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WeAT1 Kozani

Fault Diagnosis (Regular Session)

Chair: Sauter, Dominique — Lorraine Univ

Co-Chair: Groumpos, Peter — Univ. of Patras

10:30-10:50 WeAT1.1

Design of a Model-Based Calibration Method for Thermal on Board Diagnostic Functions, pp. 1-6

Hoppe, Matthias — RWTH Aachen Univ

Hesseler, Frank-Joseph — Inst. of Automatic Control, RWTH Aachen Univ

Brückner, Daniel — Bmw Ag

Abel, Dirk — RWTH Aachen Univ

This paper presents a model-based method for the calibration of thermal on board diagnostic functions. As an example application for the model-based calibration approach, the calibration of the engine temperature sensor diagnostic function is used. The model used for calibration consists of a physical description of the engine and a map-based model for the outer cooling circuit. For the calibration of the diagnostic function four parametric optimization approaches based on Least Squares and Quantile Regression are compared.

10:50-11:10 WeAT1.2

A New Meniscus Injury Diagnostic Model Using Fuzzy Cognitive Maps, pp. 7-12

Anninou, Antigoni — Univ. of Patras

Poulios, Panagiotis — Univ. of Patras

Groumpos, Peter — Univ. of Patras

Gliatis, Ioannis — Univ. of Patras

The aim of this paper is to create an integrated meniscus injury diagnostic model, which by exploiting information about patient history and clinical examination made by physicians concludes to a final diagnosis using Fuzzy Cognitive Maps. Mechanisms of injury and symptoms combined with test results constitute the first level modelled with FCM. The output of this level decides if the patient has a meniscus tear or not. The second level decides if the injury is acute or degenerative with the help of risk factors using Competitive Fuzzy Cognitive Maps in order to conclude to only one decision. The results obtained by the model are very promising without requiring sending the patient for MRI (Magnetic Resonance Imaging) which is of utmost importance in diagnosing soft tissue injuries.

11:10-11:30 WeAT1.3

Data-Driven Multi-Unit Monitoring Scheme with Hierarchical Fault Detection and Diagnosis, pp. 13-18

Zhou, Yingya — Tsinghua Univ

Chioua, Moncef — Abb Ag

Ni, Weidou — Tsinghua Univ

Various areas see the trend of increasing degree of decentralization and automation. Conventional component or unit based monitoring scheme by analytical modeling could be tedious and costly in dealing with increased number of entities. A holistic data-driven scheme able to monitor multiple units and hierarchically detect and diagnose faults is proposed, in which Multi-way Principal Component Analysis (MPCA) is employed as data analysis algorithm. The proposed scheme is illustrated using data collected from an actual onshore wind farm with multiple wind turbines. The obtained fault detection and diagnosis results are validated using maintenance reports.

11:30-11:50 WeAT1.4

Design of Synergetic Observer for Faults Detection and Identification, pp. 19-24

Radhia, Ettouil — National Engineering School of Gabes

Chabir, Karim — ENIG

Sauter, Dominique — Lorraine Univ

Abdelkrim, Mohamed Naceur — ENIG

In this paper, a new strategy of state observation is established, this method is based on the synergetic theory to construct a synergetic observer. This theory is presented for the nonlinear system control at the first. Then, it is shown that the discrete-time synergetic controller satisfies the conditions of optimality. The concept of synergetic observer is introduced for a linear system. It is proved that the proposed observer can detect a multiple faults appearing simultaneously or sequentially. The fault detection synergetic observer generates two output residuals, one delayed in time compared to the other. The boost converter is used as example of nonlinear system to simulate the synergetic control.Also, The simulation results for a linear system are presented to validate effectiveness of proposed observer.

11:50-12:10 WeAT1.5

Robust Multi-Model Fault Detection and Isolation with a State-Space Neural Network, pp. 25-30

Czajkowski, Andrzej — Univ. of Zielona Góra

Luzar, Marcel — Univ. of Zielona Góra

Witczak, Marcin — Univ. of Zielona Gora

This paper presents an design of a Robust Fault Detection and Isolation (FDI) diagnostic system by the means of state-space neural network. First, an solution utilizing multi-model technique is described, in which a Single-Input Multi-Output (SIMO) system is decomposed into a number of Multi-Input Single-Output (MISO) and Single-Input Single-Output (SISO) models. Application of such models makes possible to calculate a set of residual signals required in evaluation process with a Model Error Modelling (MEM) to obtain diagnostic signals. In turn, to isolate faults the diagnostic signals together with defined binary diagnostic table are applied. For experimental verification of the proposed approach, the laboratory stand of Modular Servo is chosen. All necessary data were gathered with the Matlab/Simulink software.

12:10-12:30 WeAT1.6

On the Unknown Input Functional Observers Design: A Polytopic Takagi-Sugeno Approach, pp. 31-37

Bezzaoucha, Souad — Interdisciplinary Centre for Security, Reliability and Trust (Sn

Voos, Holger — Univ. of Luxembourg

Darouach, Mohamed — CRAN CNRS UMR 7039, Univ. De Lorraine

Dentler, Jan — Univ. of Luxembourg

In this paper, a step by step algorithm is given to design functional

unknown input observer for continuous nonlinear systems under the Polytopic Takagi-Sugeno (T-S) framework. To nullify the effect of unknown input (UI), classical approach of decoupling the UI for the linear case is extended to the polytopic system. Applying the Lyapunov theory and the L2 attenuation, Linear Matrix Inequalities (LMI)s conditions are achieved which are solved for feasibility to obtain observer design matrices. The novelty of the proposed approach consists in solving simultaneously both structural constraints and LMIs, which ensure a mean for the efficient design of the gains of the observers. To illustrate the proposed theoretical results, simulation example of a Waste Water Treatment Plant (WWTP), which is highly nonlinear and represented in a T-S polytopic form with unmeasurable premise variables and unknown inputs, is discussed.

WeAT2 Edessa

Unmanned Systems I (Regular Session)

Chair: Pettersen, Kristin Y. — Norwegian Univ. of Science and Tech

Co-Chair: Ioannou, Stelios — European Univ

10:30-10:50 WeAT2.1

Line-Of-Sight Curved Path Following for Underactuated USVs and AUVs in the Horizontal Plane under the Influence of Ocean Currents, pp. 38-45

Moe, Signe — PhD Candidate

Pettersen, Kristin Y. — Norwegian Univ. of Science and Tech

Fossen, Thor I. — Norwegain Univ. of Sci and Tech

Gravdahl, Jan Tommy — Norwegian Univ. of Science & Tech

An essential ability of autonomous unmanned surface vessels (USVs) and autonomous underwater vehicles (AUVs) moving in a horizontal plane is to follow a general twodimensional path in the presence of unknown ocean currents. This paper presents a method to achieve this. The proposed guidance and control system only requires absolute velocity measurements for feedback, thereby foregoing the need for expensive sensors to measure relative velocities. The closed-loop system consists of a guidance law and an adaptive feedback linearizing controller combined with sliding mode, and is shown to render the path cross-track error dynamics UGAS and USGES. Simulation results are presented to verify the theoretical results.

10:50-11:10 WeAT2.2

Runtime, Capacity and Discharge Current Relationship for Lead Acid and Lithium Batteries, pp. 46-53

Ioannou, Stelios — European Univ

Dalamagkidis, Konstantinos — Private Sector - Software Consultant

Stefanakos, Elias — Univ. of South Florida

Valavanis, Kimon — Univ. of Denver

Wiley, Paris — Univ. of South Florida

Peukert's equation describes the relationship between battery capacity and discharge current for lead acid batteries. The relationship is known and widely used to this day. This paper re-examines Peukert's equation and investigate its' validity with state of the art lead acid and lithium batteries. Experimental data reveals that for the same battery, Peukert's exponent is not constant but it is a function of battery capacity and discharge current. This work proposes and validates a reformulated equation which provides an accurate prediction of the runtime for single discharge applications using only the battery name plate information such as capacity and the corresponding discharge time. The validation includes lead acid and lithium batteries. Finally, this work introduces and validates a methodology where the battery parameters can be determined in less than one hour when no battery data and usage is available.

11:10-11:30 WeAT2.3

Modeling, Simulation and Validation of the Electrical Power Consumption of Mobile Ground Vehicles, pp. 54-59

Ioannou, Stelios — European Univ

Dalamagkidis, Konstantinos — Private Sector - Software Consultant

Stefanakos, Elias — Univ. of South Florida

Valavanis, Kimon — Univ. of Denver

Wiley, Paris — Univ. of South Florida

Unmanned ground vehicles (UGVs) have strict payload limitations and limited on-board free space affecting energy storage capacity, which in turn has an impact on system endurance affecting the vehicle's operational range and its capability to handle certain types of missions. Power requirements are mostly determined by the manufacturer for a specific vehicle configuration, ignoring the impact of possible upgrades, 'off-the-self' add-on sensors. This work reviews and validates vehicle kinematics for small to mid-sized ground vehicles. Furthermore, a Matlab model has been developed to simulate the electrical power consumption including peak power demand and total required energy for user defined applications. Comparison between the simplified method estimating the total mission required energy which assumes 100% utilization and a real scenario showed that the simplified method oversized the power system by 50%.

11:30-11:50 WeAT2.4

An Autonomous Multi-Sensor UAV System for Reduced-Input Precision Agriculture Applications, pp. 60-64

Katsigiannis, Panagiotis — Interbalkan Environment Center (iBEC)

Misopolinos, Lazaros — Interbalkan Environment Center (iBEC)

Liakopoulos, Vasilis — Interbalkan Environment Center (iBEC)

Alexandridis, Thomas — Aristotle Univ. of Thessaloniki

Zalidis, George — Aristotle Univ. of Thessaloniki

The constant innovation and advancement in unmanned aerial vehicle (UAV) sensing technology has facilitated a series of applications in the field of agriculture. The adoption of precision agriculture and reduced-input farming technics entails higher level of input data, with enhanced spatial and spectral resolution, and increased frequency of information delivery. Whereas satellite remote sensing still has decisive limitations for use in farm management applications, especially in small-scale agriculture, the comparative advantages of UAVs in these aspects propelled them as an alternative data collection platform. However, automation in the deployment of UAV sensing systems for operational in-field use, integration of visible, near-infrared and thermal spectral ranges, standardization of data collection, data processing and analysis workflow, production of readily available services, and credibility of reliable economic return from their incorporation into agronomical practices are components still relatively absent from the agriculture industry. In this paper, we demonstrate the operational use of a recently developed autonomous multi-sensor UAV imaging system, which is designed to provide spectral information related to water management for a pomegranate orchard. Vegetation and water stress indices were derived from both multispectral and thermal spectral data collected simultaneously from the system, and were used as indicators for crop water stress and crop health condition. It is concluded that the developed system addresses the needs and challenges identified for the incorporation of UAV sensing technology into reduced-input precision agriculture applications.

11:50-12:10 WeAT2.5

A Command-Filtered Backstepping Approach to Autonomous Inspections Using a Quadrotor, pp. 65-70

Oland, Espen — Teknova AS

This paper applies command-filtered backstepping for position control of an underactuated quadrotor. First the dynamics are differentiated until the rotational and translational dynamics become coupled, then the paper applies command filtered backstepping to control the underactuated rigid body with constrained actuation. The thrust, roll and pitch torques are used for position control and designed through the backstepping, while the yaw torque is a available for another control objective. The yaw torque is therefore designed using a PD+ controller for target tracking, enabling the quadrotor to track any point (stationary or moving) with a sensor that is assumed to be fixed to the x-axis of the body frame. The paper applies these results to perform autonomous inspections of a wind turbine using a combination of waypoints and a desired trajectory to cover the whole structure while pointing the sensor towards the wind turbine.

12:10-12:30 — WeAT2.6

ERON: A Flexible Autonomous Surface Vessel, pp. 71-76

Demetriou, Georgios — Frederick Univ
Ioannou, Stelios — European Univ
Hadjipieri, Andreas — Frederick Univ
Panayidou, Irene Erica — Fre
Papasavva, Antonis — Frederick Univ
Prodromou Savva, Andreas — Frederick Univ

Aquatic unmanned robotic systems have gained popularity due to their abilities to perform a wide range of applications at low cost and no risk to human lives. This research investigates the development of the navigation system of “HPΩN”, an Autonomous Surface Vehicle (ASV). The PID control system composed of 3 Arduino UNO boards, a GPS, a Compass and 4 thrusters can navigate the 2,86-meter-long and 0,7 meters wide vessel, at speeds of 3-4m/s with an accuracy of less than one meter. Due to its flexible architecture, available on-board payload space, and powerful thrusters, this platform can easily accommodate the integration of various sensors and scientific equipment for a wide range of applications involving water sampling, temperature and salinity measurements to border patrol and monitoring, independent of weather conditions.

WeAT3 — Naoussa

Robust Control I (Regular Session)

Chair: Psillakis, Haris — National Tech. Univ. of Athens (NTUA)

Co-Chair: Liu, Lin — RWTH Aachen Univ

10:30-10:50 — WeAT3.1

Further Results on Robustness of the Nonlinear PI Control Method: The Ignored Actuator Dynamics Case, pp. 77-81

Psillakis, Haris — National Tech. Univ. of Athens (NTUA)

This note examines the robustness properties of the nonlinear PI control method for a simple system with unknown control directions and ignored order actuator dynamics. It is shown that global boundedness and regulation can be achieved for sector bounded nonlinearities if the actuator dynamics are sufficiently fast and the nonlinear PI control gain is chosen from a subclass of the Nussbaum function class. Simulations are also presented that demonstrate the validity of our analysis.

10:50-11:10 — WeAT3.2

P-D State Feedback Controllers for Common I/O Decoupling of Multi Model Descriptor Systems, pp. 82-87

Koumboulis, Fotios — Sterea Ellada Inst. of Tech

The problem of common Input/Output Decoupling for multi model descriptor linear systems via regular Proportional plus Derivative (P-D) state feedback controllers is solved. The necessary and sufficient conditions for the solvability of the problem are established. The analytic expressions of the general solution of the P-D state feedback controllers and the diagonal elements of the multi model decoupled closed loop system are derived.

11:10-11:30 — WeAT3.3

Positive Real Dynamic Output Feedback Controller Synthesis, pp. 88-93

Misgeld, Berno — RWTH Aachen Univ
Liu, Lin — RWTH Aachen Univ
Hewing, Lukas — ETH Zürich
Leonhardt, Steffen — RWTH Aachen Univ

In this paper we describe a synthesis procedure for the design of output feedback controllers subject to a strictly positive real constraint. The procedure addresses the minimisation of the H_2-norm, in the absence of assumptions typically made for the standard H_2-control problem. In order to impose the additional strictly positive real constraint on the controller, the well-known separation principle is applied to the corresponding linear matrix inequalities. Thus, convex numerical algorithms for the suboptimal H_2-strictly positive real control problem are provided based on a sequential design of the separated linear matrix inequalities. The controller synthesis procedure is validated in two example systems. In the first example, the control task is to design a compensator for the classical Euler-Benoulli beam and as the second example, a disturbance rejection controller for a stable nonminimum phase system is considered.

11:30-11:50 — WeAT3.4

Internal Multimodel Control for Discrete Nonlinear Systems with Time-Delay, pp. 94-99

Ben Atia, Samah — ENIG
Messaoud, Anis — National School of Engineering of Gabes, Tunisia
Ben Abdennour, Ridha — National School of Engineering of Gabes

In this paper, an internal multimodel control scheme is proposed for the control of discrete nonlinear systems with time-delay. In this framework, a decoupled polynomial multimodel is proposed for the representation of the nonlinear system. The control scheme incorporates partial internal model controls where each partial controller is associated to a specified operating zone of the nonlinear system. The switching between these controllers is ensured by a supervisor that contains a set of local predictors. A simulation example is carried out to illustrate the significance of the proposed internal multimodel control scheme.

11:50-12:10 — WeAT3.5

Robust Stability and Performance Analysis of Positive Systems Using Linear Programming, pp. 100-105

Babazadeh, Maryam — Sharif Univ. of Tech
Nobakhti, Amin — Sharif Univ. of Tech

This work presents a new necessary and sufficient condition for robust stability and robust performance of positive linear time invariant (LTI) systems with structured uncertainties. It is known that robustness analysis of LTI systems with structured uncertainties requires evaluation of structured singular value (SSV), which is known to be NP-hard. This paper shows that for positive systems, the structured singular value can be estimated efficiently using linear programming. Thus, the robustness analysis of positive systems is simplified to easily verifiable conditions that scale linearly with the dimensions of the system. This property finds great utility in analysis and synthesis of large scale positive systems with distributed control strategies.

WeAT4 Pella

Predictive Control I (Regular Session)

Chair: Ito, Kazuhisa — Shibaura Inst. of Tech

Co-Chair: Cloppenborg, Andreas — Helmut-Schmidt-Univ. Hamburg

10:30-10:50 WeAT4.1

Offset-Free Nonlinear Model Predictive Control of Electrical Power of a PEM Fuel Cell System Using an Extended Kalman Filter, pp. 106-111

Hähnel, Christian — Helmut-Schmidt-Univ. / Univ. of the Federal Armed Forc

Cloppenborg, Andreas — Helmut-Schmidt-Univ. Hamburg

Horn, Joachim — Helmut-Schmidt-Univ. / Univ. of the Federal Armed Forc

Polymer electrolyte membrane (PEM) fuel cell (FC) systems convert chemical energy from hydrogen into electrical energy via a reaction with oxygen. FCs are highly efficient, nearly noiseless, and locally emission-free. An efficient and safe operation demands several variables in certain ranges. However, the electrical characteristic of a FC systems shows a nonlinear behavior and an exact control of the electrical power using a model-based approach requires an accurate model. Due to assumptions and simplifications the model differs from the plant which leads to steady state errors. This paper deals with offset-free Nonlinear Model Predictive Control (NMPC) of electrical power of a PEMFC using an Extended Kalman Filter (EKF). The NMPC allows direct use of nonlinear models with respect to constraints whereas an EKF allows a model correction and thus an exact control without steady state error. All experiments were verified on a test bench with a 4.4kW PEMFC.

10:50-11:10 WeAT4.2

Greenhouse Temperature Control with Wooden Pellet Fuel Using Adaptive Weight, pp. 112-117

Ito, Kazuhisa — Shibaura Inst. of Tech

This study proposes the design of a temperature controller for a greenhouse using a wooden pellet heating system. This heater uses carbon-neutral fuel, however, it has several undesirable characteristics from the viewpoint of control. To compensate for these typical issues, model predictive control is applied to regulate the temperature, and the control performance is experimentally evaluated in a greenhouse. On the other hand, the total fuel cost for greenhouse heating, which consists of the consumption of wooden pellets and lamp oil, should also be considered as an optimal problem. Furthermore, how to choose the weight on total cost remains an open question.par In this study, the concept of adaptive weight is introduced to optimize the system performance including the total fuel cost for heating. The key to solve this problem is to consider the admissible temperature control error that is given by each vegetable, fruit, and flower via the optimal growing temperature depending on the growing process. The simulation results verify the effectiveness of the proposed method.

11:10-11:30 WeAT4.3

Model Predictive Control for a Revenue Account of a Cash Concentration and Disbursements System--Enter the Title of the Paper, pp. 118-124

Herrera, Carlos Antonio — Univ. Autónoma De Barcelona

Ibeas, Asier — Univ. Autonoma De Barcelona

This paper presents a Model Predictive Control (MPC) for a revenue account belonging to a cash concentration and disbursements system, based on the application of inventory policies to the cash balance. Dynamic Programming (DP) is used for the prediction model by including a standard forecasting model for uncertainty. Moreover, a band for the uncertainty is established to narrow the input of the DP model which, coupled with the introduction of a stabilizing regulator in cascade fashion using a linear feedback gain, allows determining a range for the system stability regardless of size of the prediction horizon. The reference signal used is a sawtooth function, which conveniently adapts to the inventory policy (s, S). Theoretically, and through simulation, it is shown that the proposed controller meets the control objective.

11:30-11:50 WeAT4.4

Complexity Certifications of Inexact Projection Primal Gradient Method for Convex Problems: Application to Embedded MPC, pp. 125-130

Patrascu, Andrei — Pol. Univ. of Bucharest

Necoara, Ion — Pol. Univ. of Bucharest

In this paper we introduce a primal projected gradient method based on inexact projections for solving constrained convex problems. For this algorithm we prove sublinear rate of convergence when applied to problems with objective function being convex and having Lipschitz gradient. At each iteration, our method computes a gradient step towards the solution of the unconstrained problem and then projecting approximately this step onto the feasible set. We recast the inexact projection as approximately solving a best approximation problem for the gradient step until a certain stopping criterion holds. Finally, we show that there are available powerful algorithms, with linear convergence, for computing the inexact projection, such as Dykstra algorithm and alternating direction method of multipliers. Our algorithm is especially useful in embedded model predictive control on hardware with limited computational power, where tight bounds on the computational complexity of the numerical algorithm, used for solving the control problem, are required.

11:50-12:10 WeAT4.5

Design and Implementation of Extended Predictive Functional Control for Boiler-Turbine Unit of Power Plant, pp. 131-134

Amirabadi Farahani, Maryam — Science and Res. Branch, Islamic Azad Univ

Haeri, Mohammad — Sharif Univ. of Tech

In this paper, a new model predictive controller is introduced to control a power unit process with three inputs and three outputs. This method is proposed to reduce the complexity of the required computation. In fact, the presented controller ensures achieving an acceptable performance in the presence of noise and disturbances and reduces the volume of calculations to control a complex and nonlinear boiler-turbine process. The simulation results indicate that the implementation of the proposed controller requires less computing time while the performance degradation is not more than five percent.

12:10-12:30 WeAT4.6

Nonlinear Model Predictive Control Hardware Implementation with Custom-Precision Floating Point Operations, pp. 135-140

Hultmann Ayala, Helon Vicente — PUCPR

Sampaio, Renato — Univ. of Brasilia

Muñoz, Daniel — Univ. of Brasilia

Llanos, Carlos Humberto — Univ. of Brasilia

Coelho, Leandro Dos Santos — Pontifical Catholic Univ. of Parana

Jacobi, Ricardo Pezzuol — Univ. of Brasilia

Model predictive control (MPC) based techniques have found many applications both in academia and in industry. Its reach, however, may not be compared to classical control techniques due to e.g. the difficulty of solving an optimization problem at each sampling interval with real-time requirements. Most of the efforts to make the application of MPC viable address this problem with more efficient

solvers. This paper, in contrast, proposes a new approach for a real-time MPC solution by mapping an approximate off-line solution into an artificial neural network in a FPGA (Field Programmable Gate Array). We implemented a radial basis function artificial neural network on a low cost FPGA using custom precision floating point operations and tested the control on a single-link robotic manipulator. The amount of time used to calculate the control action at each time instant is in around one microsecond. The comparison between the offline and the approximate solution shows the soundness of the idea. We provide an analysis of hardware usage and execution time in order to achieve the best compromise considering the precision for a given application.

WeAT5 Mycenae

Linear Systems (Regular Session)

Chair: Hasan, Agus — Norwegian Univ. of Science and Tech

Co-Chair: Moysis, Lazaros — Aristotle Univ. of Thessaloniki

10:30-10:50 WeAT5.1

Full and Partial Input-Output Decoupling of Square and Overactuated Systems: A Transformation-Based Approach, pp. 141-147

Khodaverdian, Saman — Tech. Univ. Darmstadt

A transformation-based approach for the full and partial input-output decoupling of square and overactuated linear systems is presented. A certain transformation is introduced which highlights the coupling effects of the system. Based on the transformed system matrices, it can simply be seen how full and partial decoupling is derived. Additionally to the square case, an analysis for overactuated systems is given and it is highlighted how the degrees of freedom coming from overactuation can be used to manipulate the decoupling result. The contribution of the paper is to present an easy to handle decoupling technique which enables a simple access to input-output decoupling and visualizes all degrees of freedom.

10:50-11:10 WeAT5.2

Reduced Integer Order Inverse Controller Design for Single Fractional Order Pole Model, pp. 148-153

Yumuk, Erhan — Istanbul Tech. Univ

Müjde, Güzelkaya — Istanbul Tech. Univ

Eksin, İbrahim — Istanbul Tech. Univ

In this study, we propose a method to design a reduced integer order inverse controller for single fractional order pole model. In this methodology, the inverse of the integer high order approximation of the fractional order model is taken into consideration. In order to have a feasible and applicable controller structure, this high order controller is reduced in such way that dominant poles and zeros of the approximate integer order transfer function of the system should be active. The closeness of the poles and zeros to each other and their closeness to the origin are basic dominance criteria for the order reduction. Then, the parameters of the controller are obtained depending on the fractional system parameters. The proposed controller possesses only a single design parameter which is the controller gain. The results of simulation examples show that the proposed controller performs as good as fractional order PID and classical integer order PID controllers which have five and three design parameters, respectively.

11:10-11:30 WeAT5.3

Finite-Time State Estimation of Sampled Output Impulsive Dynamical Linear System, pp. 154-158

Qayyum, Atif — National Univ. of Science and Tech. Islamabad

De Tommasi, Gianmaria — Univ. Degl Studi Di Napoli

This paper considers the problem of observer design for the class of sampled output impulsive dynamical linear systems, which are a special class of hybrid systems whose state trajectory undergoes finite jumps, which are assumed to be time driven. The proposed observer is an impulsive and exploits the sampled nature of the plant to achieve zero estimation error in a predefined finite time. The effectiveness of the proposed approach is shown by means of an application to impulsive input observer and the ripple estimation.

11:30-11:50 WeAT5.4

A Minimum Variance Filter for Discrete Time Linear Systems with Parametric Uncertainty, pp. 159-163

Date, Paresh — Brunel Univ

Allahyani, Seham — Brunel Univ

A minimum variance filter for a class of discrete time systems with additive as well as multiplicative noise is investigated in this paper. We extend the results from recent work by Ponomareva and Date to account for multiplicative noise in the measurement equation. More importantly, we provide an interpretation of the multiplicative noise in both transition and measurement equations in terms of parameter perturbations in a linear additive model. The utility of the proposed filtering algorithm is demonstrated through two numerical simulation experiments using models from academic literature, where the parameters are estimated from real data.

11:50-12:10 WeAT5.5

Optimal Boundary Control of 2x2 Linear Hyperbolic PDEs, pp. 164-169

Hasan, Agus — Norwegian Univ. of Science and Tech

Imsland, Lars — Norwegian Univ. of Science and Tech

Ivanov, Ivan — Sofia Univ. "St.Kl.Ohridski"

Bogdanova, Boryana — Sofia Univ. "St. Kliment Ohridski"

Kostova, Snezhana — Inst. of System Engineering and Robotics, Bulgarian Acad

The present paper develops an optimal linear quadratic boundary controller for 2x2 linear hyperbolic partial differential equations (PDEs) with actuation on only one end of the domain. First-order necessary conditions for optimality is derived via weak variations and an optimal controller in state-feedback form is presented. The linear quadratic regulator (LQR) controller is calculated from differential algebraic Riccati equations. Numerical examples are performed to show the use of the proposed method.

12:10-12:30 WeAT5.6

Reachability of Discrete Time Causal ARMA Representations, pp. 170-175

Moysis, Lazaros — Aristotle Univ. of Thessaloniki

Karampetakis, Nikos — Aristotle Univ. of Thessaloniki

The reachability subspace of discrete time causal ARMA representations is examined. First, the conditions under which a system is causal are studied and a formula for the solution of a causal system is presented. Then, an important result regarding the set of admissible initial conditions is derived and the reachable subspace is provided.

WeBT1 Kozani

Fault Tolerant Control (Regular Session)

Chair: Kyriakopoulos, Kostas J. — National Tech. Univ. of Athens

Co-Chair: Ouladsine, Mustapha — Univ. D'aix Marseille III

14:30-14:50 WeBT1.1

Novel Stability Analysis of Direct MRAC with Redundant Inputs, pp. 176-181

Falconí, Guillermo P.	Tech. Univ. München
Heise, Christian David	Tech. Univ. München
Holzapfel, Florian	Tech. Univ. München

In this paper a novel stability proof for direct Model Reference Adaptive Control is presented. Especially the case of redundant inputs is taken into account in order to consider actuator failures and even change in the control direction. To this end, a weaker assumption than positive definiteness of the control effectiveness matrix is formulated. Furthermore, it is shown that with a special choice of parameter initial values, the parameter set can be reduced avoiding overparameterization. The control law is applied to a hexarotor example and simulation results show the performance.

