that are modeled as a quadratic matrix to make a relationship between exogenous input and output signals. Moreover, the problem of bounding outputs peak amplitude for bounded disturbance inputs is named bounded peak to peak gain performance. Sufficient conditions are derived for the existence of a set of state feedback controllers guaranteeing the closed-loop switched system with time-varying delay in states not only is positive and globally uniform exponential stable but also has two stated performances for switching signals with an average dwell-time, which is greater than a positive certain constant. By using the Lyapunov-Krasovskii functional theorem, these conditions are formulated in terms of linear matrix inequalities. The quadruple tank system model is employed to illustrate the effectiveness of the proposed method.

10:20-10:40 ThA04.5

Delayless Controllers for Diagonal Decoupling and Disturbance Rejection of Time Delay Systems with Measurable and Non-Measurable Disturbances

Koumboulis, Fotios — National and Kapodistrian University of Athens
Kouvakas, Nikolaos — National and Kapodistrian University of Athens

The problem of diagonal Decoupling with simultaneous Disturbance Rejection (DDR) is studied for the class of general neutral multi delay systems with measurable and non measurable disturbances via delayless dynamic and/or static controllers. The delayless controllers use the measurement outputs and the measurable disturbances. 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. The results are successfully applied to a motion control problem.

10:40-11:00 ThA04.6

H∞ Delay-Independent Stabilization for Takagi Sugeno Fuzzy System Based on Saturated Output Control

Nasri, Mohamed — LAJ, Faculty of Science and Technology, University of Jijel
Dounia, Saifia — LAJ, Faculty of Science and Technology, University of Jijel
Chadli, Mohammed — University Paris-Saclay
Labiod, Salim — LAJ, Faculty of Science and Technology, University of Jijel

This paper is focused on non-quadratic SOF control for delayed Takagi Sugeno (T-S) models with input saturation and external disturbances. A polytopic representation is first used to describe the input nonlinearity. By using a descriptor redundancy approach, an augmented form of the closed-loop system is established. Then, in order to reduce the conservatism of the quadratic approach, a poly-quadratic function and a Lyapunov-Krasovskii function (LKF) are used to derive H∞ stabilization conditions. The design conditions are formulated and resolved in LMIs terms. A simulation example is made to show the successful of the proposed method.

ThA05 ROOM SR5

Predictive Control (Regular Session)

09:00-09:20 ThA05.1

Distributed MPC Control of a Water Delivery Canal Based on D-ADMM

Belfo, João P. — INESC-ID
Lemos, Joao M. — INESC-ID
Aguiar, A. Pedro — Faculty of Engineering, University of Porto (FEUP)

This article describes the design of distributed Model Predictive Control (MPC) strategies based on a linear model of a water delivery canal, composed of three pools, each ending with a gate. The distributed MPC control algorithm relies on a Distributed Alternating Direction Method of Multipliers (D-ADMM) optimization framework. A non-linear model of the canal is used to identify a linearized model around an equilibrium point, which is then used to design the controllers. Since the plant states are not accessible, a Kalman filter is used to estimate them. Integral action is also included together with an anti-windup algorithm. Simulations using the nonlinear plant model are presented to show the impact of control algorithm parameters on performance.

09:20-09:40 ThA05.2

Robust Path Integral Control on Stochastic Differential Games

Donge, Vrushabh — Veermata Jijabai Technical Institute, Mumbai
Patil, Akshay Kumar — Veermata Jijabai Technical Institute, Mumbai
Kharade, Sonam — Veermata Jijabai Technical Institute, Mumbai
Wagh, Sushama — Veermata Jijabai Technical Institute, Mumbai
Singh, Navdeep — Veermata Jijabai Technical Institute, Mumbai

This paper develops a robust path integral (RPI) model predictive control using the Monte Carlo (MC) sampling to address the optimal control (OC) problem for the stochastic differential game (SDG). The two-player zero-sum differential game has been extensively investigated, mostly as its outcome indicates the H_{infty} optimality. The proposed path integral (PI) control framework provides an analytically sound method for building an algorithm of optimal control for this game based on stochastic trajectory sampling. This is achieved by using Feynman-Kac (F-K) lemma which transforms the value function of stochastic optimal control (SOC) problem into an expectation over all probable trajectories. This transformation makes it possible to solve SOC problems through MC sampling of stochastic processes. Finally, the RPI model predictive control using MC sampling is efficiently implemented for an inverted pendulum system. The RPI control has achieved good performance for changes in inverted pendulum weight and friction when the complete nonlinear swing-up is concerned while such environmental adjustments are not dealt with in a regular PI control.

09:40-10:00 ThA05.3

Offset-Free Model Predictive Control: A Study of Different Formulations with Further Results

Jimoh, Isah — Glasgow Caledonian University
Kucukdemiral, Ibrahim Beklan — Glasgow Caledonian University
Bevan, Geraint — Glasgow Caledonian University
Orukpe, Patience Ebehiremen — University of Benin

This paper presents discussions on offset-free model predictive control (MPC) methods for linear discrete-time systems in the presence of deterministic system disturbances. The general approach is based on the use of a disturbance model and an observer to estimate the disturbance states. The recent development in offset-free MPC has established the equivalence of the velocity form (without output delay) to a specific choice of the disturbance model and observer. In this note, it was shown that this

particular disturbance model and observer is not necessarily equivalent to the velocity form with output delay. Nevertheless, it was shown that the velocity form with output delay is equivalent to a different choice of the disturbance model and observer. An import of this result is that the velocity forms (with and without delayed output) belong to the same general approach - disturbance model and observer. Furthermore, areas that may be considered in future researches are also highlighted. Index Terms—Model predictive control, disturbance rejection, linear discrete-time systems, offset-free control.

10:00-10:20 ThA05.4

Nonlinear MPC for Transient Charging Pressure and EGR Rate Control for a Turbocharged SI Engine

Keller, Martin — RWTH Aachen University
Geiger, Severin — RWTH Aachen University
Kluge, Kevin — RWTH Aachen University
Günther, Marco — RWTH Aachen University
Pischinger, Stefan — RWTH Aachen University
Abel, Dirk — RWTH Aachen University
Albin, Thivaharan — RWTH Aachen University

Innovative air path concepts utilizing exhaust gas recirculation (EGR) for turbocharged gasoline engines show promising results to lower the CO2 and pollutant emissions. However, the increased complexity of such systems poses high demands on the process control. With the upcoming real-driving emission (RDE) legislation, accurately managing transient operation will be one of the major challenges for the application of these systems, as rapid changes in engine speed have a considerable influence on the boost pressure buildup as well as on the obtained EGR rate.
This paper focuses on the simultaneous control of boost pressure and EGR rate for a two-stage turbocharged gasoline engine with low pressure EGR during highly transient engine operation. When accelerating a vehicle in low gears, the engine speed gradient is at its maximum. This causes the highest difficulty in adjusting the respective setpoints. To tackle this challenge, a data-based nonlinear model predictive controller is presented which explicitly considers the actual engine speed and its predicted future trajectory. After implementation of the new control system into the ECU of a prototype test vehicle, the validation of the control algorithms is done by conducting real-driving experiments on a test track.

10:20-10:40 ThA05.5

Distributed MPC Strategy with Guaranteed Stability

Odloak, Darci — University of Sao Paulo
Sarapka, Alexandre — University of Sao Paulo

Several distributed model predictive control (MPC) strategies have been presented in the last few years. Those strategies are usually suited for large applications, when it is not interesting to use centralized controllers. Sub-optimal solutions are normally achieved by those controllers, although most of them can converge to optimal solutions as well. This paper presents a distributed MPC strategy with guaranteed feasibility and stability. Infinity horizon and cooperation between controllers are considered this new strategy.

10:40-11:00 ThA05.6

Hybrid RTO with Zone Control MPC Applied to a Gas-Lift System

Shamaki, Patience Bello — University of Sao Paulo
Odloak, Darci — University of Sao Paulo

In this paper, a steady state real time optimization (SRTO) using transient measurement, implemented with a zone control model predictive control (MPC) is applied to a gas-lift system. The use of zone control MPC is suitable for processes where the exact values of the controlled output are not required, but they must be within a specified desirable zone. The control strategy allows the controller to focus on reaching the desired input target supplied by the optimization layer, as long as the outputs are kept within their specified zones and dynamic constraints are respected. With the focus on practicality of application, available, established and successfully implemented process optimization and control techniques are harnessed; through some modifications to fit the process and achieve an optimum. Simulations show that the controller can drive the process to and keep the output within their specified region and also track the desired input target, even in the presence of disturbance.

ThB01 ROOM SR1

Unmanned Aerial Vehicles: Modeling and Control (Invited Session)

Organizer: Ducard, Guillaume — Université De Nice Sophia Antipolis, I3S CNRS

14:00-14:20 ThB01.1

Hexacopter Flight Performance Comparison with CCA vs. WCA Control Allocation (I)

Ducard, Guillaume — Université De Nice Sophia Antipolis, I3S CNRS
Kryenbühl, Philipp — ETH Zürich

This paper presents an extensive discussion between two control allocation methods for hexacopters. The first one is the so-called classical control allocation (CCA) based on a pseudo-inverse matrix, and the second one is the weighted control allocation (WCA) based on a weighted pseudo-inverse matrix. Control allocation is about mapping the virtual control vector v = [T; L;M;N]^T made of thrust, roll, pitch and yaw torque, respectively, to the individual motors' speed. The CCA method is studied under motor saturation circumstances, in which CCA can lead to a crash. The WCA method on the other hand displays better performance than CCA for: a) motor saturation, b) vehicle's mass changes, 3) flight-controller poorly tuned parameters, and 4) motor-fault tolerance. The performance comparison between these two control allocation techniques is made through simulations and real-flight tests.

