2009 17th Mediterranean Conference on Control & Automation

(MED 2009)

Thessaloniki, Greece
24-26 June 2009

Pages 1-527

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big. The third, the delay-dependent stabilization conditions are presented involve a single tuning parameter. The stabilization conditions are derived using single Lyapunov- Krasovskii Functional (LKF) combining the introduction of free-single matrix. Review some results are used to make these conditions in terms of Linear Matrix Inequalities (LMIs) (which can be easily solved using existing solvers such as the LMI Toolbox in Matlab). A numerical example is taken from the literature to show the advantages of the design procedures.

11:00-11:20 WeA1.5
Robust Fuzzy Control of Nonlinear Discrete-Time Systems with Polytopic Uncertainties, pp. 25-30

Sofianos, Nikolaos — Democritus Univ. of Thrace
Kosmidou, Olga — Democritus Univ. of Thrace

This paper deals with the problem of robust fuzzy control for uncertain discrete time nonlinear systems with polytopic uncertainties. Takagi-Sugeno fuzzy models with uncertainties are used in order to model the uncertain nonlinear systems. Parallel distributed compensation is utilized for the construction of the fuzzy controller. A quadratic Lyapunov function is used in order to ensure the robust stability of the T-S fuzzy uncertain system. Finally, the feasibility of some LMI optimization problem provides the desired feedback controller. The effectiveness of the proposed fuzzy controller design is illustrated by applying the proposed approach to a nonlinear uncertain discrete-time system.

WeA2 Room 2
Adaptive Control I (Regular Session)

Chair: Xargay, Enric — Univ. of Illinois at Urbana-Champaign
Co-Chair: Rovithakis, George A. — Aristotle Univ. of Thessaloniki

09:40-10:00 WeA2.1
Benchmark Problems of Adaptive Control Revisited by L1 Adaptive Control, pp. 31-36

Xargay, Enric — Univ. of Illinois at Urbana-Champaign
Hovakimyan, Naira — UIUC
Cao, Chengyu — Virginia Pol. & State Univ.

In this paper we revisit two benchmark problems of adaptive control, Rohrs' example and the two-cart example, with the recently developed L1 adaptive controller. The paper includes an overview of two L1 architectures, one in a state-feedback setting and another one in an output-feedback setting, which are suitable for the control of these two systems respectively. Also, we analyze fundamental differences between conventional adaptive control and the L1 adaptive control, and show, purely from qualitative considerations, some of the advantages of this new control philosophy.

10:00-10:20 WeA2.2
An Application of the RMMAC Methodology to an Unstable Plant, pp. 37-42

Hassani, Vahid — Inst. Superior Técnico
Athans, Michael — Inst. Superior Tecnico
Pascoal, Antonio Manuel — Inst. Superior Tecnico

In this paper we extend and generalize previous work on Robust Adaptive Control of uncertain plants using Multiple Models (the RMMAC methodology) [1]. We formulate and study the problem of robust adaptive control of open-loop unstable plants with structured and unstructured uncertainty in the presence of external disturbances, an issue that poses considerable theoretical and practical challenges. In particular, we show how a slight modification of the technique introduced in previous work on the RMMAC for stable plants yields a methodology that can deal with unstable plants. A design example and computer simulations are presented and discussed.

10:20-10:40 WeA2.3
Adaptive Neural Network Control of Nonholonomic Systems with Unknown Virtual Control Coefficients, pp. 43-48

Yuan, Zhanping — Tongji Univ.
Wang, Zhuping — Tongji Univ.
Chen, Qijun — Tongji Univ.

In this paper, adaptive neural network control is presented to solve the control problem of nonholonomic systems in chained form with unknown virtual control coefficients and strong drift nonlinearities. The proposed adaptive neural network control proves that all the signals in the closed-loop system are uniformly ultimately bounded, and the systems states converge to a small neighborhood of zero. The adaptive neural network control laws are developed using state scaling and backstepping without a prior knowledge of the signs of the unknown virtual control coefficients. Nussbaum-type functions are used to solve the problem of the unknown

control direction. The proposed adaptive neural network control is free of control singularity problem. Simulation results are provided to show the effectiveness of the proposed approach.

10:40-11:00 WeA2.4

Robust Adaptive Fuzzy Tracking Control for a Class of Nonlinear Systems, pp. 49-54

Essounbouli, Najib   Reims Univ.