14:50-15:10 WeBT1.2

Fault Tolerant Control of a Hexarotor Using a Command Governor Augmentation, pp. 182-187

Falconí, Guillermo P.	Tech. Univ. München
Schatz, Simon Philipp	Tech. Univ. München
Holzapfel, Florian	Tech. Univ. München

The application of Nonlinear Dynamic Inversion on agile multicopter systems is beneficial to cope with significant dynamical couplings of the axes. However, modeling errors impose drawbacks to the control concept as the inversion relies on an exact knowledge about the model for best performance. In order to improve the performance of the controller when subject to exogenous disturbances and modeling errors, a command governor augmentation is proposed in this paper. Basically, by utilizing an estimation of the time derivative of the control error, an additional command is applied to the reference model. The superior performance and robustness are demonstrated in flight experiments with a hexacopter, where controlled flight is accomplished even under severe actuator degradation.

15:10-15:30 WeBT1.3

Fault Tolerant Control of a Quadrotor Based on Parameter Estimation Techniques and Use of a Reconfigurable PID Controller, pp. 188-193

He, Xie	Isae - Disc
Chaudemar, Jean-Charles	Isae - Disc
Huang, Jun	Beihang Univ
Defay, François	ISAE-SUPAERO

This paper focuses on the fault tolerant control for a quadrotor. In this paper, both a complete dynamic model of quadrotor and a simple reconfigurable PID controller are presented. Besides, FDD and FTC techniques are developed using parameter estimation techniques. The proposed approach allows to detect and to diagnose faults in a rotor. The main contribution of this article relies on the detailed modelling of a quadrotor and a use of parameter estimation techniques including an expert method based on the knowledge of the system and a logical reasoning.

15:30-15:50 WeBT1.4

Fault Tolerant Constrained Control for Switching Discrete-Time Systems with Delays, pp. 194-200

Benzaouia, Abdellah	Faculty of Science Semlalia
Ouladsine, Mustapha	Univ. D'aix Marseille III
Ananou, Bouchra	Univ. Paul Cézanne
Naamane, Aziz	Univ. Aix-Marseille (U3)

In this paper, fault tolerant control (FTC) problem for discrete-time switching systems with delay and constrained input is studied. Sufficient conditions of building an observer are obtained by using common Lyapunov function. These conditions are worked out using cone complementarity technique. The obtained results are applied on a numerical example showing fault detection, localization of fault and reconfiguration of the control to maintain asymptotic stability even in presence of a permanent sensor fault and constraints on the control.

15:50-16:10 WeBT1.5

Design of Predictive Fault Tolerant Control by the Means of State Space Neural Networks, pp. 201-206

Czajkowski, Andrzej	Univ. of Zielona Góra
Patan, Krzysztof	Univ. of Zielona Gora

This paper deals with the design of Predictive Fault Tolerant Control (PFTC) system by the means of State Space Neural Networks. In this paper the PFTC idea is very simple. The aim is to link the predictive controller with robust fault detection and isolation algorithm to properly switch fault compensation. Also very important property is to achieve very efficient and no computationally burdening approach. Therefore, it was decided to apply an instantaneous linearisation of neural network model at each discreet time sample to use simple linear techniques. In this manner the linear model used in controller and fault compensation is not constant and changes together with operating conditions of the plant, which improves overall control quality.

16:10-16:30 WeBT1.6

Dynamically Efficient Kinematics for Hyper-Redundant Manipulators, pp. 207-213

Xanthidis, Marios	Univ. of South Carolina
Kyriakopoulos, Kostas J.	National Tech. Univ. of Athens
Rekleitis, Ioannis	Univ. of South Carolina

A hyper-redundant robotic arm is a manipulator with many degrees of freedom, capable of executing tasks in cluttered environments where robotic arms with fewer degrees of freedom are unable to operate. This paper introduces a new method for modeling those manipulators in a completely dynamic way. The proposed method enables online changes of the kinematic structure with the use of a special function; termed "meta-controlling function". This function can be used to develop policies to reduce drastically the computational cost for a single task, and to robustly control the robotic arm, even in the event of partial damage. The direct and inverse kinematics are solved for a generic three-dimensional articulated hyper-redundant arm, that can be used as a proof of concept for more specific structures. To demonstrate the robustness of our method, experimental simulation results, for a basic "meta-controlling" function, are presented.

WeBT2 Edessa

Unmanned Systems II (Regular Session)

Chair: Tzes, Anthony	Univ. of Patras
Co-Chair: Engelhardt, Thomas	RWTH Aachen Univ

14:30-14:50 WeBT2.1

Distributed Area Coverage Control with Imprecise Robot Localization, pp. 214-219

Papatheodorou, Sotiris	Univ. of Patras
Stergiopoulos, Yiannis	Univ. of Patras
Tzes, Anthony	Univ. of Patras

This article examines the problem of area coverage for a network of mobile robots with imprecise agents' localization. Each robot has uniform radial sensing ability, governed by first order kinodynamics. The convex-space is partitioned based on the Guaranteed Voronoi (GV) principle and each robot's area of responsibility corresponds to its GV-cell, bounded by hyperbolic arcs. The proposed control law is distributed, demands the positioning information about its GV-Delaunay neighbors and has

an inherent collision avoidance property.

14:50-15:10 WeBT2.2

A Survey on Pneumatic Wall-Climbing Robots for Inspection, pp. 220-225

Brusell, Angelica — Luleå Univ. of Tech
Andrikopoulos, George — Luleå Univ. of Tech
Nikolakopoulos, George — Luleå Univ. of Tech. Sweden

The aim of this article is to present a survey on inspection applications of Pneumatic Wall-Climbing Robots (PWCR). In general, a PWCR utilizes negative pressure as its adhesion method, through mainly suction cups or negative pressure thrust-based mechanisms. Their main advantage being their ability to climb non-ferromagnetic surfaces, such as glass and composite materials, in comparison with climbing robots based on magnetic adhesion methods. A growing application area is the utilization of PWCRs for inspection purposes for accelerating the otherwise time consuming procedures of manual inspection, while offering the important advantage of protecting human workers from hazardous and/or unreachable environments. This article will summarize the key enabling inspection applications of PWCRs in the following areas: a) Construction, b) Industrial Infrastructures, as well as c) Aircraft applications.

15:10-15:30 WeBT2.3

Particle Filter – Scan Matching Hybrid SLAM Employing Topological Information, pp. 226-231

Thallas, Aristeidis — Aristotle Univ. of Thessaloniki
Tsardoulias, Emmanouil — Aristotle Univ. of Thessaloniki
Petrou, Loukas — Faculty of Engineering

Two of the most predominant approaches regarding the SLAM problem are the Rao-Blackwellized particle filters and the Scan Matching algorithms, each approach presenting its own deficiencies. In particular, particle filters suffer from potential particle impoverishment, whereas lack of environmental features can cause scan matching methods to collapse. In the current paper techniques to combine Rao-Blackwellized particle filters with a scan matching algorithm (CRSM SLAM) aiming to overcome those defects, whilst exploiting each method's advantages are presented. CRSM is employed in feature-rich environments while concurrently reducing the particle filter dispersion, whilst the particle filter allows the maintenance of the correct hypothesis in environments with scarcity of information. Finally, a method to reduce the number of particle filter resamplings, employing topological information is proposed.

15:30-15:50 WeBT2.4

Particle Filter – Scan Matching SLAM Recovery under Kinematic Model Failures, pp. 232-237

Thallas, Aristeidis — Aristotle Univ. of Thessaloniki
Tsardoulias, Emmanouil — Aristotle Univ. of Thessaloniki
Petrou, Loukas — Faculty of Engineering

Simultaneous localization and mapping comprises two highly correlated procedures, which renders it a greatly difficult problem. Its difficulty is further increased due to the high levels of uncertainty introduced by both the environment and the robot's sensors and actuators. In the current paper we present methods to recover from extreme situations where kinematic model failures are observed – robot slipping an movement obstruction – that result in erroneous localizations, leading to complete SLAM method failures.

15:50-16:10 WeBT2.5

Biased Proportional Navigation with Exponentially Decaying Error for Impact Angle Control and Path Following, pp. 238-243

Erer, Koray — Roketsan Missiles Inc
Tekin, Raziye — Dlr Rm-Sr
Ozgoren, M Kemal — Middle East Tech. Univ

In this paper, a bias term to enhance proportional navigation is designed through an error signal that is a function of pursuit angles with the objective of accommodating both the problem of impact angle control against a stationary target and the problem of path following using the virtual target concept. The design leads to a second order transfer function describing the linear error dynamics contained within the nonlinear environment. The performance of the proposed guidance law is demonstrated in a comparative simulation study that also involves a well-known trajectory shaping guidance law. Straightforward to implement with no need for time to go, the technique may be utilized in various planar scenarios involving missiles or unmanned aerial vehicles.

16:10-16:30 WeBT2.6

Multicopter Unmanned Aerial Vehicle for Automated Inspection of Wind Turbines, pp. 244-249

Schäfer, Björn Erwin — RWTH Aachen Univ
Picchi, Davide — Height Tech. GmbH
Engelhardt, Thomas — RWTH Aachen Univ
Abel, Dirk — RWTH Aachen Univ

A concept for a multicopter unmanned aerial vehicle (UAV) automatically performing inspection flights at a wind turbine is proposed. Key aspects of the concept are (1) a priori 3D mapping of the plant and (2) spline-based flight path planning as well as (3) a collision avoidance and distance control system. A quadrotor UAV prototype and its dynamical model are presented. Validation of the different aspects is carried out in simulation and partially in indoor tests using Robot Operating System (ROS). Existence of a 3D map is an essential precondition for path planning and collision-free flight. A brief initial flight preceding the actual inspection with a 2D LiDAR sensor yields a point cloud of the plant which is used for 3D mapping. This map is efficiently generated and represented using octrees, a hierarchical data structure that can be used for 3D maps. Subsequently a smooth and collision-free flight path is generated using splines. For redundancy's sake navigation tasks not only rely on GPS but also on the LiDAR sensor mentioned before. The sensor allows for continuous estimation of the distance between multicopter and wind turbine. A distance control algorithm guarantees collision-free flight.

WeBT3 — Naoussa

Robust Control II (Regular Session)

Chair: Ignaciuk, Przemyslaw — Lodz Univ. of Tech
Co-Chair: Fekih, Afef — Univ. of Louisiana at Lafayette

14:30-14:50 WeBT3.1

DSM Relay Control of Logistic Networks under Delayed Replenishments and Uncertain Demand, pp. 250-255

Ignaciuk, Przemyslaw — Lodz Univ. of Tech

The paper investigates relay-type control of goods distribution systems organized in a networked structure. Unlike the majority of earlier approaches, mesh network configuration is permitted and goods trans-shipments are realized with non-negligible time delay. Each node is subjected to external, a priori unknown demand treated as a disturbance from the control system perspective. In order to provide stable and robust system performance, discrete-time sliding-mode (DSM) control is considered. A new, networked, relay-type strategy is formulated and compared with the classical (r, Q) inventory policy. The control system properties are formally proved and illustrated in numerical tests.

14:50-15:10 WeBT3.2

Fuzzy Sliding Control with Non-Linear Observer for Magnetic Levitation Systems, pp. 256-261

Benomair, Abdollha — The Univ. of Sheffield
Firdaus, Ahmad Riyad — The Univ. of Sheffield
Tokhi, M.O. — Univ. of Sheffield

Magnetic levitation (Maglev) systems make significant contribution to industrial applications due their reduced power consumption, increased power efficiency and reduced cost of maintenance. Common applications include Maglev power generation (e.g. wind turbine), Maglev trains and medical devices (e.g. magnetically suspended artificial heart pump). This paper proposes fuzzy sliding-mode controller, FSMC, with a nonlinear observer been used to estimate the unmeasured states. Simulations are performed with nonlinear mathematical model of the Maglev system, and the results show that the proposed observer and control strategy perform well.

15:10-15:30 WeBT3.3

Matlab Toolbox for Systems with Time Delay and General Parametric Uncertainties with Periodic Perturbations, pp. 262-267

Dlapa, Marek — Tomas Bata Univ. in Zlin

The paper presents the Robust Control Toolbox for Time Delay Systems with Parametric and Periodic Uncertainties for the Matlab system. The toolbox comprises the D-K iteration and the algebraic approach implemented for general 3rd order system with parametric and periodic uncertainties in numerator and denominator of plant transfer function and uncertain time delay. The uncertain time delay is treated using multiplicative uncertainty, the parametric uncertainty is modelled using general interconnection for the systems with parametric uncertainty in numerator and denominator. The toolbox has user-friendly graphical interface empowering intuitive control.

15:30-15:50 WeBT3.4

Tight Formation Flight Control Based on H-Infinity Approach, pp. 268-274

Renan, Pereira, Renan Lima Pereira — ITA
Kienitz, Karl Heinz — Inst. Tecnologico De Aeronautica

An H-infinity loop shaping control design is proposed to reduce the adverse vortex effects during fuel saving formation flight. The application scenario considers two commercial aircraft in cruise flight in which the wingman aircraft is flying in tight formation with a leader aircraft. The design problem consists in describing the wake vortex influence on the wingman as norm-bounded parametric uncertainties that will be incorporated as perturbations to normalized coprime factors of the shaped plant. As a consequence, a novel robust control method for the fuel saving formation flight problem is presented. A set of sufficient conditions for the existence of such controller is given in an LMI framework. Finally, the effectiveness of the method is illustrated considering an example with three phases of formation flight: forming up, maintaining formation and leaving formation.

15:50-16:10 WeBT3.5

A Feedback Linearization Control Scheme for Maximum Power Generation in Wind Energy Systems, pp. 275-279

Fekih, Afef — Univ. of Louisiana at Lafayette
Ben Hmida, Jalel — Univ. of Louisiana at Lafayette
Morshed, Mohamed Javed — Univ. of Louisiana at Lafayette

As the penetration of wind turbines into the power grid increases, greater emphasis is placed on designing advanced control approaches for optimum power generation. This paper proposes a novel control scheme for a DFIG-driven variable speed wind energy system. The approach aims at reaching optimum performance in terms of power generation at the point of common coupling. The control scheme is derived based on the feedback linearization technique, allowing both decoupling and linearization of the nonlinear multivariable system. The proposed approach is based on the theory of feedback linearization and is aimed at achieving optimum power generation at any wind speed within the operating range. Application of the proposed approach to a DFIG-based variable speed wind turbine has led to optimum operations at various speed ranges. Simplicity and ease of implementation of the overall scheme along with its fast dynamic response in addition to the optimum power production are the main positive features of the proposed approach.

16:10-16:30 WeBT3.6

Modeling and Dual Loop Sliding Mode Control of a Two Flexible-Link Robot to Reduce the Transient Response, pp. 280-285

Duarte, Franklyn — Clausthal Univ. of Tech
Ullah, Farooq — Inst. of Electrical Information Tech. Clausthal Univ
Bohn, Christian — Clausthal Univ. of Tech

In many applications, the use of slender and light flexible structures has increased due to the requirement of more efficient structures. One objective of this work is to generate a model of a two-flexible-link robot for control purposes, which includes rotational actuator, piezoelectric actuators, different kind of sensors (acceleration and deformation). The model is obtained under a classical mechanics approach: Lagrange Euler energy balance. The model of the actuators is also included. Some parts of the resulting model are calculated using symbolic programming software, where as other are implemented and calculated dynamically during simulation. The resulting model is simulated in Matlab Simulink. The second objective is to develop active vibration sliding mode controllers (AVSMC) which include observers to get an estimation of the rate of change flexible variable. The boundary values required for the implementation of the AVSMC's are obtained from the formulated model. Experimental results show the effectiveness of the proposed controller.

WeBT4 — Pella

Predictive Control II (Regular Session)

Chair: Stamatescu, Grigore — Univ
Co-Chair: Dentler, Jan — Univ. of Luxembourg

14:30-14:50 WeBT4.1

Primal and Dual Decomposition for Distributed MPC - Theory, Implementation, and Comparison in a SoS Simulation Framework, pp. 286-291

Paulen, Radoslav — Tech. Univ. Dortmund
Nazari, Shaghayegh — TU Dortmund
Shahidi, S. Amirreza — TU Dortmund
Sonntag, Christian — Univ. Dortmund
Engell, Sebastian — TU Dortmund

This paper presents two hierarchical techniques for the coordination of distributed model predictive controllers and discusses and compares their robustness to the presence of local constraints and their speed of convergence. These techniques follow feasible- and infeasible-path coordination approaches. The controlled system is assumed to consist of subsystems which are only connected by the use of shared resources. The goal is to achieve an optimal distribution of these resources so that an optimal operation of the overall system is achieved. The algorithms are applied to a benchmark problem of distributed model predictive control and the two coordination approaches are compared. The controllers and the model of the benchmark are implemented in a novel Modelica-based software framework for simulation-based validation of systems of systems that aims at reducing the engineering effort while facilitating model re-usability and the deployment of

distributed controllers in real-world industrial systems.

14:50-15:10 WeBT4.2

A Modularization Approach for Nonlinear Model Predictive Control of Distributed Fast Systems, pp. 292-297

Dentler, Jan — Univ. of Luxembourg
Kannan, Somasundar — Univ. of Luxembourg
Olivares-Mendez, Miguel A. — SnT - Univ. of Luxembourg
Voos, Holger — Univ. of Luxembourg

Distributed interconnected systems are omnipresent today. The development of advanced control methods for such systems are still challenging. Herein, the real-time applicability, flexibility, portability and ease of implementation are issues of the existing control solutions, especially for more advanced methods such as model predictive control. This paper is addressing these issues by presenting an efficient modular composition scheme for distributed fast nonlinear systems. The advantage of this modularization approach is the capability of changing control objectives, constraints, dynamics and system topology online while maintaining fast computation. This work analyzes the functions that have to be provided for a continuation generalized minimal residual method (CGMRES) model predictive controller based on the underlying control problem. The specific structure of these functions allows their decomposition into suitable fast modules. These modules are then used to recompose the functions which are required for the control of distributed systems in a computational efficient way, while maintaining the flexibility to dynamically exchange system parts. To validate this computational efficiency, the computation time of the proposed modular control approach is compared with a standard nonmodular implementation in a pursuit scenario of quadrotor unmanned aerial vehicles (UAV). Furthermore the real-time applicability is discussed for the given scenario.

15:10-15:30 WeBT4.3

Model Predictive Control for Energy-Saving and Comfortable Temperature Control in Buildings, pp. 298-303

Martincevic, Anita — Univ. of Zagreb, Faculty of Electrical Engineering and Comp
Vašak, Mario — Univ. of Zagreb
Lesic, Vinko — Univ. of Zagreb

Model predictive control has been recognized as one of the essential solutions to achieve considerable energy savings in buildings. However, its performance on a building zone level can be inferior to a well-tuned conventional controller, especially in situations with constant energy prices and conservative comfort constraints. Optimization problem in the background has to be chosen to guarantee recursive feasibility and considerable energy savings without compromising the users comfort at the same time. This paper gives a novel formulation of the model predictive temperature control problem in buildings and its fair comparison with conventional controllers with the same level of flexibility allowed in zone temperature control. All controllers are tested for a system with seasonal heating and cooling, which is the most common case in real applications. It is shown that the introduced formulation leads to the model predictive controller that significantly outperforms conventional controllers both in energy consumption and users comfort.

15:30-15:50 WeBT4.4

Open and Closed Loop Simulation for Predictive Control of Buildings, pp. 304-309

Stamatescu, Grigore — Univ. "Pol. of Bucharest
Stamatescu, Iulia — Pol. Univ. of Bucharest

The paper presents the system modeling, con- troller design and numerical simulation results for thermal energy management of a real office building. Focus is set on an efficient and unitary approach which leads from detailed civil engineering specifications of the building elements to compact and effective models which are suitable for control. A modular semi-automated approach in used in order to derive the discrete state-space representation of the system model. This combines the key thermal dynamics of the constructions with a modular list of thermal loads and losses, defined as external heat fluxes. A balanced trade-off is thus achieved between model accuracy and complexity through a compact and effective representation of the plant dynamics. The control strategy is based on a predictive controller which evolves an optimized system input vector, in a closed loop. Paths for occupant feedback integration into a single framework, by using human-in-the-loop models via disturbance channels are also discussed.

15:50-16:10 WeBT4.5

Direct Control of a Large Population of Electrical Space Heaters Based on Bin State Transition Model, pp. 310-315

Zemtsov, Nikita — Tech. Univ. of Liberec
Hlava, Jaroslav — Tech. Univ. in Liberec

Thermostatically controlled loads have great potential for being used as a demand side resource for ancillary service provision. Developing smart communication and metering infrastructure provides possibility to embed advanced control strategies, such as model predictive control, into electrical energy production and distribution processes using concepts of smart grid and virtual power plant. This paper deals with aggregated modelling of a large group of electrical space heaters and model-based control system design using this model. Aggregated model is designed using bin state transition model principle. The obtained results show that the model predictive controller based on this model is able to control large groups of thermostatically controlled loads in a way that meets the requirements on the secondary control. This holds even if significant difference between model (assuming homogeneous population) and reality (heterogeneous population) exists.

16:10-16:30 WeBT4.6

Model Predictive Control Based Torque Vectoring Algorithm for Electric Car with Independent Drives, pp. 316-321

Bogdan, Stjepan — Univ. of Zagreb
Vasiljevic, Goran — Univ. of Zagreb

We present torque vectoring algorithm for the electric car with four independent drives using the model predictive control (MPC). The presented method uses the linearized model of the car in every step of the simulation to create the quadratic problem with criteria selected in such a way that distribution of torques to each wheel causes the best achievable behavior of the car. The presented algorithm is tested in the simulation environment and compared with the results obtained by distributing torques symmetrically to each wheel.

WeBT5 Mycenae

Modeling and Control (Regular Session)

Chair: Zivanovic, Rastko — The Univ. of Adelaide
Co-Chair: Groumpos, Peter — Univ. of Patras

14:30-14:50 WeBT5.1

Improvement of Energy Consumption for a Lower Limb Exoskeleton through Verticalization Time Optimization, pp. 322-326

Savin, Sergei — Southwest State Univ
Jatsun, Sergey — Southwest State Univ
Yatsun, Andrey — Southwest State Univ

This paper focuses on a lower limb exoskeleton. The problem of improvement of energy efficiency of the exoskeleton during sit-to-stand motion (verticalization) is considered. Optimization of the time allocated for the verticalization motion is proposed as a way to

improve energy efficiency. It is shown that optimal time of verticalization depends on the initial position of the exoskeleton and the relation between the two can be approximated by a polynomial function. An analysis and suggestions for practical applications of the obtained results are presented.

14:50-15:10 WeBT5.2

Towards a Fully Automated Tool for Annotation of Phasic Electromyographic Activity, pp. 327-331

Karvelis, Petros — Univ. of Nebraska Medical Center
Georgoulas, George — Luleå Univ. of Tech
Fairley, Jacqueline — Emory Univ
Stylios, Chrysostomos — TEI of Epirus
Rye, David — Emory Univ
Bliwise, Donald — Emory Univ

Salient muscle activity identification via the phasic electromyographic metric (PEM) in human polysomnograms/sleep studies (PSGs) represent a potential quantitative metric to aid in differentiation between neurodegenerative disorder populations and age-matched controls. A major impairment to the implementation of PEM analysis for clinical assessment of neurodegenerative disorders includes the time consuming aspects for both visual and automated supervised methods, which require exhaustive expert scoring of PEM and non-PEM events. In order to surmount the aforementioned concerns, we propose a semi-supervised classification methodology encased within an easy-to-use graphical user interface (GUI) utilizing an embedded Minimum Description Length (MDL) criterion to automatically classify PEM and non-PEM events based on expert labeling of a single PEM instance. Results indicate that the application of a semi-supervised approach for PEM identification provides an excellent option to reduce the labeling burden within current human PSG muscle activity identification schemes.

15:10-15:30 WeBT5.3

Online Learning and Reachability Analysis for Stochastic Hybrid Systems Using Mixtures of Gaussian Processes, pp. 332-337

Abdel-Aziz, Hamzah — Vanderbilt Univ
Koutsoukos, Xenofon — Vanderbilt Univ

Robust and efficient modeling and reachability analysis of stochastic hybrid systems for control and decision is very demanding and challenging task. In this paper, we develop a novel methodology which provides a model of stochastic hybrid systems based on Gaussian Processes. This model uses observed data to update the model in an online fashion. In addition, we provide an efficient reachability analysis methodology that utilizes mixtures of Gaussian Processes to predict the reachable states for a finite horizon. We demonstrate the efficiency of the proposed approach using a multi-room heating system. Despite dynamic changes in the system parameters, the results show that the model can adapt and efficiently predict the reachable states

15:30-15:50 WeBT5.4

The Weak Maximum Principle for Hybrid Systems, pp. 338-343

Suski, Damian — Warsaw Univ. of Tech
Pytlak, Radoslaw — Military Univ. of Tech

The aim of this paper is to formulate the weak maximum principle for hybrid optimal control problems. We give definitions of a hybrid system and a hybrid state trajectory. These definitions are kept at an equation-based level, to make the analysis helpful while constructing an appropriate numerical procedure. We then define an optimal control problem for a hybrid system. Next, we analyze the perturbations of a hybrid state trajectory in response to variations of a control function. We build first order approximations to the trajectory perturbations and utilize them to approximate the variations of cost and constraint functionals in the optimal control problem. Finally, we introduce the adjoint variables, which enables to formulate the weak maximum principle in an elegant way. We also give some remarks concerning a construction of a numerical procedure for hybrid optimal control problems.

15:50-16:10 WeBT5.5

Rational Approximation of Frequency Responses Via Singular Value Decomposition, pp. 344-349

Zivanovic, Rastko — The Univ. of Adelaide

This paper describes a non-iterative method for rational approximation of frequency-domain responses based on application of the Singular Value Decomposition algorithm. Using causality, a system response measured for positive frequencies is extended to negative frequency range. Impulse response is directly available through known inverse Fourier transform of a rational approximation in the partial fraction expansion form. The method is demonstrated using an example with known Fourier transform pair, as well as a practical example, where measured frequency response of a power transformer has been used.

16:10-16:30 WeBT5.6

A Revised Approach in Modelling Fuzzy Cognitive Maps, pp. 350-354

Groumpos, Peter — Univ. of Patras
Mpelogianni, Vassiliki — Univ. of Patras

Fuzzy Cognitive Maps (FCMs) are a very simple, useful and powerful tool for modeling and analyzing dynamic complex systems. FCMs can structure virtual worlds that dynamically change with time. Mathematical models of FCMs are reviewed and a number of problems which emerged with them are briefly analyzed. In order to address some of these drawbacks a revised approach is proposed. This approach is being used to analyze the behavior and control the basic automation of a building. Simulation results of the new method are presented and discussed.

WeCT1 Kozani

Fault Detection, Fault Diagnosis and Fault Tolerant Control in Real-World Electromechanical Applications (Invited Session)

Chair: Nikolakopoulos, George — Luleå Univ. of Tech. Sweden
Co-Chair: Georgoulas, George — Luleå Univ. of Tech
Organizer: Nikolakopoulos, George — Luleå Univ. of Tech. Sweden
Organizer: Benbouzid, Mohamed — Univ. of Brest
Organizer: Georgoulas, George — Luleå Univ. of Tech

17:00-17:20 WeCT1.1

Local Damage Detection Methods Based on the Stochastic Modelling Techniques (I), pp. 355-360

Zak, Grzegorz — Wroclaw Univ. of Tech
Wyłomańska, Agnieszka — Wroclaw Univ. of Tech
Zimroz, Radoslaw — Wroclaw Univ. of Tech

Problem of selection of informative frequency band (IFB) for local damage detection using vibration signal is often discussed in the literature. One of the approaches used in this context is based on the analysis of sub-signals obtained in time-frequency representation of the vibration signal. Mentioned sub-signals are analyzed using appropriate statistics (called selectors). Till now, the most popular statistic was kurtosis, one of the measures that can point out these frequency bins on time-frequency map that reveal

the most impulsive nature. However, for many real signals the spectral kurtosis does not give expected results because it can be sensitive for impulses not related to damage (i.e. artifacts). In this paper we extend the idea of spectral kurtosis. We propose a novel method combining time-frequency representation, namely spectrogram, dependency measure suitable for heavy-tailed distributions, statistical features for novel time-frequency representation and statistical modeling of such features. The new time-frequency representation is based on the measure of dependence appropriate for more general class of distribution, namely heavy tailed. This measure, called autocovariation, is an extension of the classical measures of dependences, namely autocovariance or autocorrelation. The new time-frequency representation was developed in order to enhance informative parts of the signal while reducing inadvisable parts of the signal like artifact or high-energy deterministic parts. Next, the Kuiper statistic is applied to novel time-frequency representation for IFB detection and we design the filter characteristic. Moreover, we propose also the automatic procedure of filter characteristic thresholding based on the α-stable distribution approach.