14:20-14:40 ThB01.2

Fused-PID Control for Tilt-Rotor VTOL Aircraft (I)

Bauersfeld, Leonard — ETH Zürich
Ducard, Guillaume — Université De Nice Sophia Antipolis, I3S CNRS

This work presents a fused-PID (FPID) control strategy for a tilt-quadrotor VTOL (vertical takeoff and landing) where the FPID generates attitude setpoints based on the pilot's velocity commands. The FPID controller consists of two separate PID controllers where one can handle fixed-wing aircraft and the other is designed for multicopters. The output of both controllers is fused depending on the airspeed to obtain an attitude setpoint and a tilt angle of the rotors. In contrast to the commonly-used binary switch between helicopter flight (propellers pointing upwards) and airplane flight (propellers pointing forwards), the FPID makes a smooth transition between the two flight modes possible. The proposed controller design has been extensively tested in simulation and with a real radio-controlled tilt-quadrotor VTOL aircraft. The results presented in this work clearly show that the FPID approach, despite its simplicity, is suited very well for tilt-rotor VTOL aircraft.

14:40-15:00 ThB01.3

Control Allocation for an Unmanned Hybrid Aerial Vehicle (I)

Spannagl, Lukas — ETH Zurich
Ducard, Guillaume — Université De Nice Sophia Antipolis, I3S CNRS

This work presents a novel control allocation strategy for model tilt-rotor type VTOL aircraft. The aircraft considered has four tilting propellers and the aerodynamic actuators of an airplane. Control allocation converts the high-level commands in terms of total desired thrust and torques into commands distributed among the vehicle's eleven actuators. The proposed method independently tilts two pairs of propellers to generate torque along the thrust vector, which results in close-to-optimal solutions while being computationally efficient. This approach showed promising results both in simulation and tests on the vehicle and can be used in combination with any controller that generates a two-dimensional thrust and a three-dimensional torque vector.

15:00-15:20 ThB01.4

Model Predictive Control of a Convertible Tiltrotor Unmanned Aerial Vehicle (I)

Allenspach, Mike — ETH Zürich
Ducard, Guillaume — Université De Nice Sophia Antipolis, I3S CNRS

This paper presents a Model Predictive Control (MPC) based control structure for a convertible Unmanned Aerial Vehicle (UAV) with fixed wings and tiltrotor thrust vectoring. The controller encompasses full flight envelope trajectory tracking, thereby optimally exploiting the aircraft's Vertical Take Off and Landing (VTOL) and cruising-forward flight capabilities. An adaptive control allocation is designed to handle the changing control authorities of the actuators and efficiently distribute the required control actions between propellers, tilt servos and control surfaces. Preliminary simulation results show the feasibility of the proposed control approach.

15:20-15:40 ThB01.5

Design and Modeling of Unconventional Quadrotors

Derrouaoui, Saddam Hocine — Ecole Militaire Polytechnique
Bouzid, Yasser — Ecole Militaire Polytechnique
Guiatni, Mohamed — Ecole Militaire Polytechnique
Islam, Dib — CSCS Laboratory, Ecole Militaire Polytechnique
Nour Eddine, Moudjari — CSCS Laboratory, Ecole Militaire Polytechnique

In this paper, we propose a new design of unconventional quadrotors with simple mechanisms. They are able to change the orientation and the length of their arms independently thanks to their adaptive morphologies, these quadrotors can be used for specific missions and in more congested spaces. Thus, the usefulness of certain configurations that our quadrotors can make will be shown. In addition, a detailed and generic model is proposed for three possible cases: 1) the extension of the arms, 2) the rotation of the arms, 3) the hybridization between the extension and rotation of the arms. We stress that the modeling of these unconventional quadrotors is more challenging compared to the standard quadrotors, because of the geometrical asymmetry of the quadrotor structures and the constant change of the inertia and the center of gravity during the flight. In this work, a preliminary prototype of our quadrotor with rotating arms is presented with the electronic architecture.

15:40-16:00 ThB01.6

Energy-Minimal Target Retrieval for Quadrotor UAVs: Trajectory Generation and Tracking

Henninger, Helen Clare — Free University of Bozen-Bolzano
von Ellenrieder, Karl — Free University of Bozen-Bolzano
Licht, Stephen — University of Rhode Island

When applying visual servo algorithms for unmanned aerial vehicles (UAVs) using visual registration targets, it is often desirable that the UAV would retrieve targets after the mission. In this study we plan an energy-optimal trajectory for a UAV to retrieve visual registration targets dropped on the initial flight and then construct a controller to track this trajectory in a stable way. The UAV kinematics are described as a Hamiltonian system on the Lie group SE(3); the boundary value problem (BVP) arising from the geometric framing of Pontryagin's Maximum Principle (PMP) is then applied. This BVP is solved using a numerical shooting method with a novel multi-arc interpolation approach determining simple optimal arcs between the targets using a semi-analytical Lie group integrator. A switching controller compensating for the switch between in-ground and out-of-ground dynamics is combined with a disturbance observer to create a controller to track the trajectory in a stable way under the ground effect and bounded disturbances. Simulation results complete the work.

ThB02 ROOM SR2

Renewable Energy and Sustainability (Regular Session)

14:00-14:20 ThB02.1

Fault Interaction between Inverter and Electrical Machine, at Electrical and Electromagnetic Level, Used in HEV's Application

Ginzarly, Riham — Université de Rouen
Hoblos, Ghaleb — IRSEEM/ESIGELEC
Moubayed, Nazih — Lebanese University
Hassan, Ghina — Lebanese University

The electrical propulsion system in Hybrid Electrical Vehicle (HEV) contains: the electric machine, the controller and the inverter. Several paper model and interpret each component separately without considering the interaction between those elements. In this paper, the electrical aspect of the inverter will be investigated as a preface to build a global model combining the inverter and the electrical machine. Hence the electrical model of the inverter will be built. Then, electrical faults in the inverter will be integrated and the impact of thess faults on the electrical and electromagnetic performance of the electrical machine will be displayed.

14:20-14:40 ThB02.2

Decentralized Model Predictive Control of Plug-In Electric Vehicles Charging Based on the Alternating Direction Method of Multipliers

Germanà, Roberto — Sapienza University of Rome
Liberati, Francesco — Sapienza University of Rome
Di Giorgio, Alessandro — Sapienza University of Rome

This paper presents a decentralized Model Predictive Control (MPC) for Plug-in Electric Vehicles (PEVs) charging, in presence of both network and drivers' requirements. The open loop optimal control problem at the basis of MPC is modeled as a consensus with regularization optimization problem and solved by means of the decentralized Alternating Direction Method of Multipliers (ADMM). Simulations performed on a realistic test case show the potential of the proposed control approach and allow to provide a preliminary evaluation of the compatibility between the required computational effort and the application in real time charging control system.

14:40-15:00 ThB02.3

Controlled Optimal Black Start Procedures in Smart Grids for Service Restoration in Presence of Electrical Storage Systems

Giuseppi, Alessandro — Sapienza University of Rome
Pietrabissa, Antonio — Consorzio Per La Ricerca nell'Automatica E Nelle Telecomunicazio
Liberati, Francesco — Sapienza University of Rome
Di Giorgio, Alessandro — Sapienza University of Rome

This paper presents an optimisation problem to determine the optimal reclosure order of remotely operable switches deployed in a smart grid consisting in a distribution network equipped with one or more Energy Storage Systems (ESS). The proposed solution integrates nonlinear real and reactive power flow equations, by reconducting them to a set of conic constraints, together with several network operator requirements, such as network radiality and ampacity limits. A numerical simulation validates the approach and concludes the work.

15:00-15:20 ThB02.4

Bond Graph Based Multiphysic Modelling of Anion Exchange Membrane Water Electrolysis Cell

Sumit, Sood — Université De Lille
Ould Bouamama, Belkacem — Polytech Lille
Dieulot, Jean-Yves — Polytech-Lille
Bressel, Mathieu — CRIStAL - HEI
Li, Xiaohong — University of Exeter
Ullah, Habib — University of Exeter
Loh, Adeline — University of Exeter

This work is an attempt to develop and validate a graphical dynamical model of an AEM electrolysis cell based on Bond Graphs, an energy based tool that allows to represent multiphysics systems. The model of the cell lays a foundation for developing a complete representation for AEM electrolysers, which can be used for simulation as well as for developing control algorithms and fault diagnosis. Parameter identification and model validation is achieved using experimental data.

15:20-15:40 ThB02.5

Estimation of Passivity Margins of Hydrogen-Based Hybrid Renewable Energy Systems Via Energy Tanks

Chaabna, Solène Houria — Université De Lille
Dieulot, Jean-Yves — Polytech-Lille
Sumit, Sood — Université De Lille

This paper proposes new tools to design models and controllers for power systems. Within the port-Hamiltonian modeling framework, concepts that extend passivity margins and energy tanks are used to estimate power reserves in Hybrid Renewable Energy Systems. The methodology is applied to multi-source cells with renewable energy dedicated to the production of clean hydrogen. This work can be extended to more complex networked power systems, with the aim to increase the reliability of standalone networks by fitting the power demands while avoiding damage and extending lifetime of the equipment.