Hamzaoui, Abdelaziz   IUT of Troyes

This paper deals with the design of a robust adaptive fuzzy tracking control for a class of uncertain and disturbed nonlinear systems. In addition to the desired performances and the convergence of the tracking error, the proposed approach guarantees the uniformly ultimately boundedness of the resulting closed-loop system. Furthermore, it allows overcoming many problems related to adaptive fuzzy controllers like singularity problem and constraints on the control gain, and reducing the number of used parameters, which encourage the real-time implementation. Finally two simulation examples are presented to show the effectiveness and the performances of the proposed approach.

11:00-11:20 WeA2.5

Adaptive Fuzzy Controller for Loop Control in a Distributed Control System, pp. 55-60

Abdel-geliel, Mostafa   Arab Acad. for Science and Tech.

Khalil, Alaa Eldin Ahmed   Arab Acad. for Science & Tech.

to simplify the control task and reduce the computation burden of control system, Distributed Control system (DCS) becomes the most suitable control system structure especially for medium and large size of industrial processes. In DCS system the control task is distributed among some controllers, which communicate to each other via communication network, such as PLC or/and industrial PC. In most DCS system, each controlled variable is manipulated in an individual loop, which is called control loops in DCS. Since it is difficult to design a control function that can handle all the circumstances of operations at the start phase, the control function needs to be adapted online. Adapted fuzzy controlled is suggested here in order to handle the control loops of a DCS system. An Experimental setup simulates the master loops of Liquefied Petroleum Gases (LPG) subsystem in a refining petroleum industry. The controller is implemented using HP-VEE software and Matlab packages.

11:20-11:40 WeA2.6

Adaptive Predictive Control Using Recurrent Neural Network Identification, pp. 61-66

Akpan, Vincent   Aristotle Univ. of Thessaloniki

Hassapis, George   Aristotle Univ. of Thessaloniki

This paper presents a new adaptive predictive control algorithm which consists of an on-line process identification part and a predictive control strategy which is updated every time a process model change is identified. The identification method is based on recurrent neural network nonlinear AutoRegressive with eXternal input (NNARX) model derived from dynamic feedforward neural network by adding feedback connection between output and input layers. Two model-based predictive control strategies have been studied: the generalized predictive controller (GPC) and nonlinear adaptive model predictive controller (NAMPC). The neural network training and validation data are obtained from the open-loop simulation of a validated first principles plant model. The identified neural network (NN) model is validated using the following three different validation algorithms: (1) one-step ahead cross-validation of the training and test data predicted by the trained network;(2) Akaike's final prediction error (AFPE) estimate of the average generalization error; (3) 5-step prediction simulations. The algorithm has been applied to the temperature control of a fluidized bed furnace reactor of the steam deactivation unit of a fluid catalytic cracking (FCC) pilot plant used to evaluate catalyst performance. The validation results show that the RNN models the reactor to a high degree of accuracy. Simulation results show that the proposed NAMPC control strategy outperforms the GPC at the expense of extra computation time.

Mobile Robots (Regular Session)

Chair: Parlangeli, Gianfranco   Univ. degli studi di Lecce
Co-Chair: Zohar, Ilan   Ben-Gurion Univ. of the Negev

09:40-10:00   WeA3.1

Controllers for Mobile Robot Dynamic Models: Trajectory Tracking with Applications to Convoy-Like Vehicles, pp. 67-72

Zohar, Ilan   Ben-Gurion Univ. of the Negev
Ailon, Amit   Ben Gurion Univ. of The Negev
Rabinovici, Raul   Ben-Gurion Univ. of the Negev

This paper establishes control strategies for a wheeled mobile robot model that includes the kinematic and dynamic equations of motion. The vehicle model accounts also for the actuator dynamics. The paper proposes simple control schemes for tracking a time-parameterizing path. Applications of the tracking controller for convoy-like vehicles are presented. Simulation results and demonstrations of the controller performances are discussed.

10:00-10:20   WeA3.2

A Motion Planning Algorithm for Smooth Paths of Bounded Curvature and Curvature Derivative, pp. 73-78

Parlangeli, Gianfranco   Univ. degli studi di Lecce
Ostuni, Luigi   Univ. of Salento
Mancarella, Luisa   Univ. of Salento
Indiveri, Giovanni   Univ. of Salento

This paper proposes an algorithm for planning mathcal{C}^infty paths with bound curvature and curvature derivative linking two fixed (initial and final) configurations and passing through a given number of intermediate via-points. The proposed solution is derived solving an optimization problem such that a smooth curve of bounded curvature and curvature derivative approximates Dubin's shortest paths. The effectiveness of such strategy is verified by simulations. Preliminary experimental results are also briefly described.