17:20-17:40 WeCT1.2

Cyclic Modulation Spectrum - an Online Algorithm (I), pp. 361-365

Kruczek, Piotr — KGHM CUPRUM Ltd
Obuchowski, Jakub — Kghm Cuprum R&d

Many profitable methods of damage detection in rotating machines involve cyclostationarity. This approach exploits the fact that vibrations of a damaged machinery possess a periodic envelope. The frequency related to this periodic behavior is strictly related to one of the characteristic frequencies associated with design and specific operation of the considered machine. Nowadays, such methods are rarely implemented in industrial condition monitoring systems for several reasons. One of the main reasons is related to computational complexity. Algorithms that calculate cyclostationary features are said to be computationally expensive, thus their involvement in monitoring systems is limited. This drawback becomes critical in online systems in which the monitored features are updated just after arrival of the next measurement. Because of complexity of cyclostationary approach other tools are preferred instead, especially those which do not require intensive computations. In this paper we discuss algorithms for calculation of a basic cyclostationary tool, namely cyclic modulation spectrum (CMS). In this paper we provide several novel algorithms that update CMS when new measurements arrive.

17:40-18:00 WeCT1.3

Fault Diagnosis, Failure Prognosis and Fault Tolerant Control of Aerospace/Unmanned Aerial Systems (I), pp. 366-371

Vachtsevanos, George — Georgia Inst. of Tech
Georgoulas, George — Luleå Univ. of Tech
Nikolakopoulos, George — Luleå Univ. of Tech. Sweden

Fault-tolerant control and operation of complex unmanned and aircraft systems is an emerging technology intended to provide the designer and operator with flexibility, interoperability, sustainment and reliability under changing operational requirements or mission profiles. Moreover, it is intended to reconfigure online hardware and software to maintain the operational integrity of the system in the event of contingencies (fault/failure modes). This paper presents an hierarchical architecture that uses available sensor information, fault isolation, failure prognosis, system restructuring and controller reconfiguration. The fault tolerant control framework relies on prognostic information to reconfigure system components and preserve the operational integrity of the aircraft. The hierarchical structure starts at the lowest component level and migrates to the middle system/subsystem level ending with the final mission level. We illustrate the methodology with several case studies from the unmanned and aircraft system domains.

18:00-18:20 WeCT1.4

Start-Up Analysis Methods for the Diagnosis of Rotor Asymmetries Induction Motors Seeing Is Believing (I), pp. 372-377

Georgoulas, George — Luleå Univ. of Tech
Climente-Alarcon, Vicente — Department of Electrical Engineering and Automation, Aalto Univ
Dritsas, Leonidas — ASPETE
Antonino, Jose Alfonso — Univ. Plotécnica De Valencia
Nikolakopoulos, George — Luleå Univ. of Tech. Sweden

This article presents a qualitative analysis of different methods proposed for the diagnosis of broken rotor bars using the stator current during start-up operation. The slip dependent components, caused by the asymmetry, which is created by the breakage of rotor bar(s) and especially the left sideband harmonic (LSH) component, can create a distinctive pattern in a time- frequency plane. Short Time Fourier Transform, Wavelet analysis, and Winger-Ville Distribution are evaluated by using signals coming from motors operating in real industrial settings. The corresponding analysis presents the pros and the cons of these approaches for their potential application under realistic industrial conditions using the larger number of real life cases encountered in the literature.

18:20-18:40 WeCT1.5

New Prognostic Framework for Degradation Assessment and Remaining Useful Life Estimation of Photovoltaic Module, pp. 378-383

Laayouj, Nabil — National School of Applied Sciences Industrial Department, Ibn Z
Jamouli, Hicham — Ibn Zohr Univ
El Hail, M.Amine — Univ. Ibn Zohr, ENSA

All industrial systems or machines are subjected to degradation processes which can be related to the operating conditions. This degradation can cause unwanted stops at any time and major maintenance work sometimes. The prediction of an accurate Remaining useful life (RUL) of machines or industrial systems is an important challenge in condition based maintenance. Prognostic activity allows to estimate the RUL before a failure occurs and triggers actions to mitigate faults at the right time when needed. In this paper, we have developed a new smart prognostic method for photovoltaic module health degradation, which is based on two approaches; the on-line diagnosis and data-driven prognosis to achieve more accurate predictions. This framework of forecasting integrates the strengths of real time monitoring in the first approach and Relevant Vector Machine in the second. The results show that the proposed method is plausible due to the good prediction of RUL, and can be effectively applied to many systems for monitoring and prognostics.

18:40-19:00 WeCT1.6

Practical Fault Management Using Real-Time Decision Tree Analysis, pp. 384-389

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

Risk evaluation and management are important stages in the design and maintenance of all industrial plants, especially in the oil and gas, power or nuclear fields. As current methods only address the design phase, the maintenance or the need of an emergency shutdown, our method provides a solution for a practical implementation of a fault management strategy that is able to detect abnormal process behavior, identify erroneous variables and react for the minimization of possible unwanted consequences.

WeCT2 Edessa

Unmanned Systems III (Regular Session)

Chair: Kyriakopoulos, Kostas J. — National Tech. Univ. of Athens

Co-Chair: Grzejszczak, Tomasz — Silesian Univ. of Tech

17:00-17:20 WeCT2.1

Attitude Tracking of Quadrotor UAV Via Mixed H2/H∞ Controller: An LMI Based Approach, pp. 390-395

Emam, Seyedmasoud — Qazvin Islamic Azad Univ

Fakharian, Ahmad — Islamic Azad Univ. Branch

in this paper, a robust mixed H2/H∞ static state feedback tracking controller with measurement noise and external disturbance robustness is presented for attitude tracking of a Quadrotor Unmanned Aerial Vehicle. Also, time response of the mixed H2/H∞ controller is improved by adding regional pole-placement constraints. Since presented control design problem is a multi-objective convex optimization problem, so this problem is solved by Linear Matrix Inequalities (LMI). To ensure the presented robust controller performance, this controller and nonlinear model of quadrotor (with real parameters) are simulated in hard situation such as measurement noise and external disturbance and robust performance of the presented controller is proofed. Another contribution of this paper is, avoiding non-applicable simulation results that usually are happened in numerous articles. To reach this purpose, a saturation algorithm is developed which prevents the creation of non-applicable control signal values.

17:20-17:40 WeCT2.2

On the Selection of Calculable Residual Generators for UAV Fault Diagnosis, pp. 396-401

Zogopoulos Papaliakos, Georgios — National Tech. Univ. of Athens

Kyriakopoulos, Kostas J. — National Tech. Univ. of Athens

Structural Analysis is an established method for Fault Detection and Identification (FDI) in large-scale systems, enabling the discovery of Analytical Redundancy Relations (ARRs) which serve as residual generators. However, most techniques used to enumerate ARRs do not specify the matching used to calculate each of those ARRs. This can result in non-implementable or unusable residual generators, in the presence of non-invertibilities in the equations involved or in lack of computational tools. In this paper, we propose a methodology which combines a priori and a posteriori information in order to reduce the time required to find implementable, usable residual generators of minimum cost. The method is applied to a fixed-wing Unmanned Aerial Vehicle (UAV) model.

17:40-18:00 WeCT2.3

Set-Based Line-Of-Sight (LOS) Path Following with Collision Avoidance for Underactuated Unmanned Surface Vessel, pp. 402-409

Moe, Signe — PhD Candidate

Pettersen, Kristin Y. — Norwegian Univ. of Science and Tech

A cornerstone ability of an autonomous unmanned surface vessel (USV) is to avoid collisions with stationary obstacles and other moving vehicles while following a predefined path. USVs are typically underactuated, and this paper extends recent results in set-based guidance theory to an underactuated surface vessel, resulting in a switched guidance system with a path following mode and a collision avoidance mode. This system can be used with any combination of path following and collision avoidance guidance laws. Furthermore, a specific guidance law for collision avoidance is suggested that ensures tracking of a safe radius about a moving obstacle. The guidance law is specifically designed to assure collision avoidance while abiding by the International Regulations for Preventing Collisions at Sea (COLREGs). It is proven that the USV successfully circumvents the obstacles in a COLREGs compliant manner and that path following is achieved in path following mode. Simulations results confirm the effectiveness of the proposed approach.

18:00-18:20 WeCT2.4

Design of Obstacle Detection and Avoidance System for Guanay Ii Auv, pp. 410-414

Galarza Bogota, Cesar Mauricio — Univ. Pol. De Cataluña

Masmitja Rusiñol, Ivan — Univ. Pol. De Catalunya

Prat Tasias, Jordi — Univ. Pol. De Cataluña

Gomáriz Castro, Spartacus — Univ. Pol. De Cataluña

This paper presents the design of an obstacle avoidance algorithm for Guanay II AUV. The obstacle detection system disposes a SONAR and its use guarantees the safety in navigation of AUV. The strategy obstacle avoidance is performed based on a fuzzy reactive architecture for different forward speeds of the vehicle. The simulation results obtained through the implementation of the algorithms designed in Matlab validate the designs.

18:20-18:40 WeCT2.5

Approximation of Thrust Generated by Rotor in Quadrotor Unit with Use of Generalized Polynomial, pp. 415-419

Janusz, Wojciech — Silesian Univ. of Tech

Grzejszczak, Tomasz — Silesian Univ. of Tech

Niezabitowski, Michał — Silesian Univ. of Tech

Binias, Bartosz — Silesian Univ. of Tech

This paper presents the way of modeling thrust generated by a quadrotor flying unit. The highly non-linear equations describing rotor thrust are derived with use of momentum theory and approximated with use of generalized polynomial. The article includes the model formulation and the example of approximation. The polynomial approximation ensures the simplicity in solving during simulation with sufficient accuracy.

18:40-19:00 WeCT2.6

Self Feeding Aerial Robots, Methods for Detection and Localization of AC Wall Outlets, pp. 420-425

Morton, Scott — Cse, Umn

Bosch, Benjamin — Cse, Umn

Papanikolopoulos, Nikos — Univ. of Minnesota

This work describes computer vision methods developed for autonomous recharging of a quadrotor from a NEMA-15 standard wall outlet. Specifically, this work encompasses two algorithms for detecting and tracking an outlet in a video stream acquired by an ARdrone 2.0. Two different algorithms were developed for assumptions and requirements associated with different distances between the quadrotor and an outlet. The close-range algorithm achieves higher frequency and accuracy, however is effective within a limited range. The long-range detection algorithm requires greater processing time, but imposes fewer assumptions and can detect outlets at greater distances (lower resolution). The algorithms overlap in their effective ranges and therefore allow the system to continuously track from over 6 feet to within several inches of an outlet. The close-range algorithm has been implemented in OpenCV with a processing frequency greater than 15 Hz and has been used to successfully plug into a wall outlet. The long-range detector has been implemented in MATLAB and produces scale invariant hole detection with automatic scale selection.

WeCT3 Naoussa

Adaptive Control (Regular Session)

Chair: Landau, Ioan Dore — CNRS
Co-Chair: Vilanova, Ramon — Univ. Autonoma De Barcelona

17:00-17:20 WeCT3.1

Stabilization of Linear Plants with Unknown Delay and Sinusoidal Disturbance Compensation, pp. 426-430

Borisov, Oleg — ITMO Univ
Gromov, Vladislav — ITMO Univ
Pyrkin, Anton — ITMO Univ
Bobtsov, Alexey — ITMO Univ

A stabilization problem for linear plants under conditions of the unavailable state vector, external sinusoidal disturbance and unknown constant delay is addressed in this paper. Plant parameters, lower bound on the disturbance frequency, upper bound on the delay are assumed to be known, while all parameters of the sinusoidal disturbance (a bias, amplitude, frequency and phase) are unknown. The task is carried out in several steps. First, a delay-free disturbance observer based on the frequency estimation scheme is constructed. Second, a delay identifier based on the gradient approach and regression model is designed and used to estimate the exact value. Third, stabilization of the plant state to zero is conducted using a predictor-based feedback with the estimated time delay. An example confirming the relevance of the proposed approach is presented.

17:20-17:40 WeCT3.2

Robust Voltage Regulation in Islanded Microgrids: A LMI Based Mixed H2/H∞ Control Approach, pp. 431-436

Sedghi, Leila — Qazvin Islamic of Azad Univ
Fakharian, Ahmad — Islamic Azad Univ. Branch

In this paper, islanded operation of a microgrid system under load uncertainties is considered using a robust control strategy. This system includes two Distributed Generation (DG) units that are connected to the local load using inverter and LC filters. The main objective is regulating the load voltage in the presence of large perturbations in the local load. To achieve the objective, a LMI-based mixed H2/H∞ state-feedback control technique with regional pole placement is utilized for each DG. Fast tracking, zero steady-state error, and robust performance in presence of uncertainties are some of the achievements of the proposed technique. The effectiveness of the proposed method is illustrated in different operating conditions using MATLAB/SimPower System. A PWM inverter block from SimPower System toolbox is used in all simulations to implement a realistic nonlinear model of each DG.

17:40-18:00 WeCT3.3

State Monitoring of Systems Augmented by Model Reference Adaptive Control Using Analytic Time-Series Forecasting, pp. 437-442

Mühlegg, Maximilian — Tech. Univ. Munchen
Chowdhary, Girish — Massachusetts Inst. of Tech
Holzapfel, Florian — Tech. Univ. München

Certification of adaptive control algorithms for use on aerospace applications has not yet been accomplished in the aerospace industry. According to an emerging consensus between various authors, online monitoring and health assessment will play an integral role in closing this gap. In this paper we propose a monitoring system for Model Reference Adaptive Controllers, which enables online detection of future state requirement violations. We achieve this by employing Gaussian Process regression, which leads to a belief on the uncertainty in the system dynamics. Using analytic Bayesian time-series forecasting, the system dynamics can be projected into the future, thus allowing for a statistical assertion whether a state requirement will be violated during the prediction horizon. We show the concept in numerical simulation.

18:00-18:20 WeCT3.4

Interlaced Direct Adaptive Regulation Scheme Applied to a Benchmark Problem, pp. 443-448

Landau, Ioan Dore — CNRS
Castellanos Silva, Abraham — GIPSA-LAB
Dugard, Luc — CNRS-INPG
Chen, Xu — Univ. of Connecticut

Direct adaptive regulation schemes using Internal Model Principle and FIR Youla-Kucera controller parametrization have been extensively used for attenuation of multiple unknown and time varying narrow band disturbances. This approach provides very good results but requires a very careful design of the central controller in order to keep the water bed effect on the output sensitivity function at a an acceptable level. To simplify the design of the central controller, an adaptive regulation scheme is proposed in this paper which will incorporate a particular adaptive IIR Youla-Kucera Filter, called r-notch structure (the denominator is a projection inside the unit circle of the poles of the model of the disturbance which has roots on the unit circle). The adaptive scheme estimates separately the numerator and denominator parameters of the IIR Youla-Kuˇcera Filter. The use of this approach drastically simplify the design of the central controller in comparison with adaptive FIR Youla Kucera schemes and provides even better results with the advantage to use a single central controller independently of the number of narrow band disturbances. Real-time results obtained on an active vibration control system will illustrate the potential of this approach. Comparison with other approaches applied to the same system are also provided.

18:20-18:40 WeCT3.5

Fast Two-Degree-Of-Freedom Tracking Controller Design for Linear Systems Subject to Actuator Saturation and Disturbance, pp. 449-454

Gong, Zhongyi — Tech. Univ. of Darmstadt
Ma, Jian — Tech. Univ. of Darmstadt

This article presents a novel approach for fast setpoint tracking control based on two-degree-of-freedom structure for linear system subject to input amplitude and rate saturation constraints in the presence of the disturbance. Short settling times and a better control performance are achieved by the proposed approach. Furthermore, the actuating variable range is adaptively adjusted for the reference behavior and disturbance behavior. The set point tracking controller in feedforward control can be derived from a controller stabilizing the origin with an additional associated domian of attraction. A existing convex optimization procedure for the controller synthesis based in linear matrix inequalities (LMIs) can be applied by introducing the auxiliary conditions.

18:40-19:00 WeCT3.6

New Perspective on How to Build and Evaluate Control Strategies for Wastewater Treatment Plants, pp. 455-460

Barbu, Marian — Dunarea De Jos Univ. of Galati
Vilanova, Ramon — Univ. Autonoma De Barcelona
Meneses Benitez, Montse — UAB

This paper presents a new perspective on building control strategies for wastewater treatment plants and suggests a new indicator for evaluating the performance of these plants. The proposed approach is closer to the natural way in which these strategies are defined in case of real plants. Thus, the paper presents an incremental method on how to build control strategies, by going sequentially through various control actions, the results of applying a control action leading to the following actions that must be applied. Simultaneously the paper defines a new indicator for evaluating the performance of wastewater treatment plants: Global Warming Potential. This indicator is one component that arises from the Life Cycle Assessment analysis method and has the advantage that it provides information about the global environmental cost of operating the treatment plant. The study was carried out using the

platform Benchmark Simulation Model No. 2 (BSM2).

WeCT4	Pella
Automotive Control (Regular Session)	
Chair: Alexandridis, Antonios	Univ. of Patras
Co-Chair: Sajadi-Alamdari, Seyed Amin	Univ. of Luxembourg

17:00-17:20 WeCT4.1

Indirect Adaptive Pole Placement Control with Performance Orientated Anti-Windup for Electronic Throttle Plates, pp. 461-466

Thiel, Manus — Iav GmbH
Schwarzmann, Dieter — Robert Bosch GmbH
Jeinsch, Torsten — IAV GmbH
Schultalbers, Matthias — IAV GmbH

The pressure or the flow of gases and fluids are often controlled by the position of electromechanical actuators. The position control of these actuators usually have high performance requirements in the sense that their positioning has to be as fast as possible. Due to defects and aging, it is difficult to achieve constant performance for all actuators during their lifetime. Therefore, an adaptive controller is designed, that can compensate for changing or unknown parameters without the need of predefined experiments. In addition, an adaptive anti-windup method is applied, which has to fulfill two tasks. On the one hand it prevents windup of the controller, which can easily occur if the whole range of the input signal is utilized due to the performance requirements. On the other hand, it provides the possibility to influence the closed-loop performance, when the input saturates, without changing the controller. The control scheme is tested on a real electronic throttle plate of a car. The results show a quick self-tuning ability and high closed-loop performance.

17:20-17:40 WeCT4.2

Nonlinear Model Predictive Extended Eco-Cruise Control for Battery Electric Vehicles, pp. 467-472

Sajadi-Alamdari, Seyed Amin — Univ. of Luxembourg
Voos, Holger — Univ. of Luxembourg
Darouach, Mohamed — CRAN CNRS UMR 7039, Univ. De Lorraine

Battery Electric Vehicles are becoming a promising technology for road transportation. However, the main disadvantage is the limited cruising range they can travel on a single battery charge. This paper presents a novel extended ecological cruise control system to increase the autonomy of an electric vehicle by using energy-efficient driving techniques. Driven velocity, acceleration profile, geometric and traffic characteristics of roads largely affect the energy consumption. An energy-efficient velocity profile should be derived based on anticipated optimal actions for future events by considering the electric vehicle dynamics, its energy consumption relations, traffic and road geometric information. A nonlinear model predictive control method with a fast numerical algorithm is adapted to determine proper velocity profile. In addition, a novel model to describe the energy consumption of a series-production electric vehicle is introduced. The hyperfunctions concept is used to model traffic and road geometry data in a new way. The proposed system is simulated on a test track scenario and obtained results reveal that the extended ecological cruise control can significantly reduce the energy consumption of an electric vehicle.

17:40-18:00 WeCT4.3

Robust Control of Externally Excited Synchronous Machine Based on Passivity Theory, pp. 473-478

Mocanu, Razvan — Tech. Univ." Gh. Asachi" of Iasi
Onea, Alexandru — Gheorghe Asachi Tech. Univ. of Iasi

This paper proposes a robust Passivity Based Control (PBC) strategy for an Externally Excited Synchronous Machine (EESM) used in high power applications. The mathematical model of the EESM is obtained in Euler-Lagrange (EL) formalism which is the basis for the PBC control design. Variations of parameters are modelled as external perturbations and are compensated by pre-control actions determined by disturbance observers. The reference current are calculated considering Maximum Torque Per Ampere (MTPA) and Field Weakening (FW) strategies. The proposed control structure is compared with a Field Oriented Control (FOC) algorithm based on PI current and speed controllers. Numerical simulations are carried out in Matlab - Simulink.

18:00-18:20 WeCT4.4

Dynamic Analysis of Induction Machine Driven Electric Vehicles Based on the Nonlinear Accurate Model, pp. 479-484

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

The complexity of electric vehicles (EVs) as electromechanical systems make their simulation and analysis a difficult but challenging task, especially in the case studied in this paper where the EV is driven by an induction machine (IM). While IM performance is simple enough, its dynamic model introduces a variety of significant nonlinearities. Hence a main innovation of the present paper is the integration of the IM model into the entire system in a manner that enables a rigorous stability analysis. Particularly, each part of the EV, such as the battery storage system, the IM, the power converters and finally the dc loads are all taken into account and nonlinear Lyapunov based techniques are applied to prove stability. The cumbersome task of constructing suitable Lyapunov storage functions that are used to prove input-to-state stability (ISS) of the whole system, with respect to the external mechanical torque on the car wheels and the internal battery voltage, is precisely presented. ISS property ensures robustness and as it has been recently shown it can guarantee convergence to a nonzero equilibrium for any feasible bounded duty-ratio signals. As it is proven by the simulation results the theoretical analysis is confirmed by a very satisfactory system performance without contradictions and adverse impacts between the several responses of the electric and electromechanical part.

18:20-18:40 WeCT4.5

Optimization of a Quarter Vehicle Model, pp. 485-489

Broström, Fredrik — Luleå Univ. of Tech
Gustafsson, Thomas — Luleå Univ. of Tech

This paper presents a quarter vehicle model that is currently being used in optimization for energy-efficient control. The model uses the contact-point tyre model approach together with the mapped behaviour of the powertrain to generate an approximate behaviour of the target vehicle. The model is used to optimize two driving cases. The model shows promising results and is believed to enable future research in optimal control of articulated vehicles.

18:40-19:00 WeCT4.6

A Linear-Time Algorithm for Minimum-Time Velocity Planning of Autonomous Vehicles, pp. 490-495

Consolini, Luca — Univ. of Parma
Locatelli, Marco — Univ. of Parma
Minari, Andrea — Univ. of Parma
Piazzi, Aurelio — Univ. of Parma

Velocity planning on a path to be followed by a wheeled autonomous vehicle may be difficult when high curvatures and velocities are allowed. A fast, straightforward algorithm to address this problem is presented. It has linear-time computational complexity and provides an optimal minimum-time velocity profile. The algorithm is based on a curvilinear discretization that makes

easy to take into account the constraint on the vehicle's maximal normal acceleration. Formal proofs of the algorithm's properties are included. Two examples illustrate the proposed approach.

WeCT5	Mycenae
Biologically Inspired Systems (Regular Session)	
Chair: Pettersen, Kristin Y.	Norwegian Univ. of Science and Tech
Co-Chair: Sfakiotakis, Michael	Tech. Educational Inst. of Crete

17:00-17:20 WeCT5.1

Steering-Plane Motion Control for an Underwater Robot with a Pair of Undulatory Fin Propulsors, pp. 496-503

Sfakiotakis, Michael	Tech. Educational Inst. of Crete
Gliva, Roza	Tech. Educational Inst. of Crete
Mountoufaris, Minas	Tech. Educational Inst. of Crete

This paper presents the development, control, and experimental evaluation of a bio-inspired underwater vehicle that employs for propulsion a pair of lateral undulatory fins. Each fin is comprised of three actuated fin rays, interconnected by a membrane-like flexible surface. The rays' motion profile is produced via two coupled Central Pattern Generator networks, and a simple fluid drag model is used to estimate the thrust generated by the fins. Closed-loop strategies are developed for steering-plane motion control of the vehicle, involving forward/turning swimming and in-place rotations, with feedback provided by an on-board AHRS sensor. A series of experiments are conducted to assess the validity of the computational models, the efficacy of the proposed controllers, as well as the effect of the various kinematic parameters of the fin undulations on the generated thrust and the robot's swimming performance.

17:20-17:40 WeCT5.2

Multiobjective Locomotion Optimization of Quadruped Robot with Different 2DOF Configurations of Actuated Spine, pp. 504-511

Koco, Edin	Faculty of Electrical Engineering and Computing, Univ. of Z
Kovacic, Zdenko	Univ. of Zagreb

This paper addresses the problem of finding a set of optimal foot and spine trajectories for a biologically inspired quadruped robot in order to obtain energy optimal and fast locomotion in forward direction. Based on the previous work of finding optimal foot trajectories we now extend the scope of problem by investigating the effects of an added 2DOF actuated spine on the characteristics of robot locomotion in comparison with rigid spine. To tackle this problem a multiobjective genetic optimization algorithm was used. Purpose of the optimization procedure is to give a better insight in which of the two spine configurations is more beneficial to studied bound and trot gaits and how to design a control strategy that utilizes the spine in an effective way.

17:40-18:00 WeCT5.3

Fast Knn-Based Prediction for the Trajectory of a Thrown Body, pp. 512-517

Mironov, Konstantin	Ufa State Aviation Tech. Univ
Pongratz, Martin	TU Wien

Robotic throwing and catching of objects is a promising way of material transportation. For successful catch of the flying object accurate prediction of its trajectory in the gripper workspace is required. While most state-of-the-art solutions use physical models to get a trajectory forecast we apply a predictor based on nearest neighbor regression, which does not require exact physical model of the motion. The challenge of such application consist in high volume of calculations that are needed to compare the current trajectory with examples from the database. This issue is critical as the prediction must be real-time. Two approaches for speeding up the procedure are discussed. One approach is based on fast allocation of the small subset from the entire dataset. The current trajectory is compared only with the trajectories from this subset. Another approach is based on the parallelization of computations using graphical processing units. Both approaches are evaluated and compared based on real trajectories. The parallelized version of the algorithm is implemented on the robotic catching system. It provide successful catch for up to 86 % of thrown objects.

18:00-18:20 WeCT5.4

Waypoint Guidance Control for Underwater Snake Robots Exposed to Ocean Currents, pp. 518-525

Kelasidi, Eleni	Norwegian Univ. of Science and Tech
Kohl, Anna M.	Norwegian Univ. of Science and Tech
Pettersen, Kristin Y.	Norwegian Univ. of Science and Tech
Gravdahl, Jan Tommy	Norwegian Univ. of Science & Tech

This paper presents a waypoint guidance strategy for underwater snake robots, which is an extension of the straight line path following controllers previously proposed by the authors. The proposed waypoint guidance control enables an underwater snake robot to converge towards and follow a desired path compensating for disturbances due to ocean currents effects. The ocean currents are constant and irrotational, and with unknown magnitude and direction. A set of waypoints is chosen along the desired path which is then defined by interconnecting these waypoints by straight lines. Simulation results for both lateral undulation and eel-like motion illustrate the performance of the guidance strategy.

18:20-18:40 WeCT5.5

H_infty and Peak to Peak Output-Feedback Control Analysis of the Glycolysis Pathway in Yeasts, pp. 526-531

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

The possible sensitivity and robustness of the Glycolysis pathway in yeasts is further explored via the H_infty and the peak to peak $ L_infty -L_infty$ system norms, where the system encounters uncertainties in several kinetic parameters of its enzymes. Following linearization of the pathway kinetic equations, two modelling strategies are applied the first of which tests the robustness of the nominal linearized system to various parameter uncertainties, including uncertainties in the control gain matrix of the system. In the second strategy, similar tests of the latter are applied however, the original nonlinear system is modeled as an uncertain linear system where the extent of the nonlinearity is tuned by the uncertainty interval. It is shown that the system sensitivity to the various uncertain parameters agree in both strategies and that the two system performance indices, the $ H_infty$ and the $ L_infty - L_infty$ reliably describe the system response to a concentration disturbance.

18:40-19:00 WeCT5.6

Effects of Compliance in Pedundulatory Locomotion Over Granular Substrates, pp. 532-538

Sfakiotakis, Michael	Tech. Educational Inst. of Crete
Chatzidaki, Avgousta	FORTH
Evdaimon, Theodoros	Foundation for Res. & Tech. - Hellas (FORTH)
Kazakidi, Asimina	Foundation for Res. & Tech. - Hellas (FORTH)
Tsakiris, Dimitris	FORTH

The present paper investigates the effect of compliance on the locomotion of a biologically-inspired soft-body pedundulatory robotic system, employing lateral undulations of its elongated body, which are augmented by the oscillation of sets of lateral appendages (parapodia), to propel itself on unstructured granular substrates. We explore control strategy alternatives for the robot to generate two different locomotor gaits by employing direct or retrograde lateral body waves, combined with appropriately coordinated parapodial motion (pedundulatory modes). Computational models of this class of robots have been devised, which demonstrate the effects of joint compliance on gait generation and on the characteristics of robot propulsion. A new three-segment soft-body robotic prototype has been developed, whose body was fabricated by molding polyurethane elastomers, and was tested extensively on an experimental sandbox, on various formations of the granular substrate, to compare the performance of stiff and compliant joints. Body and joint compliance were found to enhance the adaptability of the robot to environmental irregularities, however they may deteriorate the proper formation of the undulatory body wave, degrading somewhat system performance in terms of the attained velocities.