15:40-16:00 ThB02.6

Lithium-Ion Battery Monitoring and Observability Analysis with Extended Equivalent Circuit Model

Meng, Jianwen — ESTACA - GeePs
Boukhnifer, Moussa — Université de Lorraine
Diallo, Demba — Université Paris-Sud

Lithium-Ion battery (LIB) on-line monitoring based on the extended equivalent circuit model (ECM) has received considerable attention. However, up to now, only linear observability analysis has been studied. The main purpose of this paper is to derive observability conditions for the extended ECM. Firstly, the battery ECM is decomposed into two sub-models mathematically, because there is no mutual coupling relationship between the battery states. Then, for the nonlinear extended one, an observability analysis is conducted. It shows that the observability necessary conditions depend on the battery current, the initial value of the battery capacity and the square of the derivative of the open circuit voltage (OCV) with respect to the state of charge (SOC). Numerical simulations have been conducted and have successfully assessed these conditions.

ThB03 ROOM SR3

Machine Learning (Regular Session)

14:00-14:20 ThB03.1

A Multi-Agent Deep Reinforcement Learning Framework for Automated Driving on Highways

Bakker, Louis — Delft Univ. of Tech
Grammatico, Sergio — Delft Univ. of Tech

We apply deep reinforcement learning to automated driving on highways. We propose a novel, simple framework with improved performance with respect to the state of the art. When implementing our algorithm on multi-lane highway scenarios, after the training phase, we observe via numerical simulations that the vehicles are able to avoid collisions and to reach their respective destination lanes with very high probability.

14:20-14:40 ThB03.2

Multi-Model and Learning-Based Framework for Real-Time Trajectory Prediction

Benterki, Abdelmoudjib — Vedecom Institute
Judalet, Vincent — ESTACA Paris Saclay
Maaoui, Choubeila — Université de Lorraine
Boukhnifer, Moussa — Université de Lorraine

Accurate and real-time trajectory prediction of traffic participants is important in autonomous driving systems, especially for decision making and risk assessment. Existing models such as physics-based and maneuver-based models are mainly used for short-term prediction. Deep-learning-based methods have been applied as novel alternatives for trajectory prediction. This problem can be viewed as a sequence generation task, where the future trajectory of vehicles is predicted based on their past positions. Following the recent success of Recurrent Neural Network (RNN) models for sequence prediction tasks, especially Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRU), in this paper an approach that combine LSTM for driving sequences classification and GRU for trajectory prediction is proposed. The obtained experimental results show the effectiveness of the proposed approach.

14:40-15:00 ThB03.3

Towards Differential Diagnosis of Essential and Parkinson's Tremor Via Machine Learning

Skaramagkas, Vasileios — University of Patras
Andrikopoulos, George — Luleå University of Technology
Kefalopoulou, Zinovia — Patras University Hospital
Polychronopoulos, Panagiotis — Patras University Hospital

In this article, the challenge of identifying between Essential and Parkinson's tremor is addressed. To this goal, a clinical analysis was performed, where a number of volunteers including Essential and Parkinson's tremor-diagnosed patients underwent a series of pre-defined motion patterns, during which a wearable sensing setup was used to measure their lower arm tremor characteristics from multiple selected points. Extracted features from the acquired accelerometer signals were used to train classification algorithms, including decision trees, discriminant analysis, support vector machine (SVM), K-nearest neighbor (KNN) and ensemble learning algorithms, for providing a comparative study and evaluating the potential of utilizing machine learning to accurately identify between different tremor types.

15:00-15:20 ThB03.4

A New Sample-Efficient PAC Reinforcement Learning Algorithm

Zehfroosh, Ashkan — University of Delaware
Tanner, Herbert G. — University of Delaware

This paper introduces a new hybrid PAC RL algorithm for MDPs, which intelligently maintains favorable features of its parents. The DDQ algorithm, integrates model-free and model-based learning approaches, preserving some advantages from both. A PAC analysis of the DDQ algorithm is presented and its sample complexity is explicitly bounded. Numerical results from a small-scale example motivated by work on human-robot interaction models corroborate the theoretical predictions on sample complexity.

15:20-15:40 ThB03.5

Machine Learning-Based Cyber-Attack Detection and Resilient Operation Via Economic Model Predictive Control for Nonlinear Processes

Scarlett, Chen — University of California, Los Angeles
Wu, Zhe — University of California, Los Angeles
Christofides, Panagiotis — University of California, Los Angeles

This work proposes resilient operation strategies for nonlinear processes that are vulnerable to targeted cyberattacks, as well as detection and handling of standard types of cyber-attacks. Working with a general class of nonlinear systems, a modified Lyapunov-based Economic Model Predictive Controller (LEMPC) using combined closed-loop and open-loop control action implementation schemes is proposed to optimize economic benefits in a time-varying manner while maintaining closed-loop process stability. Although sensor measurements may be vulnerable to cyber-attacks, the proposed controller design and operation strategy ensure that the process will maintain stability and stay resilient against particular types of destabilizing cyber-attacks. Data-based cyber-attack detectors are developed using sensor data via machine-learning methods, and these detectors are periodically activated and applied online in the context of process operation. Using a continuously stirred tank reactor example, simulation results demonstrate the effectiveness of the resilient control and detection strategy in maintaining stable and economically optimal operation in the presence of cyber-attacks.

15:40-16:00 ThB03.6

Unsupervised Learning for Subterranean Junction Recognition Based on 2D Point Cloud

Sharif Mansouri, Sina — Luleå University of Technology
Pourkamali-Anaraki, Farhad — Umass Lowell
Miguel, Castaño Arranz — Luleå University of Technology
Agha-mohammadi, Ali-akbar — NASA-JPL, Caltech
Burdick, Joel W. — California Inst. of Tech
Nikolakopoulos, George — Luleå University of Technology, Sweden

This article proposes a novel unsupervised learning framework for detecting the number of tunnel junctions in subterranean environments based on acquired 2D point clouds. The implementation of the framework provides valuable information for

high-level mission planners to navigate an aerial platform in unknown areas or robot homing missions. The framework utilizes spectral clustering, which is capable of uncovering hidden structures from connected data points lying on non-linear manifolds. The spectral clustering algorithm computes a spectral embedding of the original 2D point cloud by utilizing the eigen-decomposition of a matrix that is derived from the pairwise similarities of these points. We validate the developed framework using multiple data sets, collected from multiple realistic simulations, as well as from real flights in underground environments, demonstrating the performance and merits of the proposed methodology.

ThB04 ROOM SR4

Signal Processing (Regular Session)

14:00-14:20 ThB04.1

A Fractional-Order Analytical Redundancy Approach for Fault Detection on a Hovering Helicopter

Paiva, Henrique Mohallem — UNIFESP - Federal University of Sao Paulo

Leal, Andreia Seixas — UNIFESP - Federal University of Sao Paulo

Almeida, Joao Paulo — UNIFESP - Federal University of Sao Paulo

This paper presents an analytical redundancy approach for fault detection on a simulated hovering helicopter. For this purpose, a standard state-observer fault-detection technique is extended to adopt a commensurate fractional-order model. The results are favorably compared with those of an integer-order state observer, in terms of after-fault residue amplification and area under the receiver operating characteristic (ROC) curve.

14:20-14:40 ThB04.2

Implementation of a 1440Hz Video Projector for Calibrating Optic Flow Sensors at High Speed

Viel, Christophe — Institute of the Movement Sciences

Varennes, Leandre — Aix Marseille Université

Viollet, Stephane — Institute of the Movement Sciences

In this paper, the results of experiments in which a high velocity movement is simulated using digital light processing methods (with a Digital Light Processing (DLP) video projector) are presented. The main aim is to simulate a fast movement in order to test optic flow (OF) sensors or event-based sensor more quickly and simply than with traditional methods based on moving wallpaper or LCD screen. To obtain an accurate movement resolution, specific pictures are generated and displayed by the DLP at a high frame rate. The results show that accurate projected movement speeds are obtained with velocities of up to 50m/s. Propositions to increase these results are discussed.

14:40-15:00 ThB04.3

Development of an UWB Based Indoor Positioning System

Molnar, Marcell — Institute for Computer Science and Control

Luspay, Tamas — University of Houston

The demand for precise indoor positioning is increasing nowadays, since traditional methods, like GPS, cannot be used in indoor environments. Lots of technologies exist that can be used for such purposes, having their own advantages and disadvantages when it comes to positioning. However, it seems that UWB is the most favorable, having the possibility to achieve the best accuracy due to its spectral features. Although, in the past years several companies appeared as a UWB chip and antenna manufacturer providing out-of-the-box solutions, most of them only have chips or demonstration kits to purchase. The paper shows the development and testing of an UWB indoor positioning system using commercially available hardware and specific software elements in order to allow flexibility required for research purposes.

15:00-15:20 ThB04.4

Fault Detection in a 3-DOF Laboratory Helicopter Using Wavelet Packets and Subspace Identification in Frequency Subbands

Paiva, Henrique Mohallem — UNIFESP - Federal University of Sao Paulo

Oliveira, Igor Luppi — Federal University of Sao Paulo - UNIFESP

Garcia, Gabriele Fernandes — UNIFESP - Federal University of Sao Paulo

This paper proposes a wavelet-packet approach for fault detection using subspace identification. The wavelet-packet decomposition tree is used to define the frequency subbands at which the plant models are created. The best decomposition tree is chosen by using a dynamic programming algorithm, that achieves a trade-off between accuracy and parsimony. A recently published framework is adopted to allow for the identification of subband models with a subspace approach. The proposed technique is validated with experimental data acquired with a Quanser™ 3-DOF laboratory helicopter and presents better results than those of a standard time-domain fault-detection technique.