10:20-10:40   WeA3.3

Characterization and Modeling of a 3D Scanner for Mobile Robot Navigation, pp. 79-84

Koceski, Saso   Univ. of L'Aquila
Koceska, Natasa   Univ. of L'Aquila
Beomonte Zobel, Pierluigi   Univ. of L'Aquila
Durante, Francesco   Univ. of L'Aquila

In this paper an accurate physics-based simulation model of the 3D laser scanner, based on 2D range sensor (SICK LD-OEM1000) is presented. The model of the 2D sensor derives from the characteristics of the physical one and includes the uncertainty of the measurement, the dependency of the beam incidence angle and the target surface properties. Some experiments aimed to characterize the effects of the operation time, time autocorrelation, different object surface properties and orientations are also presented in this paper. 3D scanner virtual model, developed in rigid body dynamics environment, was verified experimentally and the results are reported.

10:40-11:00   WeA3.4

Adaptive Backstepping Control of a Wheeled Mobile Robot., pp. 85-91

Nganga-Kouya, Donatien   ENSET Gabon
Okou, Francis A.   Royal Military Coll. of Canada

This paper proposes an adaptive nonlinear controller to stabilize an autonomous wheeled mobile robot. The controller equations are obtained following a backstepping approach. The robot model is divided into two parts: a state space model with intermediate control inputs and algebraic nonlinear equations relating the true and the intermediate control inputs. The robot parameters are assumed unknown. First, a suitable change of variable is applied to the traditional robot dynamics to reveal the strict feedback structure of this state space model. Next, a three-step adaptive backstepping control design method is applied to obtain the intermediate control input expressions. Finally the true control inputs are found by solving iteratively the nonlinear equations that relates intermediate and true control inputs. The adaptation algorithms are based on the projection method and guarantee that estimated parameters converge and remain inside predefined domains. The proposed design strategy is tested in simulation. The results show good tracking performances despite large parameter variations.

11:00-11:20 WeA3.5

Modeling and Motion Control of an Articulated-Frame-Steering Hydraulic Mobile Machine, pp. 92-97

Ghabcheloo, Reza — Tampere Univ. of Tech.
Hyvonen, Mika — Tampere Univ. of Tech.

The paper addresses autonomous motion control (path-following in particular) of an articulated-frame-steering (AFS) hydraulically actuated mobile machine. We first propose a kinematic model of the vehicle, together with a simple model for steering hydraulic actuator. The kinematic model is derived under simplifying assumptions that there are no slipping and no skidding. The accuracy of the model is then validated using an elaborated semi-empirical hardware-in-the-loop simulator (GIMsim) of an AFS machine built at IHA/TUT. A motion control strategy is then proposed and a path-following control law is derived. Finally, the efficacy of the methodology is shown using GIMsim.

WeA4   Room 4
Sensor Networks and Cooperative Control (Invited Session)

Chair: Cassandras, Christos G. — Boston Univ.
Co-Chair: Paschalidis, Ioannis — Boston Univ.
Organizer: Cassandras, Christos G. — Boston Univ.
Organizer: Paschalidis, Ioannis — Boston Univ.

09:40-10:00 WeA4.1

On the Number of Leaders Needed to Ensure Network Connectivity in Arbitrary Dimensions (I), pp. 98-103

Gustavi, Tove — Royal Inst. of Tech.
Dimarogonas, Dimos V. — Massachusetts Inst. of Tech.
Egerstedt, Magnus — Georgia Inst. of Tech.
Hu, Xiaoming — Royal Inst. of Tech.

We examine the leader-to-follower ratio needed to maintain connectivity in a leader-follower multi-agent network with proximity based communication topology. The paper extends the one-dimensional results of [2] to the two dimensional case. In the scenario we consider, only the leaders are aware of the global mission, which is to converge to a known destination point. Thus, the objective of the leaders is to drag the team to the desired goal. In the paper we obtain bounds on the number of leaders needed to complete the task. The results are first established for an initially complete communication graph and then extended to the incomplete case. Computer simulations support the derived theory.

10:00-10:20 WeA4.2

Asynchronous Distributed Algorithms for Optimal Coverage Control with Sensor Networks (I), pp. 104-105

Cassandras, Christos G. — Boston Univ.
Zhong, Minyi — Boston Univ.

We consider coverage control