ThAT1 Kozani

Robotics I (Regular Session)

Chair: Muscato, Giovanni — Univ. Degli Studi Di Catania
Co-Chair: Duleba, Ignacy — Wroclaw Univ. of Tech. Faculty of Electronics

10:30-10:50 ThAT1.1

Evaluation of Visual Localization Systems in Underground Mining, pp. 539-544

Kanellakis, Christoforos — Luleå Univ. of Tech
Nikolakopoulos, George — Luleå Univ. of Tech. Sweden

In this article an evaluation of the current technology on visual localization systems for underground mining is presented. The proposed study is considered to be the first step among others towards enabling the vision of underground localization for Unmanned Micro Aerial Vehicles. Furthermore, the aim of this article, is to verify applicable and reliable low cost existing methods and technologies for the problem of UAV localization in underground, harsh mining environments and more specifically in one of the biggest mines in Europe, the iron ore mine of LKAB in Kiruna, Sweden. In the experimental trials, the sensors employed were a RGB-D camera, a Kinect 2 and a Playstation 3 Eye web camera used in two configurations, as a stereo rig and as a monocular visual sensor. The processing of the stored data from the experiments will provide an insight for the applicability of these sensors, while it will identify what further technological and research developments are required in order to develop affordable autonomous UAV solutions for improving the underground mining production processes.

10:50-11:10 ThAT1.2

Maintaining Static Stability and Continuous Motion in Rough Terrain Hexapod Locomotion without Terrain Mapping, pp. 545-550

Roditis, Ioannis — Innora SA
Nitsos, Theofanis — Innora SA
Porichis, Antonios — Innora SA
Chatzakos, Panagiotis — National Tech. Univ. of Athens
Bertos, Georgios — National Tech. Univ. of Athens
Lika, Klajd — National Tech. Univ. of Athens
Papadopoulos, Evangelos — National Tech. Univ. of Athens

Locomotion on rough unknown terrain has been a major challenge for legged robotic systems. Hexapods offer the advantage of static stability due to their capability of maintaining their center of gravity within their support polygon. Various approaches have been proposed for moving on rough terrain that use mapping of the ground or control schemes that result to discontinuous or oscillating motion of the hexapod body. In these approaches, stability is not taken into account, and increased tip-over risk occurs. This work presents a novel approach for continuous and smooth locomotion of a hexapod on rough terrain while maintaining static stability at predefined values regardless of the terrain profile and the existence of obstacles and slopes. The locomotion of the body is adjusted through a correction algorithm that facilitates smooth body motion following the variation of the terrain while static stability is maintained. The effect of the body correction algorithm gains on the body motion behavior with respect to terrain variation is thoroughly analyzed and the approach is evaluated using the force-angle stability measure. Results using multibody dynamics simulations show the effectiveness of the developed approach.

11:10-11:30 ThAT1.3

Human-Robot Interaction through Kinect and Graphics Tablet Sensing Devices, pp. 551-556

Barbagallo, Rosario — Dipartimento Di Ingegneria Elettrica Elettronica E Informatica
Cantelli, Luciano — Dipartimento Di Ingegneria Elettrica Elettronica E Informatica
Muscato, Giovanni — Univ. Degli Studi Di Catania
Mirabella, ORazio — Dipartimento Di Ingegneria Elettrica Elettronica E Informatica

This paper analyzes three different solutions for human-robot cooperation. The proposed applications are based on two sensing devices: the Microsoft Kinect, a 3D camera by Microsoft, and a Graphics Tablet. The first solution, based on the Kinect, uses hand motion detection based on a clustering hand detection algorithm. The coordinates of the hands are sent to an application that computes the inverse kinematics and the desired robot trajectory. The second solution is based on a Graphic Tablet, which uses pen or finger input and operates in a similar way as the first system, but with higher accuracy. The third solution is also based on the Kinect but it uses the detection of the human body and voice commands together, to safely move the robotic arm without the need of a traditional teach pendant. All the three solutions adopt network sockets to send the commands to the robot controller. Behind the solutions, real time security procedures, monitors and avoids any collision of the robotic arm with humans during the movements.

11:30-11:50 ThAT1.4

Robot Finger Control for Rolling on Curved Surfaces, pp. 557-562

Droukas, Leonidas — Aristotle Univ. of Thessaloniki
Rovithakis, George A. — Aristotle Univ. of Thessaloniki
Doulgeri, Zoe — Certh Vat: El099785242

In this work the problem of designing a low complexity state feedback controller which enforces the domination of the rolling motion of a spherical robotic fingertip upon a curved surface is considered. Fingertip rolling is essential for robot object fine positioning and manipulation and should be explicitly considered as a control objective. The prescribed performance control methodology is employed. Under the designed controller, the sliding and spinning regime of the robot tip motion is quickly suppressed, a desired position and normal force is reached with prespecified transient and steady state behavior while contact maintenance is guaranteed. Simulations validate the approach.

11:50-12:10 ThAT1.5

A Suboptimal Solution of Repeatable Inverse Kinematics in Robot Manipulators with a Free Entry Configuration, pp. 563-568

Duleba, Ignacy — Wroclaw Univ. of Tech. Faculty of Electronics
Karcz-Duleba, Iwona — Wroclaw Univ. of Tech. Faculty of Electronics

In this paper a repeatable kinematic task is considered, i.e. a loop in a configuration space is searched for which corresponds to a given loop in a task-space of a manipulator. In contrast to a classic formulation, an entry configuration, where the loop in a configuration space is initialized, is free to choose. Some methods to generate almost uniformly distributed entry configurations within a~manifold of admissible configurations were discussed and their advantages and disadvantages were enumerated. As a basic tool for solving numerous repeatable kinematic tasks with an entry configuration just fixed, a recently developed method, based on an elastic band paradigm, was applied. A sub-optimal solution of the free entry configuration task is provided, minimizing the length of the path in the configurations space. A simulation study was performed on 3dof and 4dof planar manipulators.

12:10-12:30 ThAT1.6

A Passivity Based Control Signal Guaranteeing Joint Limit Avoidance in Redundant Robots, pp. 569-574

Papageorgiou, Dimitrios	Aristotle Univ. of Thessaloniki
Atawnih, Abdelrahem	Aristotle Univ. of Thessaloniki
Doulgeri, Zoe	Certh Vat: El099785242

In this work we propose a torque control signal that guarantees joint limit avoidance of a redundant arm. Its design is based on the prescribed performance control methodology that enables guarantees on the satisfaction of inequality constraints regarding the system output. It is proved that the proposed signal preserves the passivity of closed loop robot dynamics with respect to joint velocities thus allowing its use with any passive control law designed to attract the robot towards a task goal. Experimental results with a KUKA LWR4+ for a task involving the tip's position motion along a linear path confirm theoretical findings and demonstrate the proposed signal's performance in two scenarios of a feasible and an unfeasible path.

ThAT2 — Edessa

Networked Systems I (Regular Session)

Chair: Stefanovic, Margareta	Univ. of Denver
Co-Chair: Groumpos, Peter	Univ. of Patras

10:30-10:50 — ThAT2.1

Congestion Control for Real-Time Communications: A Comparison between NADA and GCC, pp. 575-580

Carlucci, Gaetano	Pol. Di Bari
De Cicco, Luca	Pol. Di Bari
Ilharco Magalhaes, Cesar	Google Inc
Mascolo, Saverio	Pol. Di Bari

Congestion control for Web real-time communication (WebRTC) is a hot topic currently addressed at the IETF. Differently from congestion control for TCP, congestion control for WebRTC not only aims at containing packet losses, but also aims at minimizing queuing delays to provide interactivity. In this paper we describe two algorithms under discussion at IETF: Network Assisted Dynamic Adaptation (NADA) proposed by Cisco Systems and Google Congestion Control (GCC) proposed by Google. A performance comparison in a simulation environment is carried out. Results show that GCC exhibits slow convergence whereas NADA exhibits a remarkable oscillating behavior.

10:50-11:10 — ThAT2.2

Modeling Vineyards Using Fuzzy Cognitive Maps, pp. 581-586

Groumpos, Peter	Univ. of Patras
Groumpos, Vasilios	Univ. of Athens

The aim of this paper is to present a new approach in modelling Vineyards using Fuzzy Cognitive Maps trained by non linear Hebbian learning algorithm. The basics of Vineyards are critically reviewed. The methodology described extracts the knowledge from the experts and exploits their experience of vineyard cultivation. Data from four Vineyards of the island of Kefalonia are considered. A new FCM model for Vineyards is developed and tested. Simulation studies are conducted The results of this study show that software tools based on FCMs methods can be used to investigate the grape production of a Vineyard.

11:10-11:30 — ThAT2.3

Distributed Leaderless and Leader-Follower Consensus of Linear Multiagent Systems under Persistent Disturbances, pp. 587-592

Rezaei, Vahid	Univ. of Denver
Stefanovic, Margareta	Univ. of Denver

The presence of unknown disturbances prevents agreement in multiagent systems. In this article, we propose observer-based leaderless and leader-follower consensus algorithms to achieve agreement in the presence of the unknown unmatched persistent disturbances. Agents have linear time- invariant dynamics and provide only relative output measurements. The simulation results verify the feasibility of the proposed ideas for these communication topologies.

11:30-11:50 — ThAT2.4

Trust-Aware Network Utility Optimization in Multihop Wireless Networks with Delay Constraints, pp. 593-598

Paraskevas, Evripidis	Univ. of Maryland, Coll. Park
Jiang, Tao	Univ. of Maryland
Baras, John S.	Univ. of Maryland

Many resource allocation problems can be formulated as a constrained maximization of a utility function. Network Utility Maximization (NUM) applies optimization techniques to achieve decomposition by duality or the primal-dual method. Several important problems, for example joint source rate control, routing, and scheduling design, can be optimized by using this framework. In this work, we introduce an important network security concept, “trust”, into the NUM formulation and we integrate nodes' trust values in the optimization framework. These trust values are based on the interaction history between network entities and community based monitoring. Our objective is to avoid routing packets though paths with large percentage of malicious nodes. We also add end-to-end delay constraints for each of the traffic flows. The delay constraints are introduced to capture the imposed quality of service (QoS) requirements for each traffic flow.

11:50-12:10 — ThAT2.5

Consensus of Homogeneous Linear Multi-Agent Systems with Time-Varying Communication Delays, pp. 599-604

Xu, Xiang	City Univ. of Hong Kong
Liu, Lu	City Univ. of Hong Kong
Feng, Gang	City Univ. of Hong Kong

This paper studies the consensus problem of homogeneous linear multi-agent systems in directed networks with fixed topology and non-identical time-varying communication delays. A distributed static state feedback controller is proposed based on communication delays. It is proved that a no-cycle assumption is sufficient to achieve consensus under the proposed controller. A simulation example is presented to illustrate the effectiveness of the proposed controller.

12:10-12:30 — ThAT2.6

Analysing Human Movements at Mass Events: A Novel Mobile-Based Management System Based on Active Beacons and AVM, pp. 605-610

Frontoni, Emanuele	Univ. Pol. Delle Marche
Zingaretti, Primo	Univ. Pol. Delle Marche
Sturari, Mirco	Univ. Pol. Delle Marche
Pierdicca, Roberto	Univ. Pol. Delle Marche
Mancini, Adriano	Univ. Pol. Delle Marche

The representation, management and analysis of large volumes of people are growing the interest of both academic and public authority researches. This attention was triggered thanks to the increasing availability of data collection tools about spatio-temporal phenomena; the reason is that location-based technologies, coupled with mobile devices, are becoming more affordable, capillary and pervasive. In this context, we propose our work, based on proximity-based Bluetooth tracking, aimed to analyse complex dynamics of visitors moving at mass events. The whole architecture is composed of smart beacons disseminated through the festival stands, an app freely provided to the visitors and a remote

dashboard for data collection and analytics. The case study chosen for our test was the 10th Edition of Mogliano Halloween Festival which count every year about 15.000 visitors among 3 days; as a first step of this research, preliminary tests demonstrate how the proposed methodology could be needful for event's stakeholders and urban planners in general. First of all, location based services (such as push and notification) enables innovative models of interaction with stands and recreational areas by adding tremendous value to the visitors' experience, extending also the possibility to affect trajectories with way-finding services. Furthermore, we get clear statistics such as visitor counts, the share of returning visitors, and visitors flow maps, giving the possibility to distinguish different patterns, according to user profiles. The duality between location-based services and context-aware information opens up new possibilities towards new archetype of outdoor environments, becoming more digitally-integrated and sensible.

ThAT3 — Naoussa

Identification I (Regular Session)

Chair: Diversi, Roberto — Univ. of Bologna

Co-Chair: Bashir, Faraj — Univ. of Sheffield

10:30-10:50 — ThAT3.1

Handling Missing Data in Multivariate Time Series Using a Vector Autoregressive Model Based Imputation (VAR-IM) Algorithm Part I: VAR-IM Algorithm versus Traditional Methods, pp. 611-616

Bashir, Faraj — Univ. of Sheffield

Wei, Hua-Liang — Univ. of Sheffield

There is an abundance of literature on handling missing data from analytical methods to artificial intelligence and statistical approaches. Given an observed data set, there are different methods that can be used to impute missing data. While excellent work has been done in this field, most available approaches are focused on some particular applications, such as static data and univariate time series. The primary aim of the two papers – Part I VAR-IM algorithm v.s. traditional methods and Part II VAR-IM algorithm v.s. modern algorithms - is to introduce an algorithm for handling missing data in multivariate time series based on vector autoregressive (VAR) model by combining an expectation and minimization (EM) algorithm with the prediction error minimization (PEM) method. In the first part, we conduct two cases studies (one for simulation data and another for real ECG data) to compare the proposed algorithm with three traditional methods for imputing missing data: Mean substitution, list-wise deletion and linear regression substitution. In the second part, the proposed method is compared with more powerful modern techniques: MARRS Package, nearest neighbour, and the full information maximum likelihood (FIML) method. Furthermore, we demonstrate the use of the proposed method together with an empirical example of multivariate time series to ECG data and discuss its advantages and limitations.

10:50-11:10 — ThAT3.2

Identification of Switched Linear Systems Using Self-Adaptive SVR Algorithm, pp. 617-621

Sellami, Lamaa — Univ

Zidi, Salah — USTL1

Kamel, Abderrahim — National School of Engineers of Gabes

We consider the problem of switched linear system identification from input-output data set. This set may be a mixte set whose data are generated from a different switching affine subsystems so that one does not know a priori or a switching dynamics is unavailable. To overcome this main challenge, we develop an identification approach which consists in determining simultaneously a linear regression function which represents each submodel and a switching signal estimation via a self-adaptive clustering algorithm. The regression function is identified based on the Support Regression Vector (SVR) approach. However, the switching signal is provided by an unsupervised classification algorithm with self-adaptive capacities.

11:10-11:30 — ThAT3.3

A Three-Step Identification Procedure for ARARX Models with Additive Measurement Noise, pp. 622-627

Diversi, Roberto — Univ. of Bologna

This paper concerns the identification of extended ARARX models that consider also an additive white noise affecting the output. This model allows to take into account the presence of both a process disturbance and an additive measurement noise. A three-step identification procedure is described for identifying the extended ARARX model. The first step consists in an iterative bias-compensated least squares algorithm while the subsequent steps are based on simple (non-iterative) least squares equations. Simulation results are included to show the effectiveness of the proposed method.

11:30-11:50 — ThAT3.4

Identification Algorithm for Piecewise Affine Systems with Bounded Disturbances, pp. 628-633

Goudjil, Abdelhak — Univ. of Caen Normandy

Pouliquen, Mathieu — Univ. of Caen

Pigeon, Eric — GREYC

Gehan, Olivier — ENSICAEN

This paper presents a new identification algorithm for Piecewise Affine Autoregressive exogenous (PWARX) models in the presence of bounded disturbances. This problem includes the estimation of both parameters of the sub-models and the polyhedral partition of the regressor domain. The proposed algorithm proceeds in two stages. In the first stage, it associates each data point to the most suitable sub-model and realizes the identification of the parameters of each sub-model. This stage is based on an Outer Bounding Ellipsoid (OBE) type algorithm suitable for system identification with bounded disturbances. In the second stage, the algorithm achieves the estimation of the parameter defining the polyhedral partition. A numerical example is given to illustrate performance of the algorithm.

11:50-12:10 — ThAT3.5

Orthotopic Set-Membership Parameter Estimation of Fractional Order Model, pp. 634-639

Hamdi, Saifeddine — ENIG

Amairi, Messaoud — National Engineering School of Gabes (ENIG)

Aoun, Mohamed — National Engineering School of Gabes, Tunisia. Res. Unit Of

This paper presents a new orthotopic set-membership method for the identification of linear fractional orders systems. This method consists in recursively constructing an outer orthotope that contains all feasible parameters when the probability distribution of the disturbances is unknown but bounded and when the differentiation orders are known. A numerical example shows the effectiveness of the proposed method.

12:10-12:30 — ThAT3.6

Instrumental Variable Based Methods for Continuous-Time Linear Parameter Varying System Identification with Fractional Models, pp. 640-645

Salem, Thouraya — ENIG

Chetoui, Manel — Univ. Bordeaux 1, France

Aoun, Mohamed — National Engineering School of Gabes, Tunisia. Res. Unit Of

This paper deals with continuous-time linear parameter varying (LPV) system identification with fractional models. Two variants of instrumental variables based techniques are proposed to estimate continuous-time parameters of a fractional differential equation linear parameter varying model when all fractional orders are assumed known a priori: the first one is the instrumental variables estimator based in an auxiliary model. The second one is the simplified refined instrumental variables estimator. A comparison study between the developed estimators is done via a numerical example. A Monte Carlo simulation analysis results are presented to illustrate the performances of the proposed methods in the presence of an additive output noise.

ThAT4 Pella

On Aerial Manipulators: Design and Control (Invited Session)

Chair: Nikolakopoulos, George	Luleå Univ. of Tech. Sweden
Co-Chair: Fumagalli, Matteo	Aalborg Univ
Organizer: Fumagalli, Matteo	Aalborg Univ
Organizer: Nikolakopoulos, George	Luleå Univ. of Tech. Sweden
Organizer: Stramigioli, Stefano	Univ. of Twente

10:30-10:50 ThAT4.1

A Comparison of Control Approaches for Aerial Manipulators Handling Physical Impacts (I), pp. 646-652

Bartelds, Teun	Univ. of Twente
Wopereis, Han	Univ. of Twente
Stramigioli, Stefano	Univ. of Twente
Fumagalli, Matteo	Department of Mechanical and Manufacturing Engineering

This paper presents and compares different control strategies for aerial manipulators to handle highly dynamic physical interaction with the environment. These control strategies are compared in simulation using an ideal model developed using the bond graph representation. Simulation results are presented to demonstrate the effectiveness of and the differences between the proposed solutions.

10:50-11:10 ThAT4.2

Modeling and Control Aspects of a UAV with an Attached Manipulator (I), pp. 653-658

Stergiopoulos, Yiannis	Univ. of Patras
Kontouras, Efstathios	Univ. of Patras
Gkountas, Konstantinos	Univ. of Patras
Giannousakis, Konstantinos	Univ. of Patras
Tzes, Anthony	Univ. of Patras

This article addresses the problem of the modeling and control of an Unmanned Aerial System (UAS) that consists of a UAV carrying a robotic manipulator. The dynamics of the UAS are derived based on the recursive Newton-Euler equations in order to handle the floating-base effect. Accordingly, the dynamics account for the force and torque transferred from the base of the manipulator to the UAV and the translational and angular velocities and accelerations from the UAV to the manipulator. The integrated nonlinear dynamic equations are symbolically derived and efficient code for execution at embedded systems is generated. An efficient nonlinear control scheme regulates the states of the UAS to a desired configuration. Simulation results are provided to evaluate the performance of the developed strategy, in comparison to the ones derived by simplifying the coupling of the UAV and manipulator dynamics by considering only the spatial coordinates of the center of mass of the manipulator.

11:10-11:30 ThAT4.3

Full-Body Multi-Objective Controller for Aerial Manipulation (I), pp. 659-664

Kamel, Mina	ETHZ
Comari, Simone	Autonomous Systems Lab, ETH Zurich
Siegwart, Roland Y.	ETH Zürich

In this paper we present an multi-objective dynamic controller for a micro-aerial vehicle (MAV) equipped with dexterous aerial manipulator. The MAV and the manipulator are considered as a multi-body system where the control input is generated for the MAV and the manipulator joints simultaneously, taking into account dynamic effects. The redundancy of the system is exploited by setting various desired tasks with associated priorities. The proposed controller is compared against classic control approach. Extensive simulation results are presented in Micro Aerial Vehicles Simulator RotorS.

11:30-11:50 ThAT4.4

On the Design, Modeling and Control of a Novel Compact Aerial Manipulator (I), pp. 665-670

Wuthier, David	Luleå Univ. of Tech
Kominiak, Dariusz	Luleå Univ. of Tech
Kanellakis, Christoforos	Luleå Univ. of Tech
Andrikopoulos, George	Luleå Univ. of Tech
Fumagalli, Matteo	Department of Mechanical and Manufacturing Engineering
Schipper, Gerben	Saxion Univ. of Applied Science
Nikolakopoulos, George	Luleå Univ. of Tech. Sweden

The aim of this article is to present a novel 4 Degree-of-Freedom (DoF) aerial manipulator allowing a multirotor Unmanned Aerial Vehicle (UAV) to physically interact with the environment. The proposed design is characterized by low disturbances on the UAV flight dynamics, extended workspace (with regard to its retracted configuration) and fast dynamics (compared to the UAV dynamics). The dynamic model is mathematically formulated and a control structure consisting of an inverse kinematics algorithm and multiple PID-based independent joint controllers is presented. Furthermore, the design specifications of the prototype are analyzed in detail, while experimental evaluations are conducted for the extraction of the manipulator's workspace and the evaluation of system's tracking capabilities over pick and place trajectory scenarios. Finally, it is shown that the selected joint position sensors, combined with the derived inverse dynamic algorithm allow to determine the wrenches exerted at the base, due to swift motions of the arm.

11:50-12:10 ThAT4.5

Slung Load Transportation with a Single Aerial Vehicle and Disturbance Removal (I), pp. 671-676

Otao Pereira, Pedro Miguel	KTH, Department of Automatic Control
Herzog, Manuel	KTH
Dimarogonas, Dimos V.	Royal Inst. of Tech. (KTH)

We present a trajectory tracking controller for a quadrotor-load system, composed of a single load and a single unmanned aerial vehicle connected by a cable or rope. The load is modeled as a point mass while the aerial vehicle is assumed to be fully actuated, with thrust and attitude of the quadrotor as inputs to the system quadrotor-load. We assume there is a constant input disturbance at the thrust input, and a disturbance estimator is presented that guarantees that asymptotic tracking is guaranteed in the presence of such a disturbance. The load and the aerial vehicle are connected by a cable of fixed length that behaves as a rigid link under tensile forces, and as a non-rigid link when under compressive forces. The proposed controller guarantees that the cable is always under

tensile forces, provided that the position trajectory to be tracked satisfies some mild conditions. The system quadrotor-load can be transformed into a form that resembles that of systems describing underactuated aerial vehicles, and for which a variety of control strategies have been proposed. In particular, we propose a controller based on a backstepping procedure in conjunction with a bounded double integrator controller. We present simulations validating the proposed control algorithm, and some preliminary experimental results are also presented.

ThAT5	Mycenae
Nonlinear Control (Regular Session)	
Chair: Dumur, Didier	CentraleSupelec
Co-Chair: Lamouchi, Rihab	Cnam

10:30-10:50 ThAT5.1

Stability Analysis of Oilwell Drilling Torsional Vibrations, pp. 677-682

Toumi, Samir	Evry Univ. and Pol. School of Tunisia
Mlayeh, Rhouma	Pol. School of Tunisia
Beji, Lotfi	Univ. of Evry
Abichou, Azgal	Pol. School of Tunisia

Compared to the known waves and transport PDEs, boundary conditions in drilling aren't trivial and depend on the system parameters. Further, nonlinearities are present due to bit-rock interaction. In this paper, torsional vibrations stabilization resulting from the bit stick-slip behavior are investigated. The second-order vibration dynamic is transformed into $2 times 2$ first-order PDEs. The boundary stabilizing control law is constructed such that the transformed system tracks a designed stable target system. The backstepping techniques combined with kernel equations and the Lyapunov theory are used to prove the local exponential stability of the new system variables, consequently, the vibration suppression due to torsional dynamics. Simulations are presented to illustrate the effectiveness of the control laws.

10:50-11:10 ThAT5.2

Model-Based versus Model-Free Control Designs for Improving Microalgae Growth in a Closed Photobioreactor: Some Preliminary Comparisons, pp. 683-688

Tebbani, Sihem	CentraleSupelec
Titica, Mariana	Univ. De Nantes
Join, Cédric	Nancy Univ
Fliess, Michel	Ec. Pol
Dumur, Didier	CentraleSupelec

Controlling microalgae cultivation, i.e., a crucial industrial topic today, is a challenging task since the corresponding modeling is complex, highly uncertain and time-varying. A model-free control setting is therefore introduced in order to ensure a high growth of microalgae in a continuous closed photobioreactor. Computer simulations are displayed in order to compare this design to an input-output feedback linearizing control strategy, which is widely used in the academic literature on photobioreactors. They assess the superiority of the model-free standpoint both in terms of performances and implementation simplicity.

11:10-11:30 ThAT5.3

Two General State Feedback Control Laws for Compressor Surge Stabilization, pp. 689-695

Uddin, Nur	Norwegian Univ. of Science and Tech
Gravdahl, Jan Tommy	Norwegian Univ. of Science & Tech

Active surge control system (ASCS) can be classi- fied into two types: upstream energy injection and downstream energy dissipation [1]. Two novel state feedback control laws termed φ-control for the upstream energy injection and ψ- control the downstream energy dissipation are presented. Both state feedback control laws are derived by using the Lyapunov based control method such that the closed loop systems are global asymptotic stable (GAS). The φ-control applies feedback from the compressor mass flow sensor to generate extra pressure to the compressor upstream line, while the ψ-control generates an extra flow out of the plenum using feedback from the compressor discharged pressure and the plenum pressure. Both state feedback control laws offer a minimum number of sensors requirement. Moreover, the ψ-control requires feedback from pressure sensors only which are readily available and make real-time implementation of the system to be easier.

11:30-11:50 ThAT5.4

Nonlinear and Observer-Based PD Position and Sway Control of Convey-Crane Systems, pp. 696-700

Papadopoulos, Aristotelis-Angelos	Univ. of Patras
Rompokos, Athanasios	Univ. of Patras
Alexandridis, Antonios	Univ. of Patras

Convey-cranes suffer by undesirable swings when different payloads are carried and therefore a main task of a controller applied on these systems is to sufficiently suppress and eliminate the sway performance. To this end, an energy based nonlinear proportional-derivative (PD) controller for overhead cranes is proposed with its stability examined by using classical Lyapunov techniques and LaSalle's invariance theorem. Despite the constant gains of the conventional PD controller, in this paper, a D-term varying gain is proposed that takes into account the influence of the payload swing angle and its derivative. Moreover, since in the present case all the system states are needed to be fed-back, a suitable dynamic observer is included to estimate the unmeasurable states, namely the position derivative and the swing angle. The simulation results conducted for two different payload weights verify the superior performance of the system and its robustness, while comparisons made with the conventional PD controllers indicate significant response enhancements in the sway performance.

11:50-12:10 ThAT5.5

Nonlinear Modeling and Control of a VSC-HVDC Transmission Systems, pp. 701-706

Belhouane, Mohamed Moez	Ec. Centrale De Lille
Ayari, Mohamed	Advanced Systems Lab. (LSA-EPT)
Benhadj Braiek, Naceur	Ec. Pol. De Tunisie
Guillaud, Xavier	Lab. of Electrical Engineering and Power Electronic (L2EP)

This paper presents a new modeling and control strategy of VSC-HVDC transmission system in order to improve system damping oscillations, and enhancing transient and voltage stability. This control strategy is based on linear and bilinear state space deviation models. The structure of the control method is designed in order to minimize the number of the control loops (as known as inner and outer control loops) in the classical strategy to single control loop for each output. These control loops concerne the active power or DC voltage for the first output, and the reactive power for the other output. Simulations for VSC-HVDC transmission system model show the validity of the derived models and the effectiveness of the proposed control strategy.