15:20-15:40 ThB04.5

Anisotropy-Based Estimation for Linear Discrete Time Varying Finite Horizon Systems with Missing Measurements

Belov, Ivan — Institute of Control Sciences RAS

In this paper, the anisotropy-based estimating problem for linear discrete time-varying multiplicative noises finite horizon systems is considered. We examine the linear discrete time-varying system with uncertainty in the measurement output. The anisotropy-based bounded real lemma is obtained in terms of studied system matrices and desired estimator matrices. As result, we have the system of linear matrix inequalities in terms of estimator matrices. The numerical example of anisotropy-based estimating problem solution for the LDTVFH system is illustrated by the graphs.

15:40-16:00 ThB04.6

Low-Complexity Direction Finding Method for MIMO Radar Based on Compressive Sensing

Meng, Zhen — Harbin Engineering University

Zhou, Weidong — Harbin Engineering University

We propose a direction finding method for multiple-input multiple-output (MIMO) radar by using sparse sensing in low computational cost. Since the targets are sparsely distributed in the space, we employ the compressive sensing technique to reduce the sampling rate. Based on the compressive sensing, we utilize the convex combination to approximate the real target parameters in MIMO radar. We formulate an optimization problem for sparse vector recovery and off-grid mismatch estimation, which involves four set of variables. We employ the alternating direction method of multipliers approach to fast solve this optimization problem. In each iteration of sparse recovery, four subproblems are alternately optimized over only one of four set of parameters where each subproblem has a closed-form solution. With the recovered sparse vector and the estimated off-grid mismatch, we develop a grid adjustment method to accurately resolve the directions of targets by iteratively deleting the redundant grid points. Numerical simulations indicate that the proposed method is able to achieve accurate signal recovery, improved estimation accuracy and reduced computational cost.

ThB05 ROOM SR5

Power Systems and Industrial Automation (Regular Session)

14:00-14:20 ThB05.1

Charge Sustaining Hybrid Electric Bikes in Free-Floating Sharing Service

Duz, Alessandra — Politecnico Di Milano

Corno, Matteo — Politecnico Di Milano

Savaresi, Sergio M. — Politecnico Di Milano

This paper proposes a hierarchical multilevel control strategy, adaptive on the cyclist characterization, for the energy management of a fleet of hybrid electric bikes (HEBs) in a free-floating sharing service. We pursuit the goals of independence from recharging stations and of cycling effort reduction by means of motor assistance. To achieve these goals we exploit the variability of cycling efficiency. The results are assessed in a simulation environment.

14:20-14:40 ThB05.2

Dross Attachment Estimation in the Laser-Cutting Process Via Convolutional Neural Networks (CNN)

Franceschetti, Luca — Politecnico Di Milano
Pacher, Matteo — Politecnico Di Milano
Tanelli, Mara — Politecnico Di Milano
Strada, Silvia — Politecnico Di Milano
Previtali, Barbara — Politecnico Di Milano
Savaresi, Sergio M. — Politecnico Di Milano

Laser cutting of metals offers the advantage of high precision and accuracy. Dross attachment, measured as the length of the re-solidified material perpendicular to the surface, has definitely the highest impact on the overall process quality. Dross attachment is commonly judged by skilled technicians, that evaluate the cut quality. Process parameters are optimized to maximize the cutting speed while keeping an acceptable level of dross attachment. However, in practice, increased levels of dross may occur due to different processing conditions. In this framework, a real-time dross attachment monitoring system is desired. Within the stream of vision based monitoring systems, in this work we use high frequency images generated by a precision camera, mounted on the laser head, to capture the cutting process light emission. A CNN-based classification system is developed, where captured images are fed into the trained network with the aim of automatically recognize if a predetermined dross attachment level is exceeded. To our best knowledge, this is the first work where a CNN is used for monitoring the quality of laser cutting process via dross attachment classification.

14:40-15:00 ThB05.3

Process Re-Engineering Based on Colored Petri Nets: The Case of an Italian Textile Company

Cavone, Graziana — Southwest Jiaotong University
Epicoco, Nicola — Università Degli Studi Dell'Aquila
Dotoli, Mariagrazia — Politecnico Di Bari

Business process re-engineering is crucial for manufacturing companies to improve their productivity and efficiency. The identification of the main criticalities affecting the production processes and the implementation of effective re-engineering solutions can significantly reduce the company losses. However, such actions can be unsuccessful if suitable preliminary investigations on the effectiveness of the solutions are not performed. This paper proposes an integrated process re-engineering technique that allows to: identify workflows via the Unified Modeling Language; model and simulate the business process via Colored Petri Nets (CPNs); detect bottlenecks and waste sources through the Value Stream Mapping tool; rank the impact of the detected criticalities via a mathematical formulation of the Genba-Shikumi lean philosophy; simulate the re-engineering actions and evaluate their effectiveness using the CPN model. The aim is to offer an intuitive tool for strategic decision making, deployable at a managerial level in a digital twin approach. The proposed technique is tested on a textile company located in Southern Italy, showing its effectiveness in removing inefficiencies and ensuring the continuous improvement of the production process.

15:00-15:20 ThB05.4

Implementation of a Petri-Net Based Digital Twin for the Development Procedure of an Electric Vehicle

Tsinarakis, George — Technical University of Crete
Spanoudakis, Polychronis — Technical University of Crete
Arampatzis, George — Technical University of Crete
Tsourveloudis, Nikos — Technical University of Crete
Doitsidis, Lefteris — Technical University of Crete

In the current work the development procedure (design, manufacture and assembly) of an electric vehicle is considered.. Uncertainties make difficult to follow initial time plan, so monitoring of the development procedure is necessary. To handle delays a method using Petri nets to model the tasks of the development procedure and their dependencies is introduced. The model is not used offline as a passive element but is connected and interacts with the physical system (development procedure). Based on the information exchange between physical and digital system, alternative ways to overcome delays are studied and the optimal solution is calculated, tested and applied. Results are provided according to different scenarios, in order to show the efficiency and applicability of the proposed method.

15:20-15:40 ThB05.5

Application of Pareto Optimization in an Economic Model Predictive Controlled Microgrid

Schmitt, Thomas — Technische Universität Darmstadt
Engel, Jens — Technische Universität Darmstadt
Rodemann, Tobias — Honda Research Institute Europe GmbH
Adamy, Juergen — Technische Universität Darmstadt

This paper presents an economic model predictive control approach for a linear microgrid model. The microgrid in grid-connected mode represents a medium-sized company building including storage systems, renewable energies and couplings between the electrical and heat energy system. Economic model predictive control together with Pareto optimization is applied to find suitable compromises between two competing objectives, i. e. monetary costs and thermal comfort. Using real-world data from 2018 and 2019, the model is simulated with auto-detection of the Pareto solution, which is closest to the Utopia point. The results show that the Pareto optimization can either be used in real-time control of the microgrid, or to obtain suitable weights from long term simulations. Both approaches result in significant cost reductions.

15:40-16:00 ThB05.6

Novel Droop Control Design for Overvoltage Protection of DC Microgrids with a Constant Power Load

Braitor, Andrei-Constantin — University of Sheffield
Konstantopoulos, George — University of Sheffield
Kadirkamanathan, Visakan — University of Sheffield

A novel droop controller for DC microgrid systems, consisting of multiple paralleled sources feeding a constant power load (CPL), is proposed to achieve the desired voltage regulation and accurate load power distribution, while ensuring an overvoltage protection for each source. CPLs are well-known to exhibit negative impedance characteristic due to their nonlinear behaviour, which may cause instability to a DC microgrid if the necessary impedance inequality criteria are not satisfied. In this paper, a new droop control scheme is proposed to limit the voltage of each source below a desired bound, achieve tight voltage regulation and power sharing, and guarantee closed-loop system stability with the existence of a CPL. The upper limit of the voltage of each source is rigorously proven using ultimate boundedness theory, while after a suitable manipulation of the admittance matrix of the microgrid, analytic conditions of stability are obtained to guide the control parameter design. To validate the theoretical design and analysis, a detailed simulation is performed of a DC microgrid equipped with the proposed controller

FrA01 ROOM SR1

Biology and Biologically Inspired Systems (Regular Session)

09:00-09:20 FrA01.1

Bio-Inspired Celestial Compass Yields New Opportunities for Urban Localization

Dupeyroux, Julien — Delft University of Technology
Viollet, Stéphane — Institute of the Movement Sciences
Serres, Julien — Aix Marseille University

Autonomous navigation requires multi-sensors data fusion provided either by global navigation satellite systems (GNSS) devices, inertial measurement units, radars and cameras to achieve accurate localization. Each technological solution features advantages but suffers also from drawbacks. Data fusion aims at maintaining a strong level of accuracy and robustness to make autonomous navigation systems reliable enough to be embedded on board any autonomous vehicles. However, there are still environmental contexts in which most sensors drift or even fail to provide correct estimates. In this study, we discuss the opportunity to use a celestial compass inspired by the desert ants' visual system which is able to extract heading information from the polarization pattern of the skylight in the ultraviolet (UV) spectrum. This new sensing mode has been mounted on-top a car and tested outdoor on a 18.6km-long journey in town and compared with GNSS estimates. The UV celestial compass yielded promising performances regarding its low complexity and the root mean square error of the orientation error was only 0.55°. Our results suggest the suitability of such parsimonious insect-inspired solutions for robotic purposes in urban field like the last mile delivery.