12:10-12:30 ThAT5.6

Interval Observer Design for Linear Parameter-Varying Systems Subject to Component Faults, pp. 707-712

Lamouchi, Rihab	Cnam

Amairi, Messaoud — National Engineering School of Gabes (ENIG)
Raïssi, Tarek — Conservatoire National Des Arts Et Métiers
Aoun, Mohamed — National Engineering School of Gabes, Tunisia. Res. Unit Of

In this paper an interval observer for Linear Parameter-Varying (LPV) systems is proposed. The considered systems are assumed to be subject to parameter uncertainties and component faults whose effect can be approximated by parameters deviations. Under some conditions, an interval observer with discrete-time Luenberger structure is developed to cope with uncertainties and faults ensuring guaranteed bounds on the estimated states and their stability. The interval observer design is based on assumption that the uncertainties and the faults magnitudes are considered as unknown but bounded. A numerical example shows the efficiency of the proposed technique.

ThBT1 — Kozani

Robotics II (Regular Session)

Chair: Evangeliou, Nikolaos — Ec. Department, Univ. of Patras
Co-Chair: Papadopoulos, Evangelos — National Tech. Univ. of Athens

14:30-14:50 — ThBT1.1

Towards ICT-Supported Bath Robots: Control Architecture Description and Localized Perception of User for Robot Motion Planning, pp. 713-718

Dometios, Athanasios — Inst. of Communications and Computer Systems (ICCS)
Papageorgiou, Xanthi — National Tech. Univ. of Athens
Tzafestas, Costas — National Tech. Univ. of Athens
Vartholomeos, Panagiotis — Children's Hospital Boston, Harvard Medical School

This paper describes the general control architecture and the basic implementation concepts of a bath service robotic system. The goal of this system is to support and enhance elderly's mobility, manipulation and force exertion abilities and assist them in successfully, safely and independently completing the entire sequence of showering and drying tasks, such as properly washing their back and lower limbs. This service robotic system is based on soft-robotic arms which, together with advanced human-robot force/compliance control will form the basis for a safe physical human-robot interaction that complies with the most up-to-date safety standards. In this paper an overview of the bath robotic system components is presented, and the basic modules that contribute to the overall control architecture of the system are described. Moreover, this paper proposed an algorithm that performs efficient processing of feedback data provided by a depth sensor. This algorithm supports local shape perception and geometric characterization of user body parts and will form the basis for further implementation of surface reconstruction and robot motion planning algorithms.

14:50-15:10 — ThBT1.2

Experimental Comparison of Human Gait Tracking Algorithms: Towards a Context-Aware Mobility Assistance Robotic Walker, pp. 719-724

Chalvatzaki, Georgia — National Tech. Univ. of Athens
Papageorgiou, Xanthi — National Tech. Univ. of Athens
Werner, Christian — Agaplesion, Bethanien Hospital - Geriatric Centre at the Univ
Hauer, Klaus — Agaplesion, Bethanien Hospital - Geriatric Centre at the Univ
Tzafestas, Costas — National Tech. Univ. of Athens
Maragos, Petros — School of Electrical and Computer Engineering, National Tech

Towards a mobility assistance robot for the elderly, it is essential to develop a robust and accurate gait tracking system. Various pathologies cause mobility inabilities to the aged population, leading to different gait patterns and walking speed. In this work, we present the experimental comparison of two user leg tracking systems of a robotic assistance walker, using data collected by a laser range sensor. The first one is a Kalman Filter tracking system, while the second one proposes the use of Particle Filters. The tracking systems provide the positions and velocities of the user's legs, which are used as observations into an HMM-based gait phases recognition system. The spatiotemporal results of the HMM framework are employed for computing parameters that characterize the human motion, which subsequently can be used to assess and distinguish between possible motion disabilities. For the experimental comparison, we are using real data collected from an ensemble of different elderly persons with a number of pathologies, and ground truth data from a GaitRite System. The results presented in this work, demonstrate the applicability of the tracking systems in real test cases.

15:10-15:30 — ThBT1.3

Design and Antagonistic Control of a Tendon-Driven Minimally Invasive Surgical Robotic Tool, pp. 725-730

Evangeliou, Nikolaos — Ec. Department, Univ. of Patras
Karageorgos, Dimitrios — Delft Univ. of Tech
Tzes, Anthony — Univ. of Patras

This article is concerned with the design, implementation and control of a redundant robotic tool for Minimal Invasive Surgical (MIS) operations. The robotic tool is modular, comprised of identical stages of dual rotational Degrees of Freedom (DoF). An antagonistic tendon-driven mechanism using two DC-motors in a puller-follower configuration is used for each DoF. The inherent Coulomb friction is compensated using an adaptive scheme while varying the follower's reaction. Preliminary experimental results are provided to investigate the efficiency of the robot in typical surgical maneuvres.

15:30-15:50 — ThBT1.4

Quadruped Robot Roll and Pitch Estimation Using an Unscented Kalman Filter, pp. 731-736

Nousias, Sotirios — UCL
Papadopoulos, Evangelos — National Tech. Univ. of Athens

We present a novel algorithm for estimating a quadruped robot's pitch and roll angles. Assuming even terrain and an ideal bounding gait, we compute the roll and pitch angles to be fused with on-board Inertial Measurement Unit (IMU) measurements in an unscented Kalman filter (UKF). Simulation results illustrate the validity of the methodology developed. It is shown that the error in the estimation of both angles is much smaller compared to those in the literature.

15:50-16:10 — ThBT1.5

Experimental Studies of Serpentine Motion Control of Snake Robots at Inclined Planes, pp. 737-742

Varesis, Orestis — Univ. of Patras
Diamantopoulos, Charalampos — Univ. of Patras
Tzes, Anthony — Univ. of Patras

The modeling and control problem for the serpentine motion of a planar snake-robot moving at inclined planes is the subject of this article. The effects of the gravity-induced terms, compared to the tangential and normal friction forces, compared to the snake's dynamics is presented. During the snake's controlled motion using a trajectory characterized by its curvature and heading, these terms have a detrimental effect on the system's stability. Experimental

studies with a prototype five DoF planar snake are offered to investigate this issue.

16:10-16:30 ThBT1.6

An Active Compliance Controller for Quadruped Trotting, pp. 743-748

Machairas, Konstantinos — National Tech. Univ. of Athens

Papadopoulos, Evangelos — National Tech. Univ. of Athens

In this paper, we present the idea that very simple control schemes can lead to complex running gaits. To show this, a novel control framework is proposed for dynamic quadruped trotting, consisting of a toe trajectory planning part and an active compliance part driving each leg. While keeping the con-troller's structure simple, the notion of the system virtual stiffness is introduced as a single control parameter tuned to drive a quadruped through a complete dynamic trotting scenario, with acceleration from stance, constant speed locomotion, and deceleration. The method can serve as a tool for generating robust running locomotion at a wide range of speeds, or as a basis for other high level controllers. The presented ideas are evaluated through simulation experiments with a 2d dynamic model of four three-segment legs.

ThBT2 Edessa

Networked Systems II (Regular Session)

Chair: Dimarogonas, Dimos V. — Royal Inst. of Tech. (KTH)

Co-Chair: Bertelsmeier, Fabian — Fraunhofer Res. Inst. Mechatronic Systems Design

14:30-14:50 ThBT2.1

Dual Protocol Performance Using WiFi and Zigbee for Industrial WLAN, pp. 749-754

Afifi, Ghada — American Univ. in Cairo

Halawa, Hassan — American Univ. in Cairo

Daoud, Ramez — American Univ. in Cairo

Amer, Hassanein — American Univ. in Cairo

This paper evaluates the performance of an industrial Wireless Networked Control System (WNCS) that is based on utilizing two parallel protocols for communication namely Zigbee and WiFi. The proposed WNCS demonstrates the combined advantages of both the IEEE 802.15.4 protocol (which ZigBee is based on) without modifications being low cost and low power compared to other wireless technologies as well the advantages of WiFi being increased bit rate and higher immunity to noise. OMNeT++ simulations are used to measure the end-to-end delay and packet loss from the sensors to the controller and from the controller to the actuators. It demonstrates that the measured delay of the proposed WNCS including all types of transmission, encapsulation, de-capsulation, queuing and propagation, meet real-time control network requirements while guaranteeing correct packet reception with no packet loss. Moreover, it shows that the demonstrated performance of the proposed WNCS operating redundantly with WiFi and Zigbee networks in parallel is significantly superior to a WNCS operating on either a totally wireless Zigbee or WiFi network individually in terms of measured delay and interference tolerance. All results presented in this study were based on a 95% confidence analysis.

14:50-15:10 ThBT2.2

Development and Design of Intelligent Product Carriers for Flexible Networked Control of Distributed Manufacturing Processes, pp. 755-760

Bertelsmeier, Fabian — Fraunhofer Res. Inst. Mechatronic Systems Design

Schoene, Stefan — Fraunhofer Res. Inst. Mechatronic Systems Design

Traechtler, Ansgar — Univ. of Paderborn

In the area of product-based control of manufac- turing processes, the potential to integrate intelligent products in process control has been recognized several times. However, the requirements of greatly varying intelligent products on the networked control and hybrid system dynamics of the distributed individual (sub-) processes have not been investigated. This paper begins with definitions of product-intelligence and distributed data and interface model. Based on this, a networked decentralized control structure with different intelligent products as a function of varying product properties is presented. In addition, the requirements for the design of intelligent products are presented. Through the implementation, it has been shown that the intelligent workpiece carrier represents a further module in the realization of cyber-physical production systems (CPPS) through comprehensive analysis and synthesis of a highly flexible distributed control.

15:10-15:30 ThBT2.3

Coverage Coordination in Self-Organizing Femtocell Networks, pp. 761-766

Senel, Kamil — Bogazici Univ

Akar, Mehmet — Bogazici Univ

In this paper, a novel coverage adjustment algorithm to be used in femtocell networks is proposed. An important aspect of the proposed algorithm is that channel state information is not required in the adjustment process. Moreover, perfect fairness among users is achieved in a distributed manner with minimal information exchange. The theoretical analysis shows the convergence of the proposed algorithm under dynamic conditions. The performance is further verified by simulations and comparisons to other algorithms.

15:30-15:50 ThBT2.4

On Topological Conditions to Maintain Leader-Follower Connectivity in Double-Integrator Multi-Agent Systems, pp. 767-772

Köhler, Philipp N. — Univ. of Stuttgart

Dimarogonas, Dimos V. — Royal Inst. of Tech. (KTH)

In this work, a set of sufficient conditions that guarantee consensus towards a pre-specified target state in double-integrator leader-follower proximity-based networks are derived. Since only the leader agents are aware of the global objective and proximity-based communication between agents is considered, the follower agents must not lose contact to the leaders. We establish a connectivity analysis framework which is used to show that the initial network topology is maintained if the ratio of leaders-to-followers and the magnitude of the goal attraction force experienced by the leaders are below certain bounds. Various network topologies are examined, starting from a complete graph and extending to incomplete graphs. The theoretical results are illustrated by simulations.

15:50-16:10 ThBT2.5

Critical Node Detection Based on Attacker Preferences, pp. 773-778

Faramondi, Luca — Univ. Degli Studi Roma Tre

Oliva, Gabriele — Univ. Degli Studi Roma Tre

Pascucci, Federica — Univ. Degli Studi Roma Tre

Panzieri, Stefano — Univ. Degli Studi Roma Tre

Setola, Roberto — Univ. Campus BioMedico of Rome

The identification of Critical Nodes in technological, biological and social networks is a fundamental task in order to comprehend the behavior of such networks and to implement protection or intervention strategies aimed at reducing the network vulnerability. In this paper we focus on the perspective of an attacker that aims at disconnecting the network in several connected components, and

we provide a formulation of the attacker behavior in terms of an optimization problem with two concurrent objectives: maximizing the damage dealt while minimizing the cost or effort of the attack. Such objectives are mediated according to the subjective preferences of the attacker. Specifically, the attacker identifies a set of nodes to be removed in order to disconnect the network in at least m connected components; the final objective is from one side to minimize the number of attacked nodes, and from another side to minimize the size of the largest connected component. We complement the paper by providing an heuristic approach to calculate an admissible solution to the problem at hand, based on the line graph of the original network topology and on the spectral clustering methodology.

16:10-16:30 ThBT2.6

Distributed Drift Estimation for Time Synchronization in Lossy Networks, pp. 779-784

Stankovic, Milos S. Univ. of Belgrade
Stankovic, Srdjan Univ. of Belgrade, Serbia
Johansson, Karl Henrik Royal Inst. of Tech

Two distributed asynchronous drift estimation algorithms for time synchronization in networks with random communication delays and measurement noise are proposed. The algorithms are superior to similar existing methods. Convergence of the algorithms to consensus in the mean square sense and w.p.1 is proved. Rate of convergence of the algorithms is analyzed. It is also shown that the algorithms can be applied as flooding algorithms, with one reference node. Illustrative simulation results are also given.

ThBT3 Naoussa

Identification II (Regular Session)

Chair: Pigeon, Eric GREYC
Co-Chair: Mamikoglu, Umut Luleå Univ. of Tech

14:30-14:50 ThBT3.1

Elbow Joint Angle Estimation by Using Integrated Surface Electromyography, pp. 785-790

Mamikoglu, Umut Luleå Univ. of Tech
Nikolakopoulos, George Luleå Univ. of Tech. Sweden
Pauelsen, Mascha Luleå Univ. of Tech
Varagnolo, Damiano Luleå Univ. of Tech
Röijezon, Ulrik Luleå Univ. of Tech
Gustafsson, Thomas Luleå Univ. of Tech

Electromyography (EMG) signals represent the electrical activation of skeletal muscles and contain valuable information about muscular activity. Estimation of the joint movements by using surface EMG signals has great importance as a bio-inspired approach for the control of robotic limbs and prosthetics. However, interpreting surface EMG measurements is challenging due to the nonlinearity and user dependency of the muscle dynamics. Hence it requires complex computational methods to map the EMG signals and corresponding limb motions. To solve this challenge, we here propose to use an integrated EMG signal to identify the EMG-joint angle relation instead of using common EMG processing techniques. Then we estimate the joint angles for elbow flexion-extension movement by using an auto-regressive integrated moving average with exogenous input (ARIMAX) model, which takes integrated EMG measurements as input. The experiments showed that the suggested approach results in a 21.85% average increase in the estimation performance of the elbow joint angle compared to the standard EMG processing and identification.

14:50-15:10 ThBT3.2

Identification of Circadian Rhythm, pp. 791-796

Pigeon, Eric GREYC
Fabin, Jean-Baptiste EnsiCaen
Pouliquen, Mathieu Univ. of Caen
Mauvieux, Benoit Univ. of Caen
Gehan, Olivier ENSICAEN
Ménard, Tomas GREYC
Goudjil, Abdelhak Univ. of Caen Normandy
Moussay, Sébastien Univ. of Caen

We present an identification algorithm for determining the variables characterizing a circadian rhythm. This method is based on a recursive least square algorithm combined with an appropriate observer. It has the advantage of determining all the parameters of a time-varying circadian rhythm without requiring the knowledge of the period. A comparison study with respect to the Lomb & Scargle method has been carried out to show the effectiveness of the proposed method. The presented algorithm has been applied to data collected during a laboratory experiment.

15:10-15:30 ThBT3.3

Data-Driven Identification of Two-Phase Microfluidic Flows, pp. 797-802

Cairone, Fabiana Univ. Degli Studi Di Catania
Bucolo, Maide Univ. Degli Studi Di Catania

A data driven approach for the identification of fast two-phase flow nonlinear dynamics was investigated with the characteristics to be easily adopted in different experimental conditions and embedded in a portable device for real-time applications. Two experimental campaigns were conducted using different inputs flow rates and the optical signals acquired were processed and used for the identification step. Starting from the optical process monitoring, an analysis procedure in the frequency domain for the flow characterization was developed and a classification based on bubble frequency obtained. The nonlinear autoregressive with exogene input (NLARX) technique based on the wavelet network was used as identification method for the bubble flow modeling. To evaluate the models performance both in time and frequency domain, two errors were used. Two types of data patterns were considered. In the single patterns a model per experiment was identified and in the collective pattern the same model was used for more experiments.

15:30-15:50 ThBT3.4

Multi-Variable Industrial Processes Identification : Case of Bubbling Fluidized Bed Sewage Sludge Incinerator, pp. 803-808

Rabah, Souad UPJV Amiens
Chadli, Mohammed Univ. De Picardie-Jules Verne

Regarding the new standards and environmental legislation, the research area of automatic bioprocesses is in sharp increase. This aims at improving performance of biological treatment processes. Facing the growth of urban wastewater treatment plants and toxic quality of sewage sludge, the incineration represents one of the potential methods that manage the large amount of generated sludge and reduce toxicity. In this goal, the daily operating cycle treatment and the implementation mechanisms have increased the need to take measures in order to analyse and control the effluents incineration variables. In this research, we present an identification model related to a sewage sludge incineration process based on subspace N4SID algorithms. As a result, a mathematical model has been developed and simulation output data were compared with real incineration measurement.

15:50-16:10 ThBT3.5

Maritime Surveillance, Vessel Route Estimation and Alerts Using AIS Data, pp. 809-813

Patmanidis, Spyridon National Tech. Univ. of Athens
Voulgaris, Iasonas ISI Hellas SA

Sarri, Elena — National Tech. Univ. of Athens (NTUA)
Papavassilopoulos, George P. — Univ. of Southern California
Papavasileiou, George — Isihellas Sa

This paper focuses on estimating the route of a vessel and detecting abnormal behaviors based on AIS data. Linear Filtering using ARMA models is proposed in order to create trajectory forecast. Furthermore, various alert criteria are set expressing different abnormalities. The software application created to test the proposed methodology is presented. AIS data collected from Saronikos Bay were used and the results show that the program could successfully monitor the bay in real time and report abnormalities in vessel behavior.

16:10-16:30 ThBT3.6

Analytical and Numerical Studies of Sonic Drillstring Dynamics, pp. 814-819

Ibrahim, Mnafeg — EPT
Abichou, Azgal — Pol. School of Tunisia
Beji, Lotfi — Univ. of Evry

In tunnel excavation, according to a geological shooting map for underground support, drilling of holes with limited depht is necessary. Machines with drillstring resonant frequency based input had proved their effectiveness in soil penetration. Finite element analysis (FEA) is commonly used to understand a drillstring dynamic behavior. In this paper, we quantify the system dynamics analytically and the influence of control variables of a sonic drill system. Guided by frequency analysis, it was established that the control system should preserve the resonant mode and the weight on the bit as the primary two control variables. From the temporal responses a tradeoff between the drill-bit amplitude, the resonant frequency and the drill system capability must be ensured.

ThBT4 — Pella

Unmanned Systems Control (Regular Session)

Chair: Ribeiro Lustosa, Leandro — ISAE-SUPAERO
Co-Chair: Quevedo, Joseba — Tech. Univ. of Catalonia

14:30-14:50 ThBT4.1

Adaptive Integral Sliding Mode Controller for Longitudinal Rotation Control of a Tilt-Rotor Aircraft, pp. 820-825

Kim, Jinho — Univ. of Maryland, Baltimore County
Gadsden, Stephen Andrew — Univ. of Maryland, Baltimore County
Wilkerson, Stephen — The Army Res. Lab

This paper presents an adaptive integral sliding mode controller for longitudinal rotation control of a tilt-rotor aircraft (TRA). The moveable mass, which slides along the wing of the TRA, is considered an unknown disturbance in this paper. The simplified dynamics of the TRA is proposed for the control of the longitudinal rotation during its landing, and application of the adaptive integral sliding mode controller is presented. In the design process of the controller, we applied a sliding surface including an integral term for reinforcing the control performance of the system. This paper compares the results of applying a PID controller and the adaptive integral sliding mode controller with the proposed sliding surface for improved robustness and stability to unknown disturbance.

14:50-15:10 ThBT4.2

Nonlinear Control of a Particular Tilt-Body MAV: The Roll&Fly, pp. 826-831

Alheritiere, Pierre Antoine — ISAE-SUPAERO - DCAS - Univ. De Toulouse
Olivanti, Romain — ISAE-SUPAERO - DCAS - Univ. De Toulouse
Ribeiro Lustosa, Leandro — ISAE-SUPAERO
Defay, François — ISAE-SUPAERO
Moschetta, Jean-Marc — Inst. Superieur De L'aeronautique Et De L'espace - ISAE

This paper details the design of a nonlinear controller for the Roll&Fly mode of a wheeled tilt-body micro air vehicle (MAV), developed at ISAE-SUPAERO, called the MAVion. The Roll&Fly mode consists in flying while rolling on walls or onto the ground to guide or increase the range of the MAV during detection or inspection missions. It therefore implies wall or ground mechanical interactions that calls for nontrivial control laws. Our approach consists in enabling a nonlinear obstacle-free attitude/height controller to adapt itself to wall interactions. The controller regulates the velocity and attitude of the drone by means of an approach based on backstepping and feedback linearization techniques. The attitude controller is parametrized by quaternion algebra to avoid orientation singularities.

15:10-15:30 ThBT4.3

A Novel Concept of Attitude Control for Large Multirotor-UAVs Based on Moving Mass Control, pp. 832-839

Haus, Tomislav — Univ. of Zagreb
Prkut, Nikola — Univ. of Zagreb
Borovina, Katarina — Univ. of Zagreb
Maric, Bruno — Univ. of Zagreb
Orsag, Matko — Univ. of Zagreb
Bogdan, Stjepan — Univ. of Zagreb

In this work we aim to explore the concept of using the shift in the center of gravity, which in turn produces roll and pitch moments, to control the attitude of the quadrotor. We propose constructing a UAV with moving masses within each rotor arm. In this paper we show the mathematical equations describing the dynamics of the proposed system, propose a classical PID based control approach and analyze and confirm its stability. Furthermore, we analyze the effectiveness of the proposed controller in a Gazebo based simulation environment. Finally, we build a laboratory testbed that emulates the dynam- ics of the system and test our proposed control strategy.

15:30-15:50 ThBT4.4

Design, Modelling and Control of a Single Rotor UAV, pp. 840-845

Carholt, Christoffer — Luleå Univ. of Tech
Fresk, Emil — Luleå Univ. of Tech
Andrikopoulos, George — Luleå Univ. of Tech
Nikolakopoulos, George — Luleå Univ. of Tech. Sweden

In this article, a novel Vertical Take-Off and Landing (VTOL) Single Rotor Unmanned Aerial Vehicle (SRUAV) will be presented. The SRUAV's design properties will be analysed in detail, with respect to technical novelties outlining the merits of such a conceptual approach. The system's model will be mathematically formulated, while a cascaded P-PI and PID-based control structure will be utilized in extensive simulation trials for the preliminary evaluation of the SR-UAV's attitude and translational performance.

15:50-16:10 ThBT4.5

Comparison of Two Non-Linear Model-Based Control Strategies for Autonomous Vehicles, pp. 846-851

Alcala, Eugenio — UPC
Sellart, Laura — CVC-UAB
Puig, Vicenç — Univ. Pol. De Catalunya (UPC)

Quevedo, Joseba — Tech. Univ. of Catalonia
Saludes, Jordi — UPC
Vazquez, David — CVC-UAB
López, Antonio — CVC-UAB

This paper presents the comparison of two nonlinear model-based control strategies for autonomous cars. A control oriented model of vehicle based on a bicycle model is used. The two control strategies use a model reference approach. Using this approach, the error dynamics model is developed. Both controllers receive as input the longitudinal, lateral and orientation errors generating as control outputs the steering angle and the velocity of the vehicle. The first control approach is based on a non-linear control law that is designed by means of the Lyapunov direct approach. The second approach is based on a sliding mode-control that defines a set of sliding surfaces over which the error trajectories will converge. The main advantage of the sliding-control technique is the robustness against non-linearities and parametric uncertainties in the model. However, the main drawback of first order sliding mode is the chattering, so it has been implemented a high order sliding mode control. To test and compare the proposed control strategies, different path following scenarios are used in simulation.

16:10-16:30 ThBT4.6

Flatness-Based Control for a Quadrotor Camera Helicopter Using Model Predictive Control Trajectory Generation, pp. 852-859

Engelhardt, Thomas — RWTH Aachen Univ
Konrad, Thomas — RWTH Aachen Univ
Schäfer, Björn Erwin — RWTH Aachen Univ
Abel, Dirk — RWTH Aachen Univ

This paper addresses a flatness-based controller and a Model Predictive Control (MPC) trajectory generation for a quadrotor camera helicopter. Applications like aerial videography can highly benefit from an automation of the pilot's tasks, enabling the camera operator to solely focus on camera motion control. The coupled nonlinear system dynamics of a quadrotor pose difficulties precisely controlling several channels simultaneously for agile maneuvering using conventional controllers. A flatness-based approach is employed to obtain linear input-output dynamics, even for large attitude angles. The associated state feedback equations are explicitly derived. The resulting linear system dynamics are controlled using a cascaded proportional control structure. Feasible reference trajectories are generated using a linear MPC, which translates operator commands for camera motions - e.g. relative to a point-of-interest - into quadrotor trajectories complying with operational constraints. Flatness-based controller and MPC trajectory generation show tracking errors below 1% in simulation tests. Accurate and smooth positioning is achieved in first indoor test flights. The gained results motivate adoptions of the proposed control approach to other UAV applications with similar demands for pilot automation and accuracy.

ThBT5 — Mycenae

Nonlinear Systems and Control (Regular Session)

Chair: Hasan, Agus — Norwegian Univ. of Science and Tech
Co-Chair: Zivanovic, Rastko — The Univ. of Adelaide

14:30-14:50 ThBT5.1

Nonlinear Tracking Control Scheme for a Nanopositioner, pp. 860-865

Vagia, Marialena — Sintef Ict
Eielsen, Arnfinn Aas — NTNU
Gravdahl, Jan Tommy — Norwegian Univ. of Science & Tech
Pettersen, Kristin Y. — Norwegian Univ. of Science and Tech

The ability to track periodic reference trajectory signals fast and with good accuracy, is highly required in many different nanopositioning applications. Since different factors can affect the performance of such devices, like lightly damped resonances and actuator nonlinearties including hysteresis and creep, a number of control schemes have been presented in order to overcome these difficulties, in the recent literature. In the present paper a nonlinear feedback controller is proposed that includes both force and tracking control of a nanopositioner. The nonlinear controller is an augmentation of a linear integral force controller where the constant gain used in the integral force feedback, is replaced by a passive nonlinear operator. The nonlinear control law provides improved performance with regards to disturbance rejection and vibration damping over the linear control law. In addition, a feedback component is added. The stability of the overall closed loop system is analysed using the multivariable Popov criterion.

14:50-15:10 ThBT5.2

Continuation Via Quadratic Approximation to Reconstruct Solution Branches and Locate Singularities in the Power Flow Problem, pp. 866-870

Zivanovic, Rastko — The Univ. of Adelaide

Application of the analytic continuation, based on the quadratic approximation, is able to reconstruct solution branches of a non-linear power flow problem, as well as to locate important singularities. The paper describes the quadratic approximation method, and compares its performance with the Pade-type approximation. Simulation examples are devised to demonstrate superiority of the proposed method compared to results of the Pade approximant, for this type of non-linear problem.

15:10-15:30 ThBT5.3

Output-Feedback Stabilization of the Korteweg De-Vries Equation, pp. 871-876

Hasan, Agus — Norwegian Univ. of Science and Tech

The present paper develops boundary output-feedback stabilization of the Korteweg-de Vries (KdV) equation with sensors and actuators are located at different boundaries (anti collocated set-up) using backstepping method. The feedback control law and the output injection gains are developed from the backstepping method for the linear KdV equation. The novelty of this paper is the nonlinear observer for the KdV equation. Furthermore, proof of stability is based on construction of a strict Lyapunov functional which includes the observer states. A numerical simulation is presented to validate the result.

15:30-15:50 ThBT5.4

Manipulating the Sludge Flow to Increase Methane Production and to Reduce Effluent Pollution in Wastewater Treatment Plants, pp. 877-882

Santin, Ignacio — Univ. Autonoma De Barcelona
Vilanova, Ramon — Univ. Autonoma De Barcelona
Barbu, Marian — Dunarea De Jos Univ. of Galati
Pedret, Carles — Univ. Autonoma De Barcelona

The present work deals with the manipulation of the sludge in a wastewater treatment plant. Concretely, this is done by varying wastage flow rate (Qw) and external recycle flow rate (Qr). Benchmark Simulation Model No. 2 is used as testing scenario. The objective of the proposed implementation is to reduce costs and/or limits violations of pollutants in the effluent. Ammonium and ammonia nitrogen (SNH) in the effluent (SNH, e) and total nitrogen (SNtot) in the effluent (SNtot, e) are the pollutants that are more difficult to be kept below the limits. Due to this reason, the manipulation of Qw and Qr is based on these pollutants. In the case

of Qw, its variation must consider a relationship between the sludge that is led to the anaerobic digester for methane production and the sludge that remains in the biological treatment. As Qw variation needs time to produce an effect on the variables of the plant, Qw is manipulated based on the maximum SNH and SNtot values estimated for the next two days. On the other hand, the variations of Qr have faster effects than Qw. On basis to this fact, Qr is manipulated to reduce SNH, e and SNtot,e peaks, but only when a risk of effluent limits violations is detected. This risk is detected by an artificial neural network based on some variables of the plant.