09:20-09:40 FrA01.2

A Model of Apoptosis Receptor Reactions to Study Cell Fate Decision

Gomes-Pereira, Luis — Université Côte D'Azur
Chaves, Madalena — INRIA
Roux, Jeremie — CNRS

The apoptotic signaling pathway designates a set of biochemical reactions involved in programmed cell death. One of the triggering mechanisms of apoptosis is the binding of death ligands to death receptors on the cell membrane, a known stimulus for the activation of the so-called extrinsic apoptosis signaling pathway. Stimulation by death ligands results in an important variability in cell response dynamics that elicits differing fates: cell survival or cell death. To understand the hallmarks of this cell fate decision and the heterogeneity of cell response, a system of ordinary differential equations based on mass-action rate laws was implemented to represent the reactions at the receptor level and evaluate the cell dynamics in response to anticancer drugs.

09:40-10:00 FrA01.3

Insect-Inspired Omnidirectional Vision for Autonomous Localization On-Board a Hexapod Robot

Dupeyroux, Julien — Delft University of Technology
Lapalus, Sean — Aix Marseille University
Brodoline, Ilya — Aix Marseille University
Viollet, Stephane — Institute of the Movement Sciences
Serres, Julien — Aix Marseille University

Navigating insects like desert ants are known to robustly estimate their position from their nest while foraging for food, for several hundred meters across hostile environments, by means of very low resolution visual information processing. This tour de force stands for a great source of inspiration to design smart, parsimonious and robust solutions to make robots of any size navigate in global navigation satellite systems-denied or in cluttered environments. In this study, we introduce a new insect-inspired omnidirectional visual sensor (640x120 pixels; 120 fps). The inter-pixel angle is equal to 0.6° and the acceptance angle is equal to 1.5°, which is comparable to those observed in predatory flying insects. This sensor was embedded on-board the AntBot robot, a six-legged walking robot mimicking desert ants at morphological, locomotive and sensing levels. Despite the residual visual oscillations of the field of view while walking, the robot successfully detected fixed obstacles and was able to locate itself with an accuracy as low as 25 ± 10 cm, which actually corresponds to an average error of only 3 strides (hexapod stride length: 8.2 cm) after a 9m-long journey. This suggests that low-acuity visual sensors, inherently requiring few computational resources, are good candidates for ant-like familiarity-based navigation in cluttered environments.

10:00-10:20 FrA01.4

Pseudospectral Method Based Optimal Control of Tuberculosis Model

Salik, Mohammad — National Institute of Technology, Srinagar
Banerjee, Arunava — Indian Institute of Technology Delhi
Nabi, Mashuq-un- — Indian Institute of Technology-Delhi

This paper discusses the use of optimal control strategies for ascertaining efficient usage of infection eliminating methodologies. The mathematical model of tuberculosis is considered which is incorporated with three control terms. The preventive controls used for containing the spread of tuberculosis, include vaccinations along with treatment control for the latent, susceptible and infected population. By implementing the Pseudospectral method on the Tuberculosis model, the original continuous-time optimal control problem is converted into its equivalent non-linear programming problem and then solved. On the application of the proposed control scheme, a minimization in the intervention cost and a significant reduction in the disease burden is expected. A comparative analysis between the widely used Legendre Pseudospectral method and Chebyshev Pseudospectral method when applied to the mathematical model of tuberculosis is included in this work. The response of the states in the absence of any control effort is also included to demonstrate the effect of optimal control strategy on the disease.

10:20-10:40 FrA01.5

Improving TCI Control for the Automatic Delivery of Rocuronium

Mendonça, Teresa — University of Porto
Rocha, Paula — University of Porto
Silva, Jorge — University of Porto

The contribution of this paper is to present a state-feedback design method for the automatic control of the Neuromuscular Blockade Level (NMB) based on pole placement scheme. The typical clinical procedure in surgery room begins by the administration of an initial bolus in order to enable a fast intubation, followed by a piecewise constant infusion of a certain neuromuscular relaxant (here, rocuronium). This latter procedure, known as TCI (Target Controlled Infusion) aims at reaching and maintaining a desired level for the NMB. First, the identification of the parameters of a PPM (parameter parsimonious model) is performed using the bolus response until the NMB reaches the target NMB level. Thereafter, the controller is tuned according to the identified patient parameters, in order to suitably place the poles, leading to an individualized target control infusion. The pole placement criterion is based on a weighted cost function that takes into account both the tracking performance and the average administered drug dose. The obtained results are illustrated by means of simulations.

FrA02 ROOM SR2

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

Organizer: Popescu, Dan — Politehnica University of Bucharest
Organizer: Lazar, Corneliu — Gheorghe Asachi Technical University of Iasi
Organizer: Ichim, Loretta — Politehnica University of Bucharest
Organizer: Stamatescu, Grigore — Politehnica University Bucharest

09:00-09:20 FrA02.1

Distributed Model Predictive Control Algorithm with

Communication Delays for a Cooperative Adaptive Cruise Control Vehicle Platoon (I)

Maxim, Anca	Gheorghe Asachi Technical University of Iasi
Lazar, Corneliu	Gheorghe Asachi Technical University of Iasi
Caruntu, Constantin-Florin	Gheorghe Asachi Technical University of Iasi

This paper proposes a distributed model predictive control (DMPC) strategy with known delays in the communication network. The algorithm is suitable for a vehicle platooning application in the cooperative adaptive cruise control (CACC) framework. All the platoon vehicles are connected in a uni-directional wireless communication network. The simulation results for a five-vehicle platoon show that the DMPC optimization problem can successfully accommodate for the communication delays, while a velocity-dependent inter-vehicle spacing-policy for the follower vehicles is used.

09:20-09:40 FrA02.2

Trajectory Optimization through Connected Cooperative Control for Multiple-Vehicle Flocking (I)

Caruntu, Constantin-Florin	Gheorghe Asachi Technical University of Iasi
Pascal, Carlos	Gheorghe Asachi Technical University of Iasi
Ferariu, Lavinia	Gheorghe Asachi Technical University of Iasi
Comsa, Ciprian Romeo	Gheorghe Asachi Technical University of Iasi

The ever-increasing number of vehicles that use the current infrastructure brings many disadvantages, among which one can emphasize traffic congestion and decreased safety, mostly due to human error. While the human drivers are aided more and more by different automated functionalities that help them make the best decisions at certain times or may even be replaced by higher-level functionalities, automated vehicles are far from being deployed in series on the roads because it is difficult to ensure functional safety at all times. Moreover, automated vehicles would solve only half of the problem, i.e., removing the human factor from the loop, but the number of vehicles would not decrease which leads to the same traffic congestion. One solution would be to reduce the space between the vehicles, but this implies even higher functional safety of the automated features. Another idea is to make use of the vehicle platooning concept based on cooperative adaptive cruise control and extend it to the multiple-lane use-case. This would involve coordinating a group of vehicles traveling on a multiple-lane road to maintain small gaps between them even at highway speeds. The solution implies an exchange of information between vehicles, such that their trajectories are optimized at all times. Thus, this paper considers the design and development of a control architecture for multiple-lane vehicle flocking based on their cooperative decisions. The simulation results obtained using a simulator based on SUMO and Matlab illustrate the capabilities of the proposed methodology.

09:40-10:00 FrA02.3

IoT Gateway for Personalized User Comfort Management in Smart Home Applications (I)

Chenaru, Oana	Politehnica University of Bucharest
Popescu, Dan	Politehnica University of Bucharest

Smart Home applications tend to be more focused not only on responding to user's actions but also on anticipating his needs and adding controls to support these needs. Researchers have developed so far methods which consider behavior modeling for easier identification of deviating situations or automating user actions, comfort and energy saving models which aim to optimize consumption while keeping the habitant perception of the environmental state at a proper level, or context awareness integrated with the building automatic control systems to adapt environmental control rules to the house special characteristics. This paper proposes a user comfort management architecture which processes inputs from context analysis and behavior modelling modules to achieve a narrow control scheme fitted to user's perception of comfort and able to adapt to different action scenarios. Such a system considers the acquisition of temperature, humidity, and CO2 data, as well as inputs from presence sensors and integrates air conditioning equipment for set-point change or room thermostat control. Electrical consumers patterns can also be identified in relationship with user behavior to support energy efficiency algorithms. The paper discusses the requirements the models should feature, the functional aspects and proposes an algorithm for their integration.

10:00-10:20 FrA02.4

Visual Servoing System for Local Robot Control in a Flexible Assembly Line (I)

Popescu, Dan	Politehnica University of Bucharest
Mihai, Viorel	Politehnica University of Bucharest
Cojocaru, Jan-Iliuță-Romeo	Politehnica University of Bucharest
Dragana, Cristian-Mihai	Politehnica University of Bucharest
Ichim, Loretta	Politehnica University of Bucharest

The paper presents a solution for visual servoing problem that is implemented on a robotic arm from an industrial flexible assembly line. This line respects the Industry 4.0 paradigm, thus having a modular structure consisting of five stations. Each station includes a Programmable Logic Controller equipment for local control and communication modules for connection with other stations. The paper is focused on the design and implementation of the visual servoing system which ensures the line flexibility. The experimental results validate the system functionality and indicate remarkable performances.