15:50-16:10 ThBT5.5

Control of Multi-Machine Power Systems with Constant Communication Time-Delay, pp. 883-888

Furtat, Igor — Inst. of Problems of Mechanical Engineering Russian Acad

Gromov, Vladislav — ITMO Univ

The paper describes the robust control of multi-machine power systems under uncertainties and constant communication time-delay. We assume that only relative speeds of each generator are available for measurement. The proposed algorithm ensures the synchronization of the multi-machine power system with the required accuracy in the normal mode and symmetrical 3-phase short circuit faults which occur on transmission lines.

16:10-16:30 ThBT5.6

A Notion of Dissipativity for Discrete Event Systems, pp. 889-894

McCourt, Michael J. — Univ. of Florida

Antsaklis, Panos J. — Univ. of Notre Dame

Dissipativity is a useful tool for analyzing and synthesizing stable feedback systems. Briefly, the property of dissipativity is that a system only stores and dissipates energy, with respect to a given energy storage function, and does not generate its own energy. This property carries a strong reliance on a notion of time that prohibits its direct application to discrete event systems (DES). The current paper takes the concept of dissipativity and applies it to DES by replacing the notion of time with an event-based definition. Two notions of dissipativity are defined, one for finite automata and the other for a general class of DES. For each notion, properties of dissipative DES are shown that connect with existing notions of stability for DES as would be expected from the classical definition of dissipativity. Examples are provided to illustrate the methods covered in the paper.

ThCT1 Kozani

Robotics III (Regular Session)

Chair: Moustris, George — National Tech. Univ. of Athens

Co-Chair: Perez Montenegro, Carlos Norberto — Pol. Di Torino

17:00-17:20 ThCT1.1

Identification and Control of a Quadrotor from Experimental Data, pp. 895-900

Lotufo, Mauricio Alejandro — Pol. Di Torino

Perez Montenegro, Carlos Norberto — Pol. Di Torino

Colangelo, Luigi — Pol. Di Torino

Canuto, Enrico — Pol. Di Torino

Novara, Carlo — Pol. Di Torino

The paper presents experimental results related to attitude control of a quadrotor rotating about a single axis. The Embedded Model Control (EMC) methodology is used for control design. Indeed, this methodology can be very effective in applications involving relevant disturbances, modeling errors and unknown nonlinearities, since it allows a cancellation of all these sources of uncertainty. EMC control design is performed from a detailed quadrotor model, where the actuator dynamics is identified from experimental data. The designed EMC controller is compared with a standard proportional-integral-derivative (PID) controller in several tests, carried out on a laboratory testbench.

17:20-17:40 ThCT1.2

Numerical Stability of Inverse Simulation Algorithms Applied to Planetary Rover Navigation, pp. 901-906

Flessa, Thaleia — Univ. of Glasgow, School of Engineering, Div. of Aerosp

McGookin, Euan — Div. of Aerospace Sciences, School of Engineering, Univ

Thomson, Douglas — Div. of Aerospace Sciences, School of Engineering, Univ

Extending the navigational capability of planetary rovers is essential for increasing the scientific outputs from such exploratory missions. In this paper a navigation method based on Inverse Simulation is applied to a four-wheel rover. The method calculates the required control inputs to achieve a desired, specified response. Here this is a desired trajectory defined as a series of waypoints. Inverse Simulation considers the complete system dynamics of the rover to calculate the control input using an iterative, numerical Newton – Raphson scheme. The paper provides an insight into the numerical parameters that affect the performance of the method. Also, the influence of varying the timestep and the convergence tolerance is examined in terms of the quality of the calculated control input and the resulting trajectory, as well as the execution time. From this analysis a set of parameters and recommendations to successfully apply Inverse Simulation to a rover is presented.

17:40-18:00 ThCT1.3

Fault Tolerant Collaborative Localization for Multi-Robot System, pp. 907-913

Al Hage, Joelle — Univ. of Lille , Lab. CRIStAL

El Badaoui El Najjar, Maan — LAGIS FRE CNRS 3033 Univ. De Lille 1 (France)

Pomorski, Denis — LAGIS FRE CNRS 3033 -Univ. De Lile 1 (FRANCE)

Multi-robot system is used in some unreachable or dangerous area in order to replace the human operators. In such environments the integrity of localization should be assured by adding a sensor fault diagnosis step. In this paper, we present a method able, in addition of localizing a group of robots, to detect and exclude the faulty sensors from the team. The estimator is the informational form of the Kalman Filter (KF) namely Information Filter (IF). The developed residual test is based on the divergence between the predicted and the corrected estimation of the IF, calculated in term of the Kullback-Leibler divergence (KLD). The main contributions of this paper: - developing a method able simultaneously to localize a group of robots and to detect the faulty sensor - using the information filter and the KLD as a residual test - Application of the proposed framework to a real environment with real robots.

18:00-18:20 ThCT1.4

SURF and Image Processing Techniques Applied to an Autonomous Overhead Crane, pp. 914-918

Kajkouj, Majdeddin — Philadelphia Univ

AlShaer, Samer — Philadelphia Univ

Hatamleh, Khaled — Jordan Univ. of Science and Tech

Salameh, Iyad — Philadelphia Univ

Al-Shabi, Mohammad — Univ. of Sharjah

Gadsden, Stephen Andrew — Univ. of Maryland, Baltimore County

Lee, Andrew — Univ. of Maryland, Baltimore

County

This work presents the use of an autonomous overhead crane that detects a moving object. The crane matches the velocity of the object while its grabbers extend to reach its location. The position and velocity of the object are detected and tracked once the object is in range of the crane. This is achieved using image processing and image enhancement techniques. The SURF (speeded-up robust features) algorithm is used to extract the object's features and then detect its location. The centroid of the object and its location are calculated continuously to obtain the targeted position and velocity. A digital PID (proportional integral derivative) controller is used to control the crane's three DC (direct current) motors in order to acquire the target with a desired performance, such as a fast response and less than 2% overshoot. The proposed mechanism reduces the processing time of an industrial application which increases the productivity rate. The mechanism was built for experimentation and the algorithm and the controller were experimentally verified and validated.

18:20-18:40 ThCT1.5

Simplifying Mobile Robot Tracking Control through Feedback Equivalence, pp. 919-924

Moustris, George — National Tech. Univ. of Athens
Tzafestas, Costas — National Tech. Univ. of Athens

In this paper a feedback equivalence map that simplifies the motion control of mobile robots is presented. The map applies to the path tracking and the trajectory tracking tasks for non-holonomic mobile robots. A diffeomorphism that maps the reference path in the original domain, to a straight line in the transformed domain is also introduced. It is shown that this map can be extended to the entire state space and, when applied, the resulting system equations have the same form with the original model. This allows the simplification of motion control since the problem is now reduced to the tracking of straight lines. However, since the models are the same, one can use existing tracking controllers and tailor them to track only straight lines, thus reducing their complexity, or use existing straight line tracking controllers, and apply them to curved reference paths. An analysis of the type of paths that allow for this transformation is also presented along with simulation results.

ThCT2 Edessa

Power Systems and Smart Grid (Regular Session)

Chair: Konstantopoulos, George — The Univ. of Sheffield
Co-Chair: Alexandridis, Antonios — Univ. of Patras

17:00-17:20 ThCT2.1

Optimal Energy-Based Stabilizing Controllers for DC-DC Converters, pp. 925-930

Yfoulis, Christos — Alexander Tech. Inst
Giaouris, Damian — Centre for Res. and Tech. Hellas
Ziogou, Chrysovalantou — Centre for Res. and Tech. Hellas (CERTH)
Stergiopoulos, Fotis — Centre for Res. and Tech. Hellas (CERTH)
Voutetakis, Spyridon — Centre for Res. and Tech. Hellas (CERTH)
Papadopoulou, Simira — Alexander Tech. Educational Inst

This paper aims at presenting new ideas and insights towards a novel optimal energy-based stabilizing control approach for power electronic converters. The stabilizing or Lyapunov-based control paradigm is well-known in the area of energy-based control of DC-DC converters. Such laws rely on an energy-based Lyapunov function to control the speed of the energy dissipation by which power electronic converters reach their steady-state operation and are parameterized by a positive scalar $lambda$, whose selection is critical for the performance of the closed-loop system. A typical optimal control problem for stabilizing control laws is formulated, whose solution involves the search for the optimal value for $lambda$. Two different averaging continuous-time models for DC-DC converters are adopted (nonlinear and linearized) and corresponding methods for solving the optimal control problem are presented. In the general nonlinear case, the optimal control problem is reduced to a nonlinear optimization problem for which analytical gradient information is available. In the linearized case, the optimal control problem is reduced to a simple optimization problem of finding the minima of a polynomial function of $lambda$. The methods are evaluated in a boost converter using simulation.

17:20-17:40 ThCT2.2

State-Feedback Control of an Interleaved DC-DC Boost Converter, pp. 931-936

Gkizas, Georgios — Automation Engineering Department, Alexander Tech. Educa
Amanatidis, Christos — Automation Engineering Department, Alexander Tech. Educa
Yfoulis, Christos — Alexander Tech. Inst
Stergiopoulos, Fotis — Centre for Res. and Tech. Hellas (CERTH)
Giaouris, Damian — Centre for Res. and Tech. Hellas
Ziogou, Chrysovalantou — Centre for Res. and Tech. Hellas (CERTH)
Voutetakis, Spyridon — Centre for Res. and Tech. Hellas (CERTH)
Papadopoulou, Simira — Alexander Tech. Educational Inst

This paper extends a recently proposed state-feedback control design method from a simple DC-DC boost converter to a multi-phase interleaved DC-DC boost converter with an arbitrary number of legs. Both static and dynamic state-feedback pole placement control laws are considered. In the case of static state-feedback control a bifurcation analysis procedure that can predict the generation of multiple equilibria is introduced. This analysis can be integrated into the control design so that multiple equilibria can be completely avoided or ruled out of the operating region of interest. %A novel feature of our approach is that the design can be performed using two dimensional linearized averaged dynamics, due to symmetry and independent control of different legs. The proposed control laws are digitally implemented and verified in a 2-leg case study using both simulation and real experimentation.

17:40-18:00 ThCT2.3

Control and Stability Analysis of Inverter-Dominated Autonomous Distributed Generation Power Systems, pp. 937-942

Makrygiorgou, Despoina — Univ. of Patras
Alexandridis, Antonios — Univ. of Patras

In distributed generation (DG), the voltage source inverter provides excellent control capabilities which are absolutely necessary, especially when DG is in stand-alone mode. As a consequence, the stability analysis of an autonomous DG system with the controllers incorporated is a challenging issue. In the present paper, based on the accurate complete power system/inverter model and adopting the well-known and practically used cascaded controller structure, a rigorous stability analysis is conducted. Particularly, in this scheme, the inner-loop controllers are considered to be fast proportional-integral (PI) current controllers with decoupling terms and the outer-loop ones to be slower standard PI controllers that provide the current references of the inner-loops in accordance to the frequency/voltage regulation tasks. As it is proven, the system with the fast inner-loop current controllers included, is globally

stable and converges at steady state to the desired nonzero equilibrium. The overall analysis is based on the input-to-state (ISS) notion and its extensions while Lyapunov techniques are applied on the full-order system. Thus, the stability of this kind of controllers, proven up to now only for a simple inverter device, it is effectively guaranteed for a complete DG system. As expected, the simulation results of such a complete system fully verify the theoretical analysis.

18:00-18:20 ThCT2.4

Power Grid Modeling Based on the Electromechanical Energy Approach Aiming Power Systems Stability Studies, pp. 943-948

Trentini, Rodrigo — Hochschule Hannover
Kutzner, Rüdiger — Hochschule Hannover
Hofmann, Lutz — Leibniz Univ. Hannover

This paper presents a new modeling approach for power systems aiming its small-signal stability analysis. The work employs an electromechanical correspondence for the electrical grid along with the Lagrangian Energy Method for obtaining system's differential equations. The approach generalizes the so-called Steady-State one, introducing a full matrix for the damping coefficients, which in practice are responsible for damping the oscillations between machines, i.e. the inter-area modes. Modal Analysis results show that the proposed method reaches up to 96% of accuracy for two exemplary benchmark system when compared to simulations from a specialized power systems software.

18:20-18:40 ThCT2.5

Nonlinear Control of Dc/dc Power Converters with Inherent Current and Power Limitation, pp. 949-954

Konstantopoulos, George — The Univ. of Sheffield
Zhong, Qing-Chang — The Univ. of Sheffield

A nonlinear controller with an inherent current-limiting capability is presented in this paper for different types of dc/dc power converters (boost, buck-boost). The proposed controller is based on the idea of applying a dynamic virtual resistance in series with the inductor of the converter, which varies according to a nonlinear dynamical system. It is shown that the proposed approach acts independently from the converter parameters (inductance, capacitance) or the load and has a generic structure that can be used to achieve different regulation scenarios, e.g. voltage, current or power regulation. Based on the nonlinear model of the boost and the buck-boost converter, it is analytically proven that the inductor current remains always bounded below a given maximum value using input-to-state stability theory under a suitable choice of the controller parameters. Hence, the proposed control strategy offers an inherent protection property since the power of the converter is limited below a given value during transients or unrealistic power demands. Simulation results for both types of dc/dc converters are presented to verify the desired controller performance.

18:40-19:00 ThCT2.6

On the Control of Energy Storage Systems for Electric Vehicles Fast Charging in Service Areas, pp. 955-960

Di Giorgio, Alessandro — Univ. of Rome "La Sapienza"
Liberati, Francesco — Ec. Univ
Germanà, Roberto — Univ. of Rome "La Sapienza"
Presciuttini, Marco — Univ. of Rome "La Sapienza"
Ricciardi Celsi, Lorenzo — Univ. Di Roma "La Sapienza"
Delli Priscoli, Francesco — Univ. Di Roma

This paper presents a real time control strategy for energy storage systems integration in electric vehicles fast charging applications combined with generation from intermittent renewable energy sources. A two steps approach taking advantage of the model predictive control methodology is designed on purpose to optimally allocate the reference charging power while managing the priority among the plugged vehicles and then control the storage for efficiently sustaining the charging process. Two different use cases are considered: in the former the charging area is disconnected from the grid, so that the objective is to minimize the deviation of electric vehicles charging power from the nominal value; in the latter the focus is on the point of connection to the grid and the need of mitigating the related power flow. In both cases the fundamental requirement for feasible control system operation is to guarantee stability of the storage's state of charge over the time. Simulation results are provided and discussed in detail, showing the effectiveness of the proposed approach.

ThCT3 Room Athens3

Process Control (Regular Session)

Chair: Fabri, Simon G. — Univ. of Malta
Co-Chair: Haßkerl, Daniel — TU Dortmund Univ

17:00-17:20 ThCT3.1

Consolidation of the Controls for Turbo-Molecular Pumping Groups at CERN's Particle Accelerator Complex, pp. 961-966

Ferreira, João Rodrigo — CERN
Blanchard, Sebastien — CERN
Pigny, Gregory — CERN
Vestergard, Henrik — CERN
Gomes, Paulo — CERN

CERN is an International Organization whose chief goal is to perform fundamental particle physics research. The main tool used for such research is a complex network of particle accelerators and detectors with very demanding requirements for vacuum levels in the beam pipes, detectors, and cryogenic insulation elements.

Vacuum is partly assured by turbo-molecular pumping groups (VPG), which are for the most part PLC controlled. This paper briefly introduces the CERN accelerator complex and its vacuum installation; it then focuses on the different control architectures used for VPGs and the types of controllers employed, identifying the shortcomings that arise from having multiple models in operation.

The final aim is to converge into a unified control solution to be used in most situations, with limited variations, simplifying maintenance and new deployments over the next decades.

17:20-17:40 ThCT3.2

Application of Model-Based Experimental Design for the Calibration of Online Composition Measurement by Near-Infrared Spectroscopy, pp. 967-972

Haßkerl, Daniel — TU Dortmund Univ
Markert, Steven — TU Dortmund
Engell, Sebastian — TU Dortmund

In this contribution we investigate the application of NIR spectroscopy to a five component system that results from the transesterification reaction of dimethyl carbonate with ethanol in a reactive distillation (RD) process. We present details on the method for calibrating the spectrometer. Due to the technical conditions of the RD-process, the temperature of the liquid phase has to be considered as an additional degree of freedom, but the thermodynamic properties of the component system impose a limitation to the multivariate calibration in terms of the vapor-liquid equilibrium. In order to design an efficient set of calibrating points considering the process conditions as well as the thermodynamic limitations, we make use of model-based experimental design. We use a MATLAB® algorithm to compute the thermodynamic equilibrium and to predict the feasible temperature region for the multivariate calibration. An accurate calibration for realistic process conditions is obtained and the experimental effort for addressing infeasible calibrating points is saved. It is shown that the calibrated NIR spectroscopy reliably predicts the composition of the mixture

under the given conditions.

17:40-18:00 ThCT3.3

Design of Control Systems for Two-Phase Microfluidic Processes, pp. 973-978

Bucolo, Maide — Univ. Degli Studi Di Catania
Cairone, Fabiana — Univ. Degli Studi Di Catania

In this work a study for the design of an active control system for two-phase microfluidic processes based on the manipulation of the input flow rates is presented. A wide experimental campaign was performed using two chips with different geometries. The approach proposed takes the advantage of the optical monitoring and the on-line signal processing. Starting from the optical process monitoring, an analysis procedure for the flow characterization (referred as soft sensor), was developed and a control parameter (named delta) identified. Using this parameter, it was possible both a classification of two flow regimes in slow and fast dynamics, and a detailed characterization of flow features as, an air/water slug shortened in slow patterns, and a reduction of the slugs inter-distance and an increase of their frequency in fast patterns. Then the control system design was defined and the open loop and closed loop control laws established considering two possible control actions: a jump from one flow regime to the another or a tuning of the input flow to have a desired slugs length or frequency.

18:00-18:20 ThCT3.4

Multi-Objective Particle Swarm Optimization (MOPSO) of Lipid Accumulation in Fed-Batch Cultures, pp. 979-984

Robles-Rodriguez, Carlos Eduardo — INSA
Bideaux, Carine — INSA Toulouse
Guillouet, Stéphane — INSA Toulouse
Gorret, Nathalie — INSA Toulouse
Roux, Gilles — LAAS-CNRS
Molina-Jouve, Carole — INSA Toulouse
Aceves-Lara, Cesar Arturo — INRA-Toulouse

Dynamic optimization of fermentation processes could demand the use of multiple criteria to attain certain objectives, which in most cases are conflicting to each other. The use of Pareto optimal sets supplies the necessary information to take decisions about the trade-offs between objectives. In this work, a multi-objective optimization algorithm based on particle swarm optimization (MOPSO) is used to optimize lipid contents in fermentations with Yarrowia lipolytica. A reduced model was developed to shorten the computation time of MOPSO. A pattern search algorithm was sequentially coupled to MOPSO to execute a dynamic optimization handling physical constraints. Three cases are analyzed to emphasize the response of our control strategy. Simulation results showed that MOPSO – pattern search algorithm achieved high lipid fraction and productivity.

18:20-18:40 ThCT3.5

Modelling and Temperature Control of a Wine Fermentation Process with Solar Cooling, pp. 985-990

Fabri, Simon G. — Univ. of Malta
Agius, Joseph — Univ. of Malta
Ghirlando, Robert — Univ. of Malta
Axisa, Redeemer — Univ. of Malta

This paper presents modelling, controller design and implementation of a solar-powered vapour absorption cooling system for wine fermentation. All the major system components are modelled and simulated, and a model predictive control approach is taken to design a closed loop system for regulation of the fermentation temperatures. The system was implemented and tested during actual wine fermentation, yielding a very good control performance. This work demonstrates the potential of energy-saving cooling technologies and control system design for the wine making industry.

18:40-19:00 ThCT3.6

Control Strategies Applied in the HYSOL Demonstrator: A Simulation-Based Evaluation, pp. 991-995

Roca, Lidia — Psa - Ciemat
Bonilla, Javier — CIEMAT-Plataforma Solar De Almería
Berenguel, Manuel — Univ. of Almeria
González, Lucía — ACS/Cobra
R. Rocha, Alberto — ACS/Cobra

HYSOL project was born under the idea of designing a new hybrid concentrating solar power plant concept fully based on renewable energies and able to provide stable power. Within this project, one of the main activities is the development of a demonstrator facility to evaluate experimentally the gas turbine heat recovery and its transference to a molten-salt storage system. This paper describes the main control loops proposed to maintain the facility at different operating points to study both nominal and off-design states.

ThCT4 — Pella

UV Agent-Based Systems (Regular Session)

Chair: Valavanis, Kimon — Univ. of Denver
Co-Chair: Popescu, Dan — Pol. Univ. of Bucharest

17:00-17:20 ThCT4.1

Incorporating Learning Modules Improves Aspects of Resilience of Supervisory Cyber-Physical Systems, pp. 996-1001

Kannappan, Prasanna — Univ. of Delaware
Karydis, Konstantinos — Univ. of Pennsylvania
Tanner, Herbert G. — Univ. of Delaware
Jardine, Adam — Univ. of Delaware
Heinz, Jeffrey — Univ. of Delaware

The paper demonstrates that aspects of resilience of supervisory Cyber-Physical Systems (CPSs) can be improved through the inclusion of appropriate learning modules in the subordinate autonomous agents. During normal operation, individual agents keep track of their supervisor's commands and utilize the learning module, based on Grammatical Inference, to learn aspects of the organizational structure of the general system and role assignments. It is shown that in cases that the supervisor fails or communication to subordinates is disrupted, these agents are able to recover normalcy of operations. Guaranteeing normalcy recovery in supervisory CPSs is critical in cases of a catastrophic failure or malicious attack.

17:20-17:40 ThCT4.2

Obstacle Avoidance Via B-Spline Parametrizations of Flat Trajectories, pp. 1002-1007

Stoican, Florin — Pol. Univ. of Bucharest
Ivănuşcă, Vlad Mihai — UPB
Prodan, Ionela — Grenoble Inst. of Tech. (Grenoble INP) - Esisar
Popescu, Dan — Pol. Univ. of Bucharest

This paper considers the collision avoidance problem in a multi-agent multi-obstacle framework. The originality in solving this intensively studied problem resides in the proposed geometrical view combined with differential flatness for trajectory generation and B-splines for the flat output parametrization. Using some important properties of these theoretical tools we show that the constraints can be validated at all times. Exact and sub-optimal constructions

of the collision avoidance optimization problem are provided. The results are validated through extensive simulations over standard autonomous aerial vehicle dynamics.

17:40-18:00 ThCT4.3

Learning-Based Formal Synthesis of Cooperative Multi-Agent Systems with an Application to Robotic Coordination, pp. 1008-1013

Valavanis, Kimon — Univ. of Denver

We propose a computationally efficient framework to automatically synthesize coordination and control strategies for cooperative multi-agent systems from global tasks via “divide-and-conquer”: first the global tasks are decomposed into local ones; then local control strategies for each agent are synthesized to satisfy local tasks; finally, compositional verification technique is adopted to coordinate the collective behavior of the agents such that the fulfillment of local tasks will guarantee the satisfaction of the global ones. Modified L algorithms are adapted to both the local synthesis and the compositional verification. In this paper, the co-design framework is applied to multi-robot coordination. The paper concludes with the presentation of a series of computational and software tools developed to integrate automatic supervisor synthesis and inter-robot communication so that the robots can cooperatively satisfy a request-response team performance through coordination

18:00-18:20 ThCT4.4

Reinforcement Learning-Based Motion Planning of a Triangular Floating Platform under Environmental Disturbances, pp. 1014-1019

Tziortziotis, Konstantinos — Univ. of Ioannina, Department of Computer Science and Engin

Vlachos, Kostas — Univ. of Ioannina

Blekas, Konstantinos — Univ. of Ioannina

This paper investigates the use of reinforcement learning for the motion planing of an autonomous triangular marine platform in unknown environments under various envi- ronmental disturbances. The marine platform is over-actuated, i.e. it has more control inputs than degrees of freedom. The proposed approach uses an online least-squared policy iteration scheme for value function approximation in order to estimate optimal policy. We evaluate our approach in simulation, taking under consideration the dynamics of the platform, the dynamics and limitations of the actuators, under the presence of wind, and sea current disturbances. We report simulation results concerning its performance on estimating optimal navigation policies to unknown environments. Despite the model dynamics, the actuation dynamics and limitations, and the environmental disturbances, the presented results are promising.

18:20-18:40 ThCT4.5

Immune-System Inspired Approach for Decentralized Multi-Agent Control (I), pp. 1020-1025

German, Servando — Cranfield Univ

Shin, Hyo-Sang — Cranfield Univ

Tsourdos, Antonios — Cranfield Univ

This paper contains the first steps towards the development of a fully decentralized system framework. The novel approach that has been taken is derived from the inherent properties of the immune system. An assessment of the proposed control architecture has been performed by comparison with a more typical approach under a search and suppress kind of mission for an unmanned fleet.

ThCT5 Mycenae

Game Theory (Regular Session)

Chair: Glizer, Valery Y. — ORT Braude Coll. of Engineering

Co-Chair: Kyriakopoulos, Kostas J. — National Tech. Univ. of Athens

17:00-17:20 ThCT5.1

Network Design for Fast Convergence to the Nash Equilibrium in a Class of Repeated Games, pp. 1026-1032

Kordonis, Ioannis — NTUA

Papavassilopoulos, George P. — Univ. of Southern California

This work studies the problem of designing a Network such that a set of dynamic rules, in a class of repeated games, converges quickly to the Nash equilibrium. Particularly a very simple class of repeated games with mean field interactions is considered and we assume that the actions of the participants are determined using some simple myopic gradient based dynamic rules. The information about the actions of the other players is transmitted through a Network, using some consensus type dynamics. The speed of the convergence to equilibrium is characterized, using the Lyapunov equation involving a Laplacian like matrix. A topology optimization problem for the communication graph is then stated and an algorithm, based on the effects of new edges to the speed of convergence, is proposed. Numerical results are also given.

17:20-17:40 ThCT5.2

A Distributed Load Balancing Algorithm for the Control Plane in Software Defined Networking, pp. 1033-1040

Cimorelli, Federico — Univ. of Rome "La Sapienza"

Delli Priscoli, Francesco — Univ. Di Roma

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

Ricciardi Celsi, Lorenzo — Univ. Di Roma "La Sapienza"

Suraci, Vincenzo — Univ. Degli Studi E-Campus

Zuccaro, Letterio — Univ. of Rome "La Sapienza"

The increasing demand of bandwidth, low latency and reliability, even in mobile scenarios, has pushed the evolution of the networking technologies in order to satisfy the requirements of innovative services. In this context, Software Defined Networking (SDN), namely a new networking paradigm that proposes the decoupling of the control plane from the forwarding plane, enables network control centralization and automation of the network management. In order to address the performance issues related to the SDN Control Plane, this paper proposes a distributed load balancing algorithm with the aim of dynamically balancing the control traffic across a cluster of SDN Controllers, thus minimizing the latency and increasing the overall cluster throughput. The algorithm is based on game theory and converges to a specific equilibrium known as Wardrop equilibrium. Numerical simulations show that the proposed algorithm outperforms a standard static configuration approach.

17:40-18:00 ThCT5.3

Nash Equilibrium in a Singular Two-Person Linear-Quadratic Differential Game: A Regularization Approach, pp. 1041-1046

Glizer, Valery Y. — ORT Braude Coll. of Engineering

A finite horizon two-person non zero-sum linear dynamics differential game is considered. Each player has its own quadratic cost functional to be minimized. The case where control costs of one player (the "singular" player) do not appear in both cost functionals is treated. Thus the game under consideration is singular. A new definition of the Nash equilibrium in such a game is proposed. Then, the game is solved by the regularization approach, yielding a new differential game. The new game is a regular Nash equilibrium game, and it is a cheap control game. Based on an asymptotic analysis of this game, a Nash equilibrium sequence of the pairs of the players' feedback controls in the original

game is designed, and the expressions for the optimal values of the cost functionals are derived. An illustrative example is presented.

18:00-18:20 ThCT5.4

Time-Efficient Trajectory Optimization in Patrolling Problems with Non-Prespecified Depots and Robots, pp. 1047-1052

Ghadiry, Walaaeldin	Concordia Univ
Habibi, Jalal	Tehran
Aghdam, Amir G.	Concordia Univ
Zhang, Youmin	Concordia Univ

Two new formulations are presented in this paper for the minimum-time trajectories in the patrolling problem, where a number of robots are desired to visit a given set of viewpoints in the shortest possible time. In the first problem, it is assumed that the starting depots and their corresponding robots are non-prespecified. In the second problem, it is desired to obtain the minimum-distance trajectories among all the possible minimum-time trajectories that could be the output of the first problem. The problem turns out to be a variant of the well-known Traveling Salesman Problem (TSP), namely, Minimum-Time Multidepot multiple Traveling Salesmen Problem (MTMmTSP). The distinguishing features of the proposed problem statement is that first of all the starting depots and the number of robots assigned to each are not prespecified. Secondly, the cost function to be minimized is total travel time of robots as opposed to the travel distance or waiting time of the salesmen at the visited nodes for a given TSP with time windows (TSPTW).

18:20-18:40 ThCT5.5

A Competitive Differential Game between an Unmanned Aerial and a Ground Vehicle Using Model Predictive Control, pp. 1053-1058

Tzannetos, George	National Tech. Univ. of Athens
Marantos, Panos	National Tech. Univ. of Athens
Kyriakopoulos, Kostas J.	National Tech. Univ. of Athens

In this work a non-cooperative competitive differential continuous game between an unmanned aerial and an unmanned ground vehicle is studied. Each player acts independently trying to satisfy its own objective function. Specifically, the Unmanned Aerial Vehicle (UAV) is trying to reduce the relative distance and orientation by the Unmanned Ground Vehicle (UGV), while the latter is trying to increase it. For this purpose, a controller is designed using the concepts of Non-Linear Model Predictive Control (NL-MPC), for each player, to calculate in real time its optimal trajectory by solving its Minimax objective function with double optimization assuming the other player moves optimal (worst case scenario) and taking into account the complete model dynamics. Furthermore, we solve iteratively the above optimization in order to increase the levels of the thinking, making the players more capable of predicting opponent's best move, thus changing their optimal trajectory for their benefit. Various conclusions are made for the strategy that each agent follows in a realistic simulation game of these two ”rational” players where one player is fast (UAV) and the other is slower (UGV) but more maneuverable.

18:40-19:00 ThCT5.6

Cheap Control Robust Tracking: Insight by Solving the Problem with Simple Motions, pp. 1059-1064

Turetsky, Vladimir	Ort Braude Coll
Glizer, Valery Y.	ORT Braude Coll. of Engineering

A robust trajectory tracking problem is considered. Based on the solvability conditions, as well as the tracking and the control boundedness conditions, derived in a previous paper of the authors, the case of tracking with simple motions is analyzed. This case is studied both analytically and numerically, giving the insight for the cheap control approach to the robust tracking problem.

FrAT1 Kozani

Agent-Based Systems (Regular Session)

Chair: Motee, Nader — Lehigh Univ

Co-Chair: Rovithakis, George A. — Aristotle Univ. of Thessaloniki

09:00-09:20 FrAT1.1

Neural Network-Based Formation Control of Unmanned Vehicles in 3D Space, pp. 1065-1070

Ramazani, Saba — Louisiana Tech. Univ

Selmic, Rastko R. — Louisiana Tech. Univ

Gardner, Andrew — Louisiana Tech. Univ

This paper addresses the decentralized formation control problem of unmanned vehicles in three-dimensional (3D) space. We propose a new Neural Network-based control algorithm that uses graph rigidity and relative positions of the vehicles. The control law for each vehicle consists of a nonlinear component that is dependent on the closed-loop error dynamics plus a neural net component that is linear in the output weights (a one-tunable layer neural net is used). A Lyapunov analysis shows that our distance-based control strategy achieves the uniformly ultimately bounded stability of the desired infinitesimally and minimally rigid formation and that neural net weights remain bounded. Simulation results are included to demonstrate the performance of the proposed method.

09:20-09:40 FrAT1.2

Cohesive Motion Control As a Regulation Problem, pp. 1071-1076

Guler, Samet — Univ. of Waterloo

Fidan, Baris — Univ. of Waterloo

Dasgupta, Soura — Univ. of Iowa

We study derivation of distributed control laws for the cohesive motion problem of multi-agent systems. In the literature, stability analysis of the established control laws for this objective are heavily dependent on the number of the agents and are left incomplete. We convert the original problem setup to an equivalent linear state regulation problem. We define the inter-agent relative position variables as system states and derive a linear system dynamics. State regulation of the system corresponds to solving the cohesive motion objective. Further, we design a distributed control law to regulate the system states, which eventually corresponds to an easy-to-implement, proportional control law for each agent. Finally, we derive a sufficient condition on the agent speed bounds for distance maintenance in minimally persistent formations.

09:40-10:00 FrAT1.3

Output Feedback Leader-Follower with Prescribed Performance Guarantees for a Class of Unknown Nonlinear Multi-Agent Systems, pp. 1077-1082

Katsoukis, Ilias — Aristotle Univ. of Thessaloniki

Rovithakis, George A. — Aristotle Univ. of Thessaloniki

The design of an output feedback control protocol to address the leader-follower synchronization problem, for a class of second-order, nonlinear multi-agent having unknown dynamics, affected by environmental disturbances, is considered in this work. Assuming a directed communication protocol, the proposed scheme solves the problem introducing prescribed transient and steady-state performance attributes, regarding the minimum convergence rate and the maximum allowable steadystate error of the output disagreement errors. All other state errors are proven uniformly ultimately bounded with respect to arbitrarily small sets, while all closed-loop signals are kept bounded. Despite the uncertainty, the proposed controller is remarkably simple (structurally and computationally) avoiding the use of approximation structures i.e., neural networks, fuzzy systems etc. Simulations clarify and verify the approach.

10:00-10:20 FrAT1.4

Demand Response Estimation Based on Aggregate Data from Heterogeneous Users, pp. 1083-1088

Materassi, Donatello — Univ. of Tennessee, Knoxville

Roozbehani, Mardavij — MIT

Dahleh, Munther A. — Massachusetts Inst. of Tech

The article presents methodologies for the prediction of the aggregate consumption of a large number of heterogeneous energy users with deferrable loads. It is assumed that the users respond to an identical coordinating signal (e.g. a price) broadcast by the system operator. The main contributions of the article are two: (i) the presence of heterogeneous users is explicitely addressed by considering the possibility of several classes of consumers; (ii) the described methodologies provide predictions and estimates that have the advantage of making use of aggregate data only. In the current grid, where consumption mostly occurs on-demand, consumers as an aggregate can be considered essentially as a system with little or no memory. However, when a dynamic response mechanism is implemented, the presence of consumers with deferrable loads introduces memory in the system in the form of the backlogged demand that has to be satisfied in the near future. Thus, the level of backlogged demand influences significantly the response of the system to the coordinating signal. From the perspective of the system operator, an accurate estimate of the current backlogged demand is of paramount importance, since it allows one to better predict what the aggregate consumption will be for a given coordinating signal. Thus, mathematical models need to be derived in order to predict future aggregate consumption using the accessible information.

10:20-10:40 FrAT1.5

Synchronization and Collision Avoidance in Non-Linear Flocking Networks of Autonomous Agents, pp. 1089-1094

Somarakis, Christoforos — Univ. of Maryland, Coll. Park

Paraskevas, Evripidis — Univ. of Maryland, Coll. Park

Baras, John S. — Univ. of Maryland

Motee, Nader — Lehigh Univ

We introduce and discuss two novel second-order consensus networks with state-dependent couplings of Cucker-Smale type. The first scheme models flocking to synchronization over a network of agents where the alignment of the agent’s states occurs over a non-trivial limit orbit that is generated by the internal dynamics of each individual agent. The second scheme models the speed alignment of a group of agents which avoid approaching each other closer than a prescribed distance. While seemingly different, both of these systems can be analyzed using the same mathematical methods. We rigorously analyze both examples and reveal their striking similarities. We arrive at sufficient conditions that relate the initial configurations and the systems' parameters that give rise to a collective common behavior. Simulation examples are presented to support our theoretical conclusions.

FrAT2 Edessa

Aerospace Control (Regular Session)

Chair: Zhang, Hao — Tech. Inst. of Tech

Co-Chair: Schatz, Simon Philipp — Tech. Univ. München

09:00-09:20 FrAT2.1

Adaptive High Order Sliding Mode Control for Relative Positioning and Trajectory Tracking of Spacecraft Formation Flying, pp. 1095-1101

Garcia Carrillo, Luis Rodolfo — Univ. of Nevada Reno

MuÑoz Palacios, Filiberto — Univ. Pol. DE PACHUCA

Espinoza Quesada, Eduardo Steed	Univ. Pol. De Pachuca
Alexis, Kostas	Univ. of Nevada, Reno

This paper considers the problem of relative position and trajectory tracking control for spacecraft formation flying. The nonlinear dynamics describing the relative positioning of multiple spacecraft are used to develop a Lyapunov-based, nonlinear, adaptive higher order sliding mode control. The strategy, known as adaptive super twisting sliding mode control law, guarantees convergence to any sufficiently smooth desired spacecraft formation flying trajectory, despite the presence of unknown disturbances. Simulation results illustrate the effectiveness of the proposed control.

09:20-09:40 FrAT2.2

Cooperative Control of Multiple Satellites Via Consensus, pp. 1102-1107

Zhang, Hao	Tech. Inst. of Tech
Gurfil, Pini	Tech. - Israel Inst. of Tech

The current work develops a distributed controller for steering a satellite cluster to the same orbit as well as for assembly under limited low thrust. The underlying concept is using consensus theory to characterize the control objective in a multi-agent system. This concept is leveraged by implementing the governing dynamics in a control-affine form as described by Gauss's variational equations. For general orbital transfer, the controller is asymptotically stable. The assembly is accomplished by changing of variables, as well as in a two-phase control process by separately controlling subsets of orbital elements based on the dynamics structure. Numerical simulations validate the analysis and demonstrate the results.

09:40-10:00 FrAT2.3

Comparison of Command Governor Augmentation and Modified Linear Extended State Observers for Uncertain Dynamical Systems, pp. 1108-1113

Schatz, Simon Philipp	Tech. Univ. München
Heise, Christian David	Tech. Univ. München
Holzapfel, Florian	Tech. Univ. München

In this paper, two approaches for model following control in the presence of uncertainties are compared. Specifically, the so-called command governor framework, originally developed as an augmentation to adaptive control, and a modified linear extended state observer are evaluated. Both approaches estimate the disturbance signal causing the plant to deviate from the desired reference model. The modified linear extended state observer uses an observer with a linear Luenberger gain to approximate the disturbance signal while the command governor augments the reference signal applied to both, reference model and uncertain plant, by filtered differentiation of the control error. By qualitative and numerical comparison of these approaches, it is illustrated that the command governor is a specific implementation of the more general modified linear extended state observer. Note that the compared approaches do not rely on nonlinear or hybrid control laws, but may be realized as a continuous time, LTI system. Therefore, these methods may be advantageous to similar approaches such as adaptive control with respect to certification.

10:00-10:20 FrAT2.4

A Novel Structure Design and Control Strategy for an Aircraft Active Sidestick, pp. 1114-1119

Fergani, Soheib	Space and Aeronautics Inst
Allias, Jean-François	ISAE-SUPAERO
Briere, Yves	ENSICA
Defay, François	ISAE-SUPAERO

This paper is concerned with a new design of an aircraft active sidestick based on Permanent Magnet Synchronous Machine (PMSM) and proposes an innovative robust control strategy based on an adaptive optimal sliding mode controller. Indeed, such an application requires high performance specifications which impose many constraints (torque, torques ripples, temperature). Here, a new design for the sidestick actuator is provided with a specific structure: a double airgap rotating one adapted to the considered process. Then, an optimization is performed to enhance the set of specifications of the PMSM w.r.t the aeronautical application. Also, a new adaptive optimal robust control for the designed actuator is provided based on the linear quadratic approach combined with the sliding mode control method. Then, an adaptive disturbances rejection is performed with the proposed strategy. Due to the considered design of the actuator (1=12 of a complete PMSM), a position control is achieved based on the LQRSliding mode approach to meet the required performances and to manage the plant parameter variation and load disturbances. Also, a varying parameter is used to adapt "on-line" the considered control to the varying level of disturbance that affect the system. First simulation results of the considered strategy applied to the newly designed actuator (compared to other strategies) proves the efficiency of the proposed solution for position control of the actuator and robustness considering load disturbances.

10:20-10:40 FrAT2.5

On Robotic Impact Docking for on Orbit Servicing, pp. 1120-1125

Mitros, Zisos	National Tech. Univ. of Athens
Paraskevas, Iosif S.	National Tech. Univ. of Athens, Mech. Eng. School, Cont
Papadopoulos, Evangelos	National Tech. Univ. of Athens

On-orbit servicing missions will rely on space robots; however, their complexity requires prior careful studies. Among these, robotic docking is especially challenging. In this work, the robotic impact docking between two space systems is considered. The impedance properties required to design an impedance controller are studied. These properties include the ratio of the masses between the systems under impact, the relative stiffness between the bodies of each space system and the associated damping factor. The velocity of the probe tip to be commanded is calculated aiming at successful latch at first impact. Simulation results validate the proposed approach.

FrAT3 Naoussa

Intelligent Control Systems (Regular Session)

Chair: Tanner, Herbert G.	Univ. of Delaware
Co-Chair: Radac, Mircea-Bogdan	Pol. Univ. of Timisoara

09:00-09:20 FrAT3.1

Data-Driven Virtual Reference Feedback Tuning and Reinforcement Q-Learning for Model-Free Position Control of an Aerodynamic System, pp. 1126-1132

Radac, Mircea-Bogdan	Pol. Univ. of Timisoara
Precup, Radu-Emil	Pol. Univ. of Timisoara
Roman, Raul-Cristian	Pol. Univ. of Timisoara

This paper compares a linear Virtual Reference Feedback Tuning model-free technique applied to feedback controller tuning based on input-output data with two Reinforcement Q-learning model-free nonlinear state feedback controllers that are tuned using input-state experimental data (ED) in terms of two separate learning techniques. The tuning of the state feedback controllers is done in a model reference setting that aims at linearizing the control system (CS) in a wide operating range. The two learning techniques are validated on a position control case study for an open-loop stable aerodynamic system. The performance comparison of our tuning techniques is discussed in terms of their structural complexity, CS performance, and amount of ED needed for learning.

09:20-09:40 FrAT3.2

A Future Internet Oriented User Centric Extended Intelligent Transportation System, pp. 1133-1139

Canale, Silvia	Univ. of Rome "Sapienza"
Di Giorgio, Alessandro	Univ. of Rome "La Sapienza"
Lisi, Federico	La Sapienza Univ. of Rome
Panfili, Martina	"Sapienza" Univ. Di Roma,
Ricciardi Celsi, Lorenzo	Univ. Di Roma "La Sapienza"
Suraci, Vincenzo	Univ. Degli Studi E-Campus
Delli Priscoli, Francesco	Univ. Di Roma

Intelligent Transportation Systems (ITS) are changing the way people plan a journey and travel around the world. Advanced mobility information systems, as well as intelligent multimodal mobility services, may take considerable advantage of consolidated technologies from emerging ICT frameworks. In this paper, we propose an Extended Intelligent Transportation System (ExITS) consisting of a basic ITS equipped with a User Centric Control System (UCCS). The proposed ExITS relies on service personalization methodologies and is conceived as a Future Internet (FI) oriented, closed-loop user centric architecture integrating and controlling ITS services. The proposed UCCS considers the trip planning module and takes into account both explicit and implicit user preferences in selecting travel solutions satisfying a given user request. The aim of the UCCS is to drive the trip planning service in proposing to the user travel typologies tailored to personal preferences. Implicit preferences are automatically inducted by similarity based unsupervised machine learning techniques and verified by a closed-loop control mechanism triggered by explicit user feedback.

09:40-10:00 FrAT3.3

A Supervisory Approach to Microgrid Demand Response and Climate Control, pp. 1140-1145

Korkas, Christos	Democritus Univ. of Thrace
Baldi, Simone	Delft Univ. of Tech
Michailidis, Iakovos	Informatics & Telematics Inst. Center for Res. and Tech
Boutalis, Yiannis	Democritus Univ. of Thrace
Kosmatopoulos, Elias	Democritus Univ. of Thrace and CERTH, Greece

Microgrids equipped with small-scale renewableenergy generation systems and energy storage units offer challenging opportunity from a control point of view. In fact, in order to improve resilience and enable islanded mode, microgrid energy management systems must dynamically manage controllable loads by considering not only matching energy generation and consumption, but also thermal comfort of the occupants. Thermal comfort, which is often neglected or oversimplified, plays a major role in dynamic demand response, especially in front of intermittent behavior of the renewable energy sources. This paper presents a novel control algorithm for joint demand response management and thermal comfort optimization in a microgrid composed of a block of buildings, a photovoltaic array, a wind turbine, and an energy storage unit. In order to address the large-scale nature of the problem, the proposed control strategy adopt a two-level supervisory strategy: at the lower level, each building employs a local controller that processes only local measurements; at the upper level, a centralized unit supervises and updates the three controllers with the aim of minimizing the aggregate energy cost and thermal discomfort of the microgrid. Comparisons with alternative strategies reveal that the proposed supervisory strategy efficiently manages the demand response so as to sensibly improve independence of the microgrid with respect to the main grid, and guarantees at the same time thermal comfort of the occupants.

10:00-10:20 FrAT3.4

Programming by Demonstration for Locally K-Testable Tasks, pp. 1146-1151

Arora, Saurabh	Univ. of Delaware
Tanner, Herbert G.	Univ. of Delaware

This paper proposes PbD (Programming by Demonstration) of the tasks representable as Locally k-Testable (or LT$_k$) subclass of regular languages, in a system modeled as a Markov Decision Process. The method uses predicate abstraction and language identification in the limit to infer a symbolic task. The learned task is implemented by constraining the evolution of MDP. Using relatively small training sample, the approach generalizes to all possible ways of accomplishing a learned task, unlike inverse reinforcement learning method. A Grid-world case study validates the results.

10:20-10:40 FrAT3.5

Joint State and Parameter Estimation for a Macro Traffic Junction Model, pp. 1152-1157

Chetcuti Zammit, Luana	Univ. of Malta
Fabri, Simon G.	Univ. of Malta
Scerri, Kenneth	Univ. of Malta

To contribute towards the autonomic properties of traffic light systems, a self-estimation algorithm is presented to jointly estimate the states describing the traffic flow dynamics in a junction under different traffic conditions, with model parameters and measurement and process noise. The novel proposed algorithm, based on the Expectation-Maximization algorithm, makes use of a sliding window over time, to estimate junction traffic conditions in quasi real-time. The proposed model and algorithm are validated on a signalized 3-arm junction within the traffic network of Malta.

FrAT4 Pella

Image Processing I (Regular Session)

Chair: Bauer, Peter	Inst. for Computer Science and Control, HungarianAcademyof Sciences
Co-Chair: Popescu, Dan	Pol. Univ. of Bucharest

09:00-09:20 FrAT4.1

Hierarchical RANSAC for Accurate Horizon Detection, pp. 1158-1163

Mou, Xiaozheng	NTU
Shin, Boksuk	Nanyang Tech. Univ
Wang, Han	Nanyang Tech. Univ

The horizon in marine scenes provides an important prior feature for unmanned surface vehicles (USV) based research and applications. However, most of existing research in horizon detection usually consider specific or simple scenarios. In this paper, we propose a novel approach to detect the horizon in maritime images with various situations by applying the algorithm of random sample consensus (RANSAC) hierarchically. First, a rough horizon line is estimated with RANSAC in the gradient map of downsized image. Thus, a region of interest (ROI) is defined by the neighborhood of the estimated horizon. Then a proper amount of patches are sampled from the edge map of the original image in the ROI, and a straight line is fitted in each patch using RANSAC. Finally, patches with lower rate of outliers for their fitted lines are selected and aggregated to compute the final horizon via RANSAC. Experimental results on our own dataset with diverse scenarios demonstrate that the proposed approach is more robust and more accurate than the traditional methods.

09:20-09:40 FrAT4.2

Face Recognition Using Fusion of PCA and LDA : Borda Count Approach, pp. 1164-1167

Borade, Sushma Niket	Dr. Babasaheb Ambedkar Marathwada Univ. Aurangabad

Deshmukh, Ratnadeep	Dr. Babasaheb Ambedkar Marathwada Univ. Aurangabad
Ramu, Sivakumar	Department of Information and Computer Tech. Yanbu Univ

Face recognition has become one of the most successful applications in the field of image analysis and understanding. This paper presents a new approach for identity recognition using rank-level fusion of multiple face representations. In this paper, we propose face recognition based on fusion of two well-known appearance-based techniques, Principal Component Analysis and Linear Discriminant Analysis. Fusion is done at rank level using Borda count method. Our experimental work demonstrates significant improvement in recognition accuracy over individual face representations.

09:40-10:00 FrAT4.3

Monocular Image-Based Time to Collision and Closest Point of Approach Estimation, pp. 1168-1173

Bauer, Peter	Inst. for Computer Science and Control, HungarianAcademyof S
Hiba, Antal	Hungarian Acad. of Sciences Inst. for Computer Science And
Vanek, Balint	The Computer and Automation Res. Inst. HungarianAcademy
Zarándy, Ákos	Computer and Automation Res. Inst
Bokor, Jozsef	Hungarian Acad. of Sciences

This paper deals with monocular image-based time-to-collision (TTC) and closest point of approach (CPA) estimation for aircraft sense and avoid. First, it proposes a disc-based pinhole camera projection model which can better represent a real 3D object. Then it proposes simple least squares optimal line fitting-based techniques for TTC and CPA estimation based-on measurable image parameters only. Possible errors in the image are considered through design nomograms and a collision decision threshold selection technique is presented. Theoretical results are verified through software-in-the-loop simulation and real flight test results. To the best of the author's knowledge the disc-based projection model and the line fit-based TTC and CPA estimation are new contributions in this field.

10:00-10:20 FrAT4.4

Exploring Video Descriptions for Handwashing Activities As Part of an Obsessive-Compulsive Disorder Study, pp. 1174-1179

Fasching, Joshua	Cse, Umn
Walczak, Nicholas	Univ. of Minnesota
Hadjiyanni, Tasoulla	Coll. of Design
Bernstein, Gail	Psychiatry, UMN
Cullen, Kathryn	Psychiatry, UMN
Mikkelsen, Mackenzie Mikkelsen	Cse, Umn
Studanski, Nathan	Cse, Umn
Morellas, Vassilios	Univ. of Minnesota
Papanikolopoulos, Nikos	Univ. of Minnesota

Analysis of behavior using video is a promising approach for identifying risk markers for psychopathology that can be applied in a wide range of populations. As part of a study on the environmental factors that relate to obsessive-compulsive disorder (OCD) behaviors, videos were recorded of everyday tasks being performed by two groups of children: a control group and a group diagnosed with OCD. One of the activities involved handwashing, since contamination compulsions are frequent amongst those who suffer from OCD. Being able to classify these handwashing videos as containing behaviors associated with OCD or not is a step towards helping to automate important aspects of this psychiatric study. This paper explores using various feature descriptors sampled from dense motion trajectories to determine which combination of features and encodings would be best for video classification. Dense motion trajectories are computed for the videos from the OCD study and the points in these trajectories are described using several methods, including histograms of oriented gradient, histograms of optical flow, and motion boundary histograms. Various encoding techniques for these descriptors are also explored, including bag of words, pyramid bag of words, and sparse coding. To determine which feature/encoding techniques would perform the best, several dimensionality reduction techniques are used and the methods are ranked based on separability in the low dimensional space. This separability is measured by classifying using a linear discriminant and also by using kNN.

10:20-10:40 FrAT4.5

CLASS: Contemplative Landscape Automated Scoring System, pp. 1180-1185

Navickas, Lukas	Tech. Univ. of Berlin
Olszewska, Agnieszka	Univ. of Porto
Mantadelis, Theofrastos	Univ. of Porto

This paper presents an interdisciplinary study joining insights of landscape architecture and computer vision. In this work we used a dataset of contemplative landscape images that was collected and evaluated by experts in landscape architecture. We used the dataset to develop nine k-means clustering and one K-nearest neighbors' models that are able to score landscape images based on seven different landscape image features (layers, landform, vegetation, color and light, compatibility, archetypal elements, character of peace and silence) that were identified as contributing to the overall contemplativeness of a landscape. Finally, we chose the combination of models that would produce the best combined contemplativeness score and created {CLASS} a scoring system that can evaluate the contemplativeness of landscape images with scores similar to those of experts.

10:40-11:00 FrAT4.6

Remote Image Classification Based on Patch Dissimilarity, pp. 1186-1191

Ichim, Loretta	Pol. Univ. of Bucharest
Popescu, Dan	Pol. Univ. of Bucharest

In case of events like earthquakes and floods, for disaster evaluation, the analysis of remote images is necessary. In this paper we propose a method for flooded areas analysis based on texture analysis of small patches from global image taken by UAV. To this end a measure based on dissimilarity between features signatures of analyzed patch and prototype of classes is used. The proposed algorithm has two phases: a) feature selection (learning) and b) classification. In the learning phase the selected of the features is made based on a degree of performances based on confusion matrix. Four classes of patches from acquired images are considered and the representative signatures for these classes were computed from 40 images. Also 1000 patches from 10 tested images were used to establish the performance of classification. The images were taken by the aid of an autonomous UAV fixed wing type (MUROS) implemented by an authors' team.

FrAT5 Mycenae

Control (Regular Session)

Chair: Koumboulis, Fotios	Sterea Ellada Inst. of Tech
Co-Chair: Almobaied, Moayed	Istanbul Tech. Univ

09:00-09:20 FrAT5.1

Design of LQR Controller with Big Bang-Big Crunch Optimization Algorithm Based on Time Domain Criteria,

pp. 1192-1197

Almobaied, Moayed	Istanbul Tech. Univ
Eksin, İbrahim	Istanbul Tech. Univ
Guzelkaya, Mujde	Istanbul Tech. Univ

LQR controller is the most popular technique that provides an optimal control law for linear systems among the state space feedback control strategies. However, the conventional LQR controller synthesis is unfortunately an iterative process due to the trial and error approach involved in determining the parameters values of the weighing matrices Q and R. Here, the Big Bang-Big Crunch (BB-BC) optimization algorithm is used that optimizes a time domain fitness function in the design of the state feedback optimal control law and thus avoiding the repeated adjustment process of LQR parameters. In this study, a special performance fitness function that is inversely proportional to the certain time domain step response criteria of a dynamical system is proposed for the optimization procedure. In order to test the performance of the proposed method, firstly a simulation study is done within the MATLAB to stabilize an inverted pendulum on cart. Then, the proposed controller is used in a real time implementation to stabilize a DC-DC boost converter benchmark in the lab. Both MATLAB simulations and laboratory experiments demonstrate the effectiveness of the proposed controller.

09:20-09:40 FrAT5.2

Delayless Dynamic Controllers for Exact Model Matching with Simultaneous Disturbance Rejection of General Neutral Time Delay Systems, pp. 1198-1204

Koumboulis, Fotios	Sterea Ellada Inst. of Tech
Kouvakas, Nikolaos	Sterea Ellada Inst. of Tech

The problem of Exact Model Matching with simultaneous Disturbance Rejection (EMMDR) via delayless dynamic controllers is solved for the class of general neutral multi delay systems with measurable disturbances. The delayless dynamic controllers are of the measurement output feedback type with dynamic compensation of the measurable disturbances. The necessary and sufficient conditions for the problem to have a solution are established and the general form of the delayless dynamic controller matrices solving the problem are derived. Based on the above results, the EMMDR problem for general neutral multi delay systems, via delayless static controllers, is solved. The results are illustrated through application to an idle speed control model for internal combustion engines.

09:40-10:00 FrAT5.3

Some Remarks on Optimal Output Regulation for Weakly Dual Redundant Plants, pp. 1205-1211

Corona, Dario	Univ. of Camerino
Cristofaro, Andrea	Norwegian Univ. of Science and Tech

In this paper the problem of optimizing the output regulation of a weakly dual redundant plant is addressed. When the system is under-actuated, only a subset of the outputs can be arbitrarily controlled, and the remaining ones are constrained. We investigate the problem of finding the input that minimize a cost function of the overall output tracking error, and how such solution is related to the inputs associated to the singularly optimal regulation of each output. Some interesting properties are revealed, such as the optimal solution being always included in the convex hull of singularly optimal controls and the existence of neutral reference spaces.

10:00-10:20 FrAT5.4

Structural Design of Shallow Neural Networks on the Basis of Minimal Complexity Principle, pp. 1212-1217

Vasilyev, Vladimir	Ufa State Aviation Tech. Univ

The problem of neural network structure selection is discussed. The constructive approach to shallow NNs design based on using the minimal complexity principle is offered. The peculiarities of its application to solving different classes of tasks often met with in practice are considered.