10:20-10:40 FrA02.5

Hybrid Sensor Network for Monitoring Environmental Parameters (I)

Popescu, Dan	Politehnica University of Bucharest
Vlasceanu, Emilian	AFT Design
Dima, Marius	AFT R&D
Stoican, Florin	Politehnica University of Bucharest
Ichim, Loretta	Politehnica University of Bucharest

The paper proposes a cheap hybrid ground-air sensor network for environmental parameter measurements. The ground sensors are grouped into clusters, each cluster having several sensory nodes connected to a cluster head that sends the relevant data to the aerial, mobile nodes - unmanned aerial vehicles (UAVs). Thus, using optimal trajectories, the UAVs are used both for measuring directly environmental parameters, as well as for collecting data from ground sensors. The authors present the modules' implementation of the hybrid system: ordinary sensory nodes, cluster heads, ground control stations, communication modems and UAV platforms. Finally, the performances of the realized hybrid network are analyzed from multiple points of view: energy consumption, time, and data acquisition efficiency.

FrA03 ROOM SR3

Adaptive Control (Regular Session)

09:00-09:20 FrA03.1

Event-Trigger Based Adaptive-Robust Guidance Strategy with Input Saturation

Banerjee, Arunava	Indian Institute of Technology Delhi
Amrr, Syed Muhammad	Indian Institute of Technology, Delhi
Nabi, Mashuq-un-	Indian Institute of Technology-Delhi

Over the last few decades, the computational capabilities of the state-of-the-art processors have increased extensively and are now capable of performing multiple parallel computations. However, due to constraint on cost, weight, and space, they are not generally installed as an on-board processor of an interceptor. This limitation

of the computational capabilities of the missile processor is addressed in this paper, by designing an event-triggered strategy, which reduces the number of control updates. In addition to achieving the primary objective of capturing the target, the proposed guidance strategy enables the interceptor to tackle external disturbances that it encounters. Further the conservative assumption of a priori knowledge about the upper bound of the disturbances is eliminated by adaptively tuning the gains of the proposed guidance law. Input saturation has also been considered on the control effort of the missile so as to be consistent with most practical interceptor systems. Lyapunov theory has been used to demonstrate asymptotic stability of the closed-loop system states under the proposed event-triggered control scheme. Numerical simulations for the guidance strategy on the commonly occurring tail-chase and head-on engagement scenarios are performed along with a comparative performance analysis with the periodic time-triggered technique.

09:20-09:40 FrA03.2

Adaptive Control of a Linear Hyperbolic PDE with Uncertain Transport Speed and a Spatially Varying Coefficient, pp. 945-951

Anfinsen, Henrik NTNU
Holta, Haavard NTNU
Aamo, Ole Morten NTNU

Recently, the first result on backstepping-based adaptive control of a 1-D linear hyperbolic partial differential equation (PDE) with an uncertain transport speed was presented. The system also had an uncertain, constant in-domain coefficient, and the derived controller achieved convergence to zero in the L∞-sense in finite time. In this paper, we extend that result to systems with a spatially varying in-domain coefficient, achieving asymptotic convergence to zero in the L∞-sense. Additionally, for the case of having a constant in-domain coefficient, the new method is shown to have a slightly improved finite-time convergence time. The theory is illustrated in simulations.

09:40-10:00 FrA03.3

Reducing Overparametrization in MRAC for Hyperbolic PDEs

Anfinsen, Henrik NTNU
Gajic, Natasa NTNU
Aamo, Ole Morten NTNU

We construct a method of dealing with the problem of over parameterization in model reference adaptive control (MRAC) of 2 x 2 linear hyperbolic partial differential equations (PDEs). The method is based on linear interpolation of the uncertain parameters. The proposed method is demonstrated in simulations of the fluid mechanics of a drilling system, and compared to a previously derived, over parameterized MRAC scheme, showing improved tracking and convergence properties.

10:00-10:20 FrA03.4

Stator Flux Finite-Time Observer for Non-Salient Permanent Magnet Synchronous Motors

Bobtsov, Alexey ITMO University
Pyrkin, Anton ITMO University
Aranovskiy, Stanislav CentraleSupelec
Nikolaev, Nikolay ITMO University
Slita, Olga ITMO University
Kozachek, Olga ITMO University

In this paper a gradient observer and finite-time observer of stator flux are developed for non-salient permanent magnet synchronous motors. The methods described here are based on implementation of LTI filters and DREM techniques. The motor resistance and inductance are assumed to be known.

10:20-10:40 FrA03.5

Adaptive Control of a Linear, Scalar Hyperbolic PDE with Time-Varying Coefficients

Anfinsen, Henrik NTNU
Aamo, Ole Morten NTNU

We extend a previous result regarding adaptive control of a linear hyperbolic partial differential equation (PDE) with time-varying in-domain source coefficient in two ways. Firstly, we introduce a parametrization of the uncertain time-varying in-domain source coefficient that allows for a broader class of systems compared to previous result. Secondly, and more importantly, we introduce an uncertain scaling factor in the input boundary condition, which is present in most applications, but wasn't handled in the previous result. All system parameters except the transport speed are uncertain and time-varying, although parametrizable as a linear combination of uncertain constants and certain time-variance. Closed-loop convergence of the state to the origin is proven, and performance is demonstrated for a numerical example.

FrA04 ROOM SR4

Robotics (Regular Session)

09:00-09:20 FrA04.1

Cartesian Genetic Programming for Control System Synthesis of Robot Group

Diveev, Askhat Federal Research Center “Computer Science and Control” of Russia

A control problem for a group of robots is considered. The robots have to move from given initial conditions to terminal ones without collisions between themselves and stationary obstacles. To solve the problem, the optimal synthesized control method is used. According to this method firstly the control system synthesis problem for each robot is solved. As a result, the control system stabilizes the robot relative to some point in the state space. After that positions of these stable equilibrium points in the state space for each robot are found so that all robots can move from point to point till the terminal positions without collisions. For synthesis problem on the first stage the Cartesian genetic programming is used. This method of symbolic regression allows to find a mathematical expression for control function in the form of special code by a special genetic algorithm. It's shown, that using the symbolic regression methods directly doesn't allow to find a synthesized control function in a code space, because this search space does not have numerical measure for distance between two elements of the space. So the Cartesian genetic programming was modified and the principle of small variations of the basic solution was included in it. A computational example of controlling eight robots on the plane with phase constraints is presented.

09:20-09:40 FrA04.2

Pursuit-Evasion Game for Nonholonomic Mobile Robots with Obstacle Avoidance Using NMPC

Sani, Mukhtar Universite Grenoble Alpes
Robu, Bogdan Universite Grenoble Alpes
Hably, Ahmad GIPSA-Lab

In this work, non-cooperative competitive games between two unmanned ground robots using Nonlinear Model Predictive Control (NMPC) while incorporating obstacle avoidance techniques are studied. The objective of the first player (pursuer) is to minimize the relative distance and orientation between itself and the second player (evader) while avoiding obstacles, whereas the evader does the opposite. The Pursuit-Evasion Game (PEG) being a typical class of a differential game is formulated as a zero-sum game with two homogeneous players in five different game scenarios. The objective function of each player is formulated as a double optimization problem and is solved separately using NMPC techniques. The optimal trajectory of each player is computed iteratively by considering the best response of the opponent player. The level of information is assumed to be symmetric. Simulations of various scenarios show the winning possibility of each player.

09:40-10:00 FrA04.3

On Determining Shortest Path in Joint Space of a Cable-Driven Parallel Robot for Point-To-Point Motion

Mishra, Utkarsh Aashu Indian Institute of Technology, Roorkee
Chawla, Ishan Indian Institute of Technology, Roorkee
Pathak, Pushparaj Mani Indian Institute of Technology, Roorkee

This paper presents a methodology to determine the shortest path in the joint space of a cable-driven parallel robot for point-to-point motions. The formulation is based on the joint space domain i.e., cable length and the shortest path in joint space is determined between the two points. The path is constrained by the 4th degree polynomial in the Cartesian space and the objective function

representing the total path length in the joint space is formulated. The parameters of the path are obtained by minimizing the objective function using genetic algorithm while satisfying the non-negative cable tension constraints. The proposed methodology is validated using a 3-DOF planar and a 6-DOF spatial cable-driven robot. The obtained optimized shortest path is compared to a straight-line path and the results obtained show a significant reduction in the joint space path length of a cable-driven parallel robot for the optimized path. The reduction will be even more significant for the large-scale cable-driven parallel robot.

10:00-10:20 FrA04.4

Convex Optimization-Based Stiffness Control for Tensegrity Robotic Structures

Savin, Sergei — Innopolis University
Balakhnov, Oleg — Innopolis University
Klimchik, Alexandr — Innopolis University

In this paper, the problem of controlling compliance of a robotic tensegrity structure (finding the state of the structure which produces desired stiffness) is discussed. Tensegrity structures have a number of unique properties: they are well suited for uncertain environments, are easily deployed, impact resistant, foldable and light-weight and thus provide a desirable component for a number of robotics applications. They are currently being used as a structural element of robotic extraterrestrial probes, crawling robots, swimming robots and others. The compliance control problem here is solved by a convex relaxation of the original non-convex program, which in turn is done by introducing two linear models: one for the stiffness matrix and one for the elastic forces. Solution accuracy is controlled by introducing an iterative scheme, solving the convex problem at each iteration. Proposed algorithm converges providing accuracy better than 0.01 N/m in terms of stiffness using only 10 iterations of the algorithm, and the accuracy of force equilibrium is better than 1 N.

10:20-10:40 FrA04.6

Trajectory Control of Omnidirectional Mobile Robots Considering Low-Level Actuator Dynamics

Phan, Huan Van — Southern Illinois University Edwardsville
Ferdowsi, Hasan — Missouri University of Science and Technology
Lotfi, Nima — Southern Illinois University Edwardsville

High degree of maneuverability in omnidirectional mobile robots, which stems from their holonomic nature, has posed them as an attractive solution in a variety of applications. This paper studies the problem of trajectory control in omnidirectional robots based on practical observations. More specifically, the dynamics of the low-level motor drivers are explicitly incorporated during the development of a hierarchical controller. Lyapunov's stability theorem is then used to analytically derive the control law which could achieve seamless integration of different control structure hierarchies. The simulation results show the effectiveness of the proposed method compared to other commonly-used algorithms. Furthermore, the controller exhibits low sensitivity to model parameter variations despite its model-based nature, which would be a very beneficial feature in practical implementations as it would limit the need for extensive modeling and calibration.

FrB01 ROOM SR1

Unmanned Systems (Regular Session)

14:00-14:20 FrB01.1

Analysis of a Novel Autonomous Underwater Robot for Biofouling Prevention and Inspection in Fish Farms

Ohrem, Sveinung Johan — SINTEF
Kelasidi, Eleni — SINTEF Ocean
Bloecher, Nina — SINTEF Ocean

Biofouling is a challenge for finfish farming as it can impact cage stability and fish health. Amongst others, current strategies against biofouling rely heavily on removal of biofouling using in-situ pressure cleaning of nets. The cleaning waste is released into the water where it can impact the health of the cultured fish. Grooming, the regular cleaning of nets to prevent biofouling communities from establishing, is one novel strategy that is currently explored using tethered underwater robots. In addition, remotely operated vehicles (ROVs) are used for inspection of the net to ensure its integrity and prevent fish escapes, while stationary sensors at the farm barge are employed to extrapolate on environmental conditions in the net pens. In this paper, the requirements for a permanently resident, autonomous and tetherless subsea robot for cleaning and inspection are proposed. As such, the robot aims to combine several application areas and offer a solution to the biofouling challenge while at the same time providing better safeguardig of net integrity and monitoring of environmental conditions directly in the pen. Using the SEATONOMY method from an operational viewpoint, the robot's individual operations are analysed. This included i) Environmental condition monitoring, ii) Net and biofouling inspection, iii) Growth prevention and iv) Docking. As a result, the specifications and requirements for the development of a novel robotic system that is able to perform simultaneous inspection, growth prevention and monitoring in fish cages fully autonomously are derived. The paper proposes the development of new technology and biofouling management strategy that will contribute to increase the efficiency and production demands in aquaculture industry.

14:20-14:40 FrB01.2

Motion Planning and Visual-Inertial Target Tracking for UAV-Based Radiation Detection

Yadav, Indrajeet — University of Delaware
Eckenhoff, Kevin — University of Delaware
Huang, Guoquan — University of Delaware
Tanner, Herbert G. — University of Delaware

This paper addresses the problem of detecting radioactive material in transit using an unmanned aerial vehicle (UAV) of minimal sensing capability, where the objective is to classify the target's radioactivity as the vehicle plans its paths through the workspace while tracking the target for a short time interval. Assuming that the prior map of the workspace is available, this paper proposes a motion planning framework that integrates a navigation function based planner with a tightly-coupled visual-inertial localization and target tracking algorithm, and generates dynamically feasible trajectories that provably converge to a moving target while avoiding obstacles. The efficacy of the proposed approach is validated through Gazebo simulations.

14:40-15:00 FrB01.3

MAV Development towards Navigation in Unknown and Dark Mining Tunnels

Kominiak, Dariusz — Luleå University of Technology
Sharif Mansouri, Sina — Luleå University of Technology
Kanellakis, Christoforos — Luleå University of Technology
Nikolakopoulos, George — Luleå University of Technology

The Mining industry considers the deployment of MAV for autonomous inspection of tunnels and shafts to increase safety and productivity. However, mines are challenging and harsh environments that have a direct effect on the degradation of high-end and expensive utilized components over time. Inspired by this effect, this article presents a low cost and modular platform for designing a fully autonomous navigating MAV without requiring any prior information from the surrounding environment. The design of the proposed aerial vehicle can be considered as a consumable platform that can be instantly replaced in case of damage or defect, thus comes into agreement with the vision of mining companies for utilizing stable aerial robots with reasonable cost. In the proposed design, the operator has access to all on-board data, thus increasing the overall customization of the design and the execution of the mine inspection mission. The MAV platform has a software core based on ROS operating on an Aaeon UP-Board, while it is equipped with a sensor suite to accomplish the autonomous navigation equally reliable when compared to a high-end and expensive platform.

15:00-15:20 FrB01.4

Constrained Control Allocation for a Remotely Operated Vehicle with Collective Azimuth Thrusters

Baldini, Alessandro — Università Politecnica Delle Marche
Felicetti, Riccardo — Università Politecnica Delle Marche

Ferracuti, Francesco — Università Politecnica Delle Marche
Freddi, Alessandro — Università Politecnica Delle Marche
Longhi, Sauro — Università Politecnica Delle Marche
Monteriù, Andrea — Università Politecnica Delle Marche

Remotely operated vehicles commonly have propellers with fixed position and orientation. In this paper, we highlight the advantages of equipping remotely operated vehicles with azimuth thrusters. In particular, both energy saving and increased trajectory tracking performances can be achieved with respect to the fixed orientation case. On the other hand, managing thrusters' orientation represents a further computational burden: the constraints are characterized by the presence of trigonometric functions, thus they require, in general, the use of onerous nonlinear solvers. Our proposal is to steer collectively the thrusters, in order to simplify both the optimization algorithm and the mechanical structure of the ROV. The proposed control allocation algorithm calculates, at first, the orientation of the propeller to minimize the energy consumption while taking into account saturation and rate limits. Then, single thrusts are calculated using a quadratic programming framework. Simulation results show the relevance of energy savings and tracking improvements.

15:20-15:40 FrB01.5

Uav Comm: A Generalized Communication between the Robot Operating System and Low-Level Flight Controllers

Small, Elias — Luleå University of Technology
Fresk, Emil — Luleå University of Technology
Nikolakopoulos, George — Luleå University of Technology, Sweden

This article presents a novel C++ template translation layer between the Robot Operating System (ROS) interface and a low-level control board, as a tool to be used by researchers developing robots to reduce time needed in writing code for new robots, to reduce vendor lock-in, and to increase interoperability between researchers low-level control boards. The last two named goals stem from the fact that research in automation of micro aerial vehicles has increased through the last decade and a need for standardization within the open- source community has risen if research is to remain vendor independent. A guide on how to design serial communication between low-level and high-level controllers is provided. Lastly, an implementation of the said translation layer was created to demonstrate its use.

15:40-16:00 FrB01.6

Clock Synchronization with Adaptive Weight Factor for Mobile Networks

Bakura, Sirajo Abdullahi — Université Paris Saclay
Lambert, Alain — Université Paris Saclay
Nowak, Thomas — École Normale Supérieure

This paper deals with high mobility mobile ad-hoc networks (MANETs) whose nodes need to be synchronized. Unlike existing solutions, which either use reference clock or broadcast synchronization messages, our algorithm achieves synchronization by sending zero-bit pulses over the network and is thus usable in the first steps of establishing MANETs. We develop a dynamic adaptive selection technique for choosing an exponential smoothing factor and show the impact of using a fixed value of this parameter on the performance of the algorithm. In addition to that, we demonstrate the strength of our algorithm to withstand the network topological changes during execution. We evaluate the algorithm through extensive simulation in vehicular ad-hoc networks (VANETs). The simulation results show significant performance improvement in terms of reducing the clock offset and drift over the previous works.

FrB02 ROOM SR2

Linear System (Regular Session)

14:00-14:20 FrB02.1

BlockNet: A New Flexible Control Architecture

Calacci, Luca — University of Rome Tor Vergata
Carnevale, Daniele — University of Rome Tor Vergata
Abruzzese, Donato — University of Rome Tor Vergata

A novel multiplatform control framework named BlockNet is introduced. It can be used either for simulations, soft real-time control in real experiments and integration of complex technologies (e.g. neural networks, vision sensors etc.). BlockNet has been developed to provide an easy to use unique tool for local or distributed applications able to guarantee the correct execution order of block codes based on their dependencies, maintaining dynamism and portability. To the best of our knowledge such features are not currently provided at once in other frameworks. We discuss the features of BlockNet, its main structures and functionalities, providing also its effectiveness in a real control application: an earthquake simulation platform.

14:20-14:40 FrB02.2

Gantry Crane Position Control Via Parallel Feed-Forward Compensator

Golovin, Ievgen — Otto-Von-Guericke University Magdeburg
Maksakov, Anton — Otto-Von-Guericke University Magdeburg
Palis, Stefan — Otto Von Guericke University Magdeburg

This article is concerned with an output feedback position control of gantry (overhead) cranes applying a parallel feed-forward compensator (PFC) that allows for a reduction of payload swinging without additional sensors or payload swing angle estimations. Performance and stability of the controlled system are achieved by defining a new output as a combination of the original output and the output of an appropriate PFC. The later provides an almost strict positive real (ASPR) condition for the augmented plant. Thus, high gain output feedback control becomes applicable. The proposed feedback control approach is successfully validated in a numerical study and in experiments on a laboratory plant.

14:40-15:00 FrB02.3

Interval Observer Design for Uncertain Linear Continuous-Time Metzlerian Systems

Krokavec, Dusan — Technical University of Kosice
Filasova, Anna — Technical University of Kosice

For linear continuous-time positive systems the paper proposes an approach, reflecting structural constraints and positiveness in the problem of Metzlerian and strictly Metzlerian interval observers design. Every interval matrix boundary is represented by a set of linear matrix inequalities representing Metzler matrix parameter constraints and reflecting potential zero elements in a Metzler matrix structure by structural diagonal matrix variables. Combined with couple of Lyapunov inequalities, the observer Metzler matrix parameters are guaranteed and interval stability is attained. A numerical example is included to assess the feasibility of the proposed technique.