10:20-10:40 FrAT5.5

Robust Norm-Bounded H_infty Control and Estimation of Retarded State-Multiplicative Discrete-Time Systems, pp. 1218-1223

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

Linear, state delayed, discrete-time systems with stochastic uncertainties in their state-space model are considered. The problems of robust norm-bounded H_infty state-feedback control and filtering are solved via an input-output approach by which the system is replaced by a nonretarded system with deterministic norm-bounded uncertainties. In this problem, a cost function is defined which is the expected value of the standard H_infty performance index with respect to the uncertain parameters.

10:40-11:00 FrAT5.6

A State Feedback Suboptimal Time Control Method Using Block Pulse Functions, pp. 1224-1229

Bichiou, Salim	LSA
Bouafoura, Mohamed Karim	Lab. Des Systèmes Avancés - LSA, Ec. Pol. De
Benhadj Braiek, Naceur	Ec. Pol. De Tunisie

In the present paper, an offline method for the determination of the stabilizing control gain for feedback control for linear time invariant systems is determined to approach at best an existing minimum time open loop control based on Block pulse functions, operational matrices of integration and kroneker product properties.

FrBT1 Kozani

Guidance, Navigation and Control for UAV Applications (Invited Session)

Chair: Shin, Hyo-Sang	Cranfield Univ
Co-Chair: Savvaris, Al	Cranfield Univ
Organizer: Shin, Hyo-Sang	Cranfield Univ
Organizer: Savvaris, Al	Cranfield Univ

14:00-14:20 FrBT1.1

Communication-Aware Convoy Following Guidance for UAVs in a Complex Urban Environment (I), pp. 1230-1235

Oh, Hyondong	Loughborough Univ
Shin, Hyo-Sang	Cranfield Univ
Kim, Seungkeun	Chungnam National Univ
Ladosz, Pawel	Loughborough Univ
Chen, Wen-Hua	Loughborough Univ

This paper proposes a communication-aware trajectory planning approach for UAVs to relay data/information (e.g. live surveillance feed) between a ground control station and friendly ground vehicles (a convoy) moving in a complex urban area. UAVs are controlled to stay: i) within the communication-feasible area (having a direct line-of-sight to the moving convoy and within the maximum communication range) and ii) as close as possible to the convoy to have better communication quality, while satisfying their kinematic and dynamic constraints. Numerical simulations and a proof-of-concept indoor flight test have been performed to validate the benefit and feasibility of the proposed algorithm.

14:20-14:40 FrBT1.2

Real-Time Autonomous Take-Off, Tracking and Landing of UAV on a Moving UGV Platform (I), pp. 1236-1241

Ghamry, Khaled A.	Concordia Univ

Dong, Yiqun — Concordia Univ
Kamel, Mohamed A. — Concordia Univ
Zhang, Youmin — Concordia Univ

This paper presents a control strategy for take-off, tracking, and landing of a quadrotor unmanned aerial vehicle (UAV) on an unmanned ground vehicle (UGV) to be applied to missions of forest fires monitoring, detection, and fighting and other applications. A combination of sliding mode control (SMC) and linear quadratic regulator (LQR) is presented as the UAV local controller, while pure-pursuit strategy is applied as the UGV controller. Leader-follower formation controller approach is used during take-off, tracking and landing phases based on SMC. Experimental results are presented in order to demonstrate the performance of the team in different scenarios.

14:40-15:00 FrBT1.3

Development of a Fuel Cell Hybrid-Power Unmanned Aerial Vehicle (I), pp. 1242-1247

Xie, Ye — Cranfield Univ
Malandrakis, Konstantinos — Cranfield Univ
LÓpez Fenoy, MatÍas JesÚs — Cranfield Univ
Savvaris, Al — Cranfield Univ
Tsourdos, Antonios — Cranfield Univ

This paper describes the design and development of a hybrid fuel cell/battery propulsion system for a long endurance small UAV. The high level system architecture is presented, followed by the hardware-in-the-loop testing and performance analysis. A high fidelity 6-DoF simulation model of the complete system was developed and used to test the system under different battery state-of-charge. The simulation model included the power manager for the hybrid propulsion system configuration, which is based on rule-based control. The simulation results are compared with the experimental results obtained from the Hardware-in-the-Loop testing.

15:20-15:40 FrBT1.5

Rigid Formation Control for a Group of UAVs with Augmented Models That Account for Input Generator Dynamics, pp. 1248-1253

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

The paper solves the trajectory tracking control problem for an unmanned aerial vehicle (UAV) when the input generator dynamic effects are taking into considerations. Using the backstepping method we establish a controller for the considered model that ensures exponential convergence to a given reference trajectory. A two-mode control strategy is applied for increasing the domain of convergence. Then, using the concept of virtual vehicles we consider the application of the proposed controller for a group of UAVs in a rigid formation flight. Simulation results are demonstrated.

15:40-16:00 FrBT1.6

Modelling and Control of a Tilt-Wing Unmanned Aerial Vehicle, pp. 1254-1259

Small, Elias — Luleå Univ. of Tech
Fresk, Emil — Luleå Univ. of Tech
Andrikopoulos, George — Luleå Univ. of Tech
Nikolakopoulos, George — Luleå Univ. of Tech. Sweden

In this article a Tilt-Wing Unmanned Aerial Vehicle (TW-UAV) and the preliminary evaluation of its hov- ering characteristics in extended simulation studies will be presented. In the beginning, an overview of the TW-UAV's design properties will be established, highlighting the novelties of the proposed structure and the overall merits. As it will be presented, the TW-UAV's design and structural properties are mathematically modeled and utilized for the synthesis of a cascaded P-PI and PID based control structure for the regulation of its hovering performance. Extensive simulation trials are performed in order to evaluate the structure's efficiency in controlling the TW-UAV's attitude and position under various noise and disturbance scenarios.

FrBT2 Edessa

Industrial Automation and Control Systems (Regular Session)

Chair: Jean-Pierre, Kenne — École De Tech. Superieure,
Co-Chair: Dadhich, Siddharth — Luleå Univ. of Tech

14:00-14:20 FrBT2.1

Machine Learning Approach to Automatic Bucket Loading, pp. 1260-1265

Dadhich, Siddharth — Luleå Univ. of Tech
Bodin, Ulf — Luleå Univ. of Tech
Sandin, Fredrik — Luleå Univ. of Tech
Andersson, Ulf — Luleå Univ. of Tech

The automation of bucket loading for repetitive tasks of earth-moving operations is desired in several applications at mining sites, quarries and construction sites where larger amounts of gravel and fragmented rock are to be moved. In load and carry cycles the average bucket weight is the dominating performance parameter, while fuel efficiency and loading time also comes into play with short loading cycles. This paper presents the analysis of data recorded during loading of different types of gravel piles with a Volvo L110G wheel loader. Regression models of lift and tilt actions are fitted to the behavior of an expert driver for a gravel pile. We present linear regression models for lift and tilt action that explain most of the variance in the recorded data and outline a learning approach for solving the automatic bucket loading problem. A general solution should provide good performance in terms of average bucket weight, cycle time of loading and fuel efficiency for different types of material and pile geometries. We propose that a reinforcement learning approach can be used to further refine models fitted to the behavior of expert drivers, and we briefly discuss the scooping problem in terms of a Markov decision process and possible value functions and policy iteration schemes.

14:20-14:40 FrBT2.2

Production Control of a Deteriorated Remanufacturing System within an Open-Loop Reverse Supply Chain, pp. 1266-1271

Jean-Pierre, Kenne — École De Tech. Superieure,
Dehayem Nodem, Fleur Inès — Univ. of Quebec, Ec. De Tech. Superieure

Reverse supply chain management is a significant issue for sustainable economy, product recovery and green thinking. In a closed loop reverse supply chain, used products are generally returned to original producers. But in an open loop reverse supply chain, used products are not returned to original producers, outsider firms recover them. This paper focuses on an open-loop reverse supply chain (OLRSC), which includes a single centralized collection point of returned products, a single remanufacturing machine (RM) and a single distribution center. The RM produces parts, and upon a breakdown, either an imperfect repair is undertaken or is replaced with a new identical one. The objective of the control problem is to find the production rate and the repair/replacement policy that minimize total incurred costs over an infinite planning horizon. This paper proposes a stochastic dynamic programming formulation of the problem and derives the optimal policies numerically. A numerical example is included and sensitivity analyses with respect to the system parameters are examined to illustrate the importance and effectiveness of the proposed methodology.

14:40-15:00 FrBT2.3

Optimal Production Planning by Reusing Components, pp. 1272-1277

Frontoni, Emanuele	Univ. Pol. Delle Marche
Marinelli, Fabrizio	Univ. Pol. Delle Marche
Paolanti, Marina	Univ. Pol. Delle Marche - Department of Information
Rosetti, Roberto	Univ. Pol. Delle Marche
Zingaretti, Primo	Univ. Pol. Delle Marche

Warehouse management aims to optimally organize stock levels and orders according to production planning and market needs. In the area of fashion goods, the variability of the demand tends to re-plan the productions in agreement with the seasonal trends and merchandise news. These changes can lead to considerable levels of raw materials that remain unused and represent a loss of profit for the company. In some cases, the whole amount of materials can be spread in many warehouses located in different locations, either in a single country or worldwide. A mathematical model for reusing old stocks (obsolescent material) is presented in this paper. The model is aimed at the optimization of the warehouse management of a business company. Considering the obsolescences and the bill of materials of each product, a mathematical Integer Linear Programming (ILP) model is used to plan the production of finished goods to maximize the revenue at the net of the costs of missing components. The mix production model is refined with side constraints that limit the budget for new components, the trade-off between the number of reused and ordered parts, the whole production and the minimum and maximum quantity for each produced model and ordered part type. Real instances are solved with different values of parameters and best solutions are presented.

15:00-15:20 FrBT2.4

Feasibility Analysis of Sustainable Methods through Manufacturing Algebra and Monte-Carlo Simulations, pp. 1278-1283

Perez Montenegro, Carlos Norberto	Pol. Di Torino
Calderon, Diomar	Univ. De San Buenaventura
Vargas, Adolfo	Univ. De Investigacion Y Desarrollo UDI
Canuto, Enrico	Pol. Di Torino
Novara, Carlo	Pol. Di Torino

From some years ago, development of sustainable methods for industrial applications are a trending topic, these present the steps to guarantee the current requirements without compromising future resources. New demands for law policies and social responsibility are constantly generated. This paper presents a low cost strategy to evaluate the feasibility of sustainable methods using an extension of manufacturing algebra that includes energy consumption, waste management, and food distribution. The steps to develop a discrete model based in manufacturing operations is developed, the model is obtained in order to implement a simulator which takes into account the parametric uncertainty. A case of study is presented in a high hierarchical level is presented.

15:20-15:40 FrBT2.5

PN Modelling, Simulation, Performance Evaluation and Production Forecast of a Tanning Industry, pp. 1284-1289

Vrontakis, Konstantinos	Tech. Univ. of Crete
Kampianakis, Andreas	Tech. Univ. of Crete
Tsinarakis, George	Tech. Univ. of Crete

In this paper a Petri Net (PN) based methodology for modelling, simulation, performance evaluation and production forecast of a tanning industry processing 5 leather types is presented. The Petri net models of the production procedures are built and simulated in order to calculate specific performance measures. Then exponential smoothing method is applied in order to forecast the overall demand of the upcoming year for each product type. Finally, a scenario concerning partial change of the equipment efficiency is tested and the results obtained are compared to the ones of the initial model.

FrBT3 Naoussa

Decentralised Control (Regular Session)

Chair: Alamaniotis, Miltiadis	Purdue Univ
Co-Chair: Sangi, Roozbeh	E.ON Energy Res. Center, RWTH Aachen Univ

14:00-14:20 FrBT3.1

Multi-Kernel Anticipatory Approach to Intelligent Control with Application to Load Management of Electrical Appliances, pp. 1290-1295

Alamaniotis, Miltiadis	Purdue Univ
Tsoukalas, Lefteri	Purdue Univ

Anticipatory systems are systems whose change of state depends on present and future information about the system itself as well as its environment. Making control decisions based on prediction of the possible outcomes is an inherent feature of human decision making process. The advent of the big data are followed by technological advancements in machine intelligence has provoked us to revisit the role of intelligent control systems and their role in decision making. In this manuscipt, a multi-kernel anticipatory system for intelligent control is proposed. In particular, multiple kernel-modeled Gaussian processes are integrated with fuzzy logic rules in order to make decisions. In the current paper, the architecture of the system is described and functionality of individual parts is explained. Finally, its application on load control in electrical appliance connected to smart power grid with data taken from GRIDLAB-d demonstrating the advantages of the proposed control system is shown.

14:20-14:40 FrBT3.2

Simulation–based Implementation and Evaluation of a System of Systems Optimization Algorithm in a Building Control System, pp. 1296-1301

Sangi, Roozbeh	E.ON Energy Res. Center, RWTH Aachen Univ
Schild, Thomas	RWTH Aachen Univ
Daum, Magnus	RWTH Aachen Univ. E.ON Energy Res. Center, Inst. F
Fütterer, Johannes Peter	RWTH Aachen Univ
Streblow, Rita	RWTH Aachen Univ
Müller, Dirk	RWTH Aachen Univ
Michailidis, Iakovos	Informatics & Telematics Inst. Center for Res. and Tech
Kosmatopoulos, Elias	Democritus Univ. of Thrace and CERTH, Greece

The objective of this research is to evaluate the performance of a system of systems optimization algorithm, namely, L4G-PCAO, in building energy systems. Since the test bed of this research is an office building with more than two hundred occupiers, the heating and cooling demands of the building must always be fully satisfied. Consequently, changes in the currently-installed control system cannot be made forthrightly. Therefore, fresh ideas like implementation of new control strategies or optimization algorithms should be firstly put to the test via dynamic simulation, which makes engineers capable of examining new control and optimization strategies. The performance should then be analyzed and evaluated before implementing in the use case. This paper presents a strategy for simulation-based implementation of L4G-PCAO in a

building energy system and also evaluates its performance. The results show that it is not only possible to conserve energy by applying this newly-developed optimization algorithm to existing control systems, but also it can shift the usage of energy sources in a more environment-friendly direction.

14:40-15:00 FrBT3.3

Partial Integrity of Unstable LTI Systems, pp. 1302-1306

Eslami, Mostafa — Sharif Univ. of Tech
Nobakhti, Amin — Sharif Univ. of Tech
Babazadeh, Maryam — Sharif Univ. of Tech

This paper considers the Integral Stabilizability (IS) and partial integrity of Linear Time Invariant (LTI) systems with an unstable sub-system. The main contribution of the paper is to show that if the unstable sub-system can be stabilized by means of output feedback, then one obtains an integrity condition which is actually equivalent to that of open-loop stable systems, with two additional assumptions. This means the condition may be evaluated solely on the basis of plant information and does not rely on the knowledge of the values of the controller parameters.

15:00-15:20 FrBT3.4

Voronoi Based Decentralized Coverage Problem: From Optimal Control to Model Predictive Control, pp. 1307-1312

Nguyen, Minh Tri — SUPELEC
Stoica Maniu, Cristina — Supelec

This paper presents a novel decentralized framework for the Multi-Agent dynamical coverage problem subject to anti-collision constraints. The control objective is to authorize each agent operating strictly in its safety zone and then enhance the coverage. These zones are the result of a spatial Voronoi partition of the common working space of the Multi-Agent system based on the current positions of the agents. Each zone provides the local information to design the control policies that make each agent converging to a fixed point inside its Voronoi cell. The performance/effectiveness of the proposed techniques will be demonstrated via numerical examples.

15:20-15:40 FrBT3.5

A Fuzzy Control Scheme for an Isolated Domestic Application Using Fuel Cell System, pp. 1313-1318

Papadimitriou, Christina — National Tech. Univ. of Athens
Vovos, Panagis — Univ. of Patras
Georgakas, Kostas — Univ. of Patras
Vovos, Nicholas — Univ. of Patras

Fuel-cell-based power generation is a promising DG technology, gaining popularity in residential applications due to its cleanliness, portability and suitability for electricity and heat generation. It also features as a great choice for remote isolated residences for covering the water needs. This paper presents an experimental study of a Proton Exchange Membrane (PEM) type Fuel Cell System (FCS), combined with a battery bank supplying some domestic loads. The system could be easily adjusted for grid-connected operation via the dc/ac converter that is employed. A fuzzy logic controller is implemented via a Digital Signal Processor (DSP) and regulates the output of the converter in real time. The controller shows good performance under severe load step changes and rapidly restores the balance between supply and demand at steady state.

FrBT4 Pella

Image Processing II (Regular Session)

Chair: Theilliol, Didier — Univ. of Lorraine
Co-Chair: Materassi, Donatello — Univ. of Tennessee, Knoxville

14:00-14:20 FrBT4.1

Extrapolation of Delayed Measurements for Fusion in a Distributed Sensor Network, pp. 1319-1324

Chagas, Ronan A. J. — Inst. Nacional De Pesquisas Espaciais
Waldmann, Jacques — Inst. Tecnologico De Aeronautica - ITA

The measurement extrapolation (ME) algorithm was devised to fuse delayed measurements in the Kalman filter. It is a suboptimal algorithm that greatly reduces the computational burden of the optimal Reiterated Kalman Filter (RKF). ME can be used in embedded systems that lack the required computational resources to compute the optimal estimate. However, it has not been extended yet to be applied in a distributed sensor network. Furthermore, it is verified here that the original ME algorithm provides a biased estimate, which can degrade the estimation accuracy. Thus, this work proposes to extend ME to fuse delayed measurements received by nodes in a distributed network, and to remove the bias using Bayesian concepts, improving the accuracy of the novel method. The ME computational burden and memory needs are theoretically analyzed and compared to those of the RKF. Finally, simulations of a simplified distributed network are presented to measure the performance of the new algorithm with respect to RKF and to validate the theoretical analysis. The results show that ME can provide an estimate with acceptable accuracy whereas the computational burden is greatly decreased and the memory requirements are only slightly increased compared to RKF.

14:20-14:40 FrBT4.2

Evaluating a Sound-Enhanced Intrusion Detection System to Identify Network Congestion, pp. 1325-1330

Rojas, David — Univ. of Toronto
Vargas Martin, Miguel — Univ. of Ontario Inst. of Tech
Kapralos, Bll — Univ. of Ontario Inst. of Tech

Although a network intrusion detection system (NIDS) is typically automated, there are times where the task of intrusion detection must be performed manually by network administrators, either by analyzing the network state in real-time or by revising network logs. However, given the vast amounts of visual-based data inherent in such logs, combing through network logs can be a tedious and time consuming task with a high potential of misclassifying or missing a threat altogether. In order to overcome some of the limitations associated with the analysis of network logs, here we present an approach whereby sonification, that is the use of sound to convey non-sound information at the computer interface, is employed to map the data within a network log into meaningful sound and thus allow for a simple and intuitive sound-based network intrusion detection system. Results of a series of experiments conducted to evaluate the sound-based NIDS across several intrusion scenarios indicate the effectiveness and promise of the approach.

14:40-15:00 FrBT4.3

Reconstructing Tree Structures of Dynamic Systems with Hidden Nodes under Nonlinear Dynamics, pp. 1331-1336

Materassi, Donatello — Univ. of Tennessee, Knoxville

The article tackles the problem of inferring information about the unknown structure of a network of dynamic systems under the assumption that the systems are connected according to a tree topology. In particular, the article introduces methodologies to address the presence of hidden (unmeasured) nodes in a scenario where only non-invasive observations are available. By non-invasive observations, it is meant that no known input signal is actively injected into the network. The whole system instead is assumed to be forced by unknown external excitations modeled as stochastic processes. No a priori assumption is made about the number and location of the hidden nodes. Current approaches are capable of consistently inferring the network structure from data,

when the dynamics are linear and/or the measurements have a jointly Gaussian distribution. This work provides an approach that can also be applied to networks with nonlinear dynamics and non-Gaussian disturbances. Sufficient conditions are found under which a consistent reconstruction of the topology can be obtained.

15:00-15:20 FrBT4.4

Normalization of Feature Distribution in Motor Imagery Based Brain-Computer Interfaces, pp. 1337-1342

Binias, Bartosz — Silesian Univ. of Tech
Niezabitowski, Michał — Silesian Univ. of Tech
Grzejszczak, Tomasz — Silesian Univ. of Tech

Brain-Computer Interfaces (BCIs) are systems capable of capturing and interpreting consent changes in the activity of brain and translating them into sets of control instructions. The most popular technical solutions in BCI are based on the signals recorded by the electroencephalograph (EEG). EEG can be used to record and monitor the bioelectrical activity of the brain. However, raw EEG scalp potentials are characterized by weak spatial resolution. Due to that reason, multichannel EEG recordings tend to provide an unclear image of the activity of brain and use of special signal processing and analysis methods is needed. A typical approach towards modern BCIs requires an extensive use of Machine Learning methods. It is generally accepted that the performance of such systems is highly sensitive to the feature extraction step. On of the most effective and widely used descriptors of EEG data is the power of the signal in specific frequency range. In order to improve the performance of chosen classification algorithm, the distribution of the extracted bandpower features is often normalized with the use of natural logarithm function. In this study the step of normalization of feature distribution was taken into careful consideration. Commonly used logarithm function is not always the best choice for this process. Therefore, the influence on the skewness of feature distributions, as well as, the general classification accuracy of different settings of Box-Cox transformation will be tested in this article. For the better evaluation of the performance of proposed approach, its effectiveness is tested in the task of classification of the benchmark data provided for the "BCI Competition III" (dataset "IVa") organized by the Berlin Brain-Computer Interface group.

15:20-15:40 FrBT4.5

Estimating Speed Profiles from Aerial Vision - a Comparison of Regression Based Sampling Techniques, pp. 1343-1348

Freis, Sebastian — Univ
Olivares-Mendez, Miguel A. — SnT - Univ. of Luxembourg
Viti, Francesco — Univ. of Luxemburg

Since traffic congestion became an increasingly complex problem, research in traffic surveillance tremendously increased in the last decades. The data obtained from the vehicles' paths is non-linear with a high complexity. This type of data is frequently treated using regression methods to obtain reasonable results and to keep track of unrealistic outliers and measured errors. Vision-based techniques are used to obtain this data from static cameras located close by to highways or high congestion traffic points. The use of Unmanned Aerial Vehicles (UAV's) for traffic surveillance is another potential and promising application of this type of robotic platform. The main advantages are that it can be equipped with different sensors based on the requirement of the situation, such as RGB, infrared or multispectral cameras and it can change its' position easily based on the traffic situation requirements. This paper describes a vision algorithm for the background subtraction based vehicle tracking approach for vehicle speed estimation using aerial images taken from an UAV. The raw data obtained from the tracker are smoothed with several common regression methods to evaluate their effectiveness to be applied to this type of non-linear data. Furthermore, an extended version of the locally weighted regression algorithm was implemented, which was proven to be the most accurate method for smoothing the tracking results. This data was compared with the ground truth data acquired by a speed sensor installed in the vehicle.

FrBT5 — Mycenae

Control and FDD Applications (Regular Session)

Chair: Graton, Guillaume — Ec. Centrale De Marseille
Co-Chair: Dahhou, Boutaieb — LAAS-CNRS

14:00-14:20 FrBT5.1

Impact of Different Spacing Policies for Adaptive Cruise Control on Traffic and Energy Consumption of Electric Vehicles, pp. 1349-1354

Bayar, Bilgehan — Univ. of Luxembourg
Sajadi-Alamdari, Seyed Amin — Univ. of Luxembourg
Viti, Francesco — Univ. of Luxemburg
Voos, Holger — Univ. of Luxembourg

This paper assesses the impact of different spacing policies for Adaptive Cruise Control (ACC) systems on traffic and environment. The largest deal of existing studies focus on assessing the performance in terms of safety, while only few deal with the effect of ACC on the traffic flow and the environment. In particular, very little is know on traffic stability and energy consumption. In this study, the vehicles equipped with ACC are modelled and controlled by two different spacing policies. Besides, Human Driving Behavior (HDB) is modelled by using Gipps model for comparison and for simulating different penetration rates. As distinguished from other studies, vehicle dynamics and energy consumption of an electric car is formulated, which has completely different characteristics and limitations than combustion engine cars. Hence the study aims at providing additional understanding of how ACC-equipped electric vehicles will behave in dense traffic conditions. HDB and ACC vehicles are placed in a roundabout at different penetration rates. String stability and energy consumption are investigated by giving a shock wave to a stable traffic condition. It is found that ACC with quadratic spacing policy has significantly positive effects on string stability and energy consumption.

14:20-14:40 FrBT5.2

Enhancing Performance in a Smartphone-Based Navigation System for Visually Impaired People, pp. 1355-1360

Croce, Daniele — Univ. of Palermo
Giarre', Laura — Univ. Di Palermo
La Rosa, Fabio Giuseppe — DEIM, Univ. Di Palermo
Montana, Elisa — DEIM, Univ. Di Palermo
Tinnirello, Ilenia — Univ. of Palermo

In this paper we show how to enhance the tracking performance of Arianna, a low-cost augmented reality system designed to meet the needs of people with problems of orientation, people with sight impairment and blind people. For augmented reality system we mean the design of: i) a set of paths and tags to be deployed in the environment, realized in various ways depending on the context (decorative elements easily identifiable, colorful stripes, QR code, RFID, etc.); ii) an instrument of mediation between the reality and the user (typically a smartphone) to access the information disseminated in the environment by means of a camera and provide a vibration feedback signal to the users for following pre-defined paths. In this paper we explore the possibility of applying optical flow techniques to the sequence of images captured by the camera along the paths, to identify the user movements and provide a position estimate. Experimental results show that the approach is promising.

14:40-15:00 FrBT5.3

Fault Diagnosis for HEX/ Reactor System Via Invertibility,

pp. 1361-1366

Zhang, Mei	CNRS -Lab. De Genie Chimique
Li, Zetao	Guizhou Univ
Dahhou, Boutaieb	LAAS-CNRS
Cabassud, Michel	Univ. Paul Sabatier, Toulouse, France; CNRS, Lab. De

A fault diagnosis approach is developed for pneumatic valve used in intensified HEX/reactor system. The pneumatic valve is viewed as an actuator subsystem interconnected with process subsystem in series. A condition of invertibility of the cascade system has been derived in [18], characterizing that effects of faults occurred in actuator subsystem are distinguishable by the global output uniquely. Using this idea, the fault diagnosis scheme proposed in this paper is based on local fault filtering, each subsystem is assigned to monitor one subsystem and provided a decision regarding its health. In particular, the connection point between the two subsystems is not accessible to measurements. An input estimator is then developed to estimate this unknown connection point only rely on the global system output. Different from [18], any information of the derivatives of the output vectors is not involved in the input estimation stage. For that, a high-gain second-order sliding mode observer is considered to exactly estimate the derivatives of the output vectors in a finite time. Numerical simulation examples are given to illustrate the effectiveness of the proposed methods.

15:00-15:20 FrBT5.4

Early Fault Diagnosis of Gearbox Using Empirical Wavelet Transform and Hilbert Transform, pp. 1367-1372

Merainani, Boualem	Solid Mechanics and Systems Lab. (LMSS), Univ. of M'
Benazzouz, Djamel	Lab. De Mécanique Du Solide Et Systèmes (LMSS), Boumerdes,
Ould Bouamama, Belkacem	Pol. Lille
Rahmoune, Chemseddine	Solid Mechanics and Systems Lab. (LMSS), Univ. of M'

Gears are one of the most common mechanisms used for transmitting power and motion in various mechanical applications. Tooth pitting fault is frequently failure modes encountered. An analytical model of one stage spur gearbox is presented where the effects of tooth pitting fault were simulated by magnitude and phase changes in the gearmesh stiffness. This paper deals with the problem by using the Empirical Wavelet Transform (EWT) and the Hilbert Transform (HT) techniques. First, the EWT is used to extract adaptive modes from the vibration signals by designing an appropriate wavelet filter bank. Then, the instantaneous frequencies are performed for each mode using the HT. The proposed tooth pitting fault diagnosis method was tested on both clean and noisy signals to evaluate its performance. The results show that the proposed method can effectively detect the fault in an early stage of development.

15:20-15:40 FrBT5.5

Self-Tuning of Dewma Controller Parameters for Mixed Product Processes with Equipment Aging, pp. 1373-1378

Graton, Guillaume	Ec. Centrale De Marseille
El Adel, El mostafa	Univ. AIX Marsille III
Ouladsine, Mustapha	Univ. D'aix Marseille III
Pinaton, Jacques	STMicroelectronics

This paper presents an iterative approach which provides a sub-optimal solution of the best achievement performance in the case of closed-loop aged-based processes applied on semiconductor manufacturing industry. The aim is to provide an online parameter estimation of dEWMA Controller in the case of mixed product Run-to-Run (RtR) control. The online estimation is done without any a priori knowledge of process parameters and noise structure. The best achievement performance improvements is illustrated using a simulation problem from literature. The example is applied on the removal rate control in a Chemical Mechanical Polishing (CMP) process.