15:00-15:20 FrB02.4

Robust Pseudo-Inversion of Polytopic Systems Using Second Order Cone Programming

Jetto, L. — Univ. Di Ancona
Orsini, Valentina — Università Politecnica Delle Marche

This paper deals with the almost exact set point regulation for Linear Time-Invariant (LTI) continuous-time polytopic systems. To this purpose, a novel robust pseudo- inversion based feedforward control is proposed. The method is based on a two Degrees of Freedom (2DoF) control scheme where the output r(t) of a pseudo-inverting feedforward filter Σff is used as input forcing a closed-loop system Σf. Σf is the feedback connection of an LTI continuous time polytopic plant Σp with an LTI robustly stabilizing controller Σc. In steady-state condition, an exact tracking is achieved endowing Σc of the internal model of constant signals. In the transient state an optimal tracking is obtained computing the transient component rt(t) of r(t) through the on-line minimization of a worst case quadratic cost functional of the transient tracking error. To improve the numerical efficiency of the optimization procedure, the transient input rt(t) is modeled as a B-spline. These functions are universal approximators, which admit a parsimonious parametric representation so that the minimization of the worst case cost functional can be formulated as a robust estimation problem. In turn, this problem can be recast as a Second Order Cone Program (SOCP), which can be efficiently solved using primal and dual point methods.

15:20-15:40 FrB02.5

Effect of Reduced Model Order on Accuracy of Trajectory Piecewise Linear Approximations for a Class of Nonlinear

Circuits

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Nabi, Mashuq-un-	Indian Institute of Technology, Delhi

Model order reduction of input affine nonlinear systems via trajectory piecewise linear approximation is a well known practice. This method along with its variants is known to generate efficient and accurate reduced models of large order nonlinear systems. The selection of the order of the reduced model is however a heuristic choice that comes with experience. There is no concrete measure of an optimum selection of the reduced order that would lead to approximations with high accuracy and least computational cost. This paper provides a study of few variants of trajectory piecewise linear method and effect of the choice of reduced order on the accuracy of the approximations and the computational cost. The results have been studied on a nonlinear transmission line circuit. This study provides a performance analysis that exhibits a range of acceptable values of reduced order that may be preferred for generating accurate trajectory piecewise approximations of circuits similar to that discussed in this paper.

15:40-16:00 FrB02.6

Synchronous Causal Digital Control and Stabilization of a Linear Periodic Object Using a Generalized Hold

Rosenwasser, Efim N.	Marine Technical University of Saint Petersburg
Drewelow, Wolfgang	University of Rostock
Jeinsch, Torsten	University of Rostock
Cepeda Gomez, Rudy	University of Rostock
Ladisch, Jens	Hochschule Stralsund

This paper discusses the digital control of a linear periodic object when using a generalized hold element. The solution for the problems of causal modal control and stabilization based on a discrete backward model formulation is given on the basis of the discrete model of the system using the apparatus of determinant polynomial equations.

FrB03 ROOM SR3

Applications (Regular Session)

14:00-14:20 FrB03.1

Prediction and Classification of Temperature Data in Smart Building Using Dynamic Mode Decomposition

Kumar, Sunny	Veermata Jijabai Technological Institute
Sheikh, Mohd Adil	Veermata Jijabai Technological Institute
Wagh, Sushama	Veermata Jijabai Technological Institute
Singh, Navdeep	Veermata Jijabai Technological Institute

With the recent trends of smart cities, the development in the sector of Smart Buildings has emerged tremendously which consists of multiple layers coordinating and interacting with each other with the help of a building management system (BMS). This interaction of different layers in the smart building with the help of a communication channel leads to exposure of layers to vulnerabilities (cyber attacks), which may lead to anomalies condition. This kind of anomalies can be avoided by proper prediction of data and coordination among different layers of the building operation. However, to develop the model for prediction of data is quite time consuming and hence, the paper proposes the concept of Dynamic Mode Decomposition (DMD) for predicting data with help of past available data even in absence of system model. In this paper temperature profile of heating, ventilation, and air conditioning (HVAC) system in BMS is predicted with the help of available past data. Once the prediction of the temperature profile is achieved the machine learning algorithm is used to classify and identify the data as normal or anomalies condition. The two-fold contribution of the paper in the prediction of temperature using DMD where all system states may not be observable and classification of data using machine learning is validated considering different test scenarios and results show the effectiveness of the DMD method in the prediction of data as well as classification using a machine learning algorithm.

14:20-14:40 FrB03.2

Run-To-Run Control of Thermal Atomic Layer Deposition

Zhang, Yichi	University of California, Los Angeles
Ding, Yangyao	University of California, Los Angeles
Wu, Zhe	University of California, Los Angeles
Christofides, Panagiotis	University of California, Los Angeles

This work focuses on the development of a computational fluid dynamic (CFD) model of a batch atomic layer deposition (ALD) process and an associated run-to-run control scheme. Specifically, a cylindrical furnace reactor is analyzed for a SiO2 thin-film ALD using BTBAS and ozone as precursors. First, a high-fidelity 2D axisymmetric multiscale CFD model for an industrial-scale furnace ALD system is developed in ANSYS Fluent to characterize the gas-phase development and the surface deposition, which is based on the previously constructed database using the kinetic Monte-Carlo (kMC) algorithm. After the validation of the multiscale CFD model, it is utilized to investigate a wide range of operating conditions, from which a regression model is developed to describe the input-output relationship between the inlet feed flow rate and the half-cycle time. Next, a run-to-run (r2r) control scheme is formulated, which uses the post-batch feedback information to adjust the operating conditions using the regression relationship and an exponentially weighted moving average (EWMA) algorithm. Finally, the multiscale CFD model and the r2r controller are integrated to generate a closed-loop system via a message passing interface (MPI) and a data synchronization scheme to evaluate the performance of the r2r controller.

14:40-15:00 FrB03.3

Deep Weed Detector/Classifier Network for Precision Agriculture

Abdulsalam, Mahmoud	City, University of London
Aouf, Nabil	City, University of London

The productivity of crop farming keeps diminishing at an alarming rate due to infestation of weeds and pests. Deep learning is becoming as the approach for identifying weeds on farmlands. However, training weed data sets with deep learning classification alone trains the whole images consisting of the weed and its background (soil) without categorically telling which particular item in the image is a weed. This makes utilizing this classification approach for precision agriculture difficult. We present an alternative approach, which involves incorporating a pre-trained network in this case ResNet-50 and YOLO v2 object detector for weed detection/classification on farmlands. Thus, weeds can precisely be located, identified (type), sprayed with the appropriate herbicide or removed with the appropriate mechanism. This sums up weeding process in precision agriculture.

15:00-15:20 FrB03.4

Emergency Resource Allocation Problem: Hazardous Material Accident Scenarios in the Ports of Northern Italy

Bersani, Chiara	University of Genoa
Sacile, Roberto	University of Genoa DIBRIS
Tomasoni, Angela Maria	University of Genoa DIBRIS
Zero, Enrico	University of Genoa DIBRIS

The resource allocation problem in case of emergency management represents a serious theme especially in the last years, when the occurrence of industrial disasters has become more frequent. Special attention has to be given to the emergency management in case of maritime or port accidents which involve hazardous material above all in MED cities where the seaport are part of the urban areas. The main challenge in emergency management is to define the optimal allocation of the available resources in timing and space in order to tackle, to mitigate and to recover effectively the hazardous event. In this paper, an optimal allocation problem has been formalized as a mathematical programming problem. The proposed model takes into account the dynamic of the first responders' availability at each node and the dynamic behavior of the hazard event to be faced. The problem minimizes the objective function that is the combination of resource allocation, damages and transfer costs. The resources refer to extinguishing powers, which may be generated by the firefighters teams of the fire stations available at each node of the network in a cooperative emergency management prospective. The model has been tested on a case study that concerns the simultaneous occurrence of two hazardous materials accidents in two ports located in Northern Italy.

15:20-15:40 FrB03.5

The Detection of the Rotor Temperature in an Induction Machine Based on a Neural Network with Particle Filtering

Mocanu, Razvan — Gheorghe Asachi Technical University of Iasi

Onea, Alexandru — Gheorghe Asachi Technical University of Iasi

This paper introduces a method for estimating the temperature of the rotor of an Induction Machine (IM) based on a feed-forward neural network used as an observation function within a particle filter. The temperature of the stator case is measured and the information is used as an input to a feed-forward network. The state transition function is a thermal model with first-order dynamics. The set-point temperature is computed out of the rotor current, stator current and angular speed. Experimental data is used from a real IM test bench and the results prove the applicability and good performances.

15:40-16:00 FrB03.6

Control of the Crop-Production in a Network of Agricultural Plots

Casenave, Céline — INRAE Montpellier

Bisson, Anne — Montpellier SupAgro, UMR MISTEA

In the present paper, we propose a strategy to control the crop-production of a network of agricultural plots. The network is composed of rangeland and cropland subsystems that are connected to each other through the livestock that is a vector of nutrient from rangeland to cropland. The objective is to reach a given crop production (at the scale of the whole network) while ensuring a minimal production in each of the cropland plot. To take into account the saturation constraints on the control inputs (that are the rangeland removal rates and the manure distribution coefficients), we use a method based on a time-scale transformation. After designing the control law, we apply it on a simple numerical example to highlight the results.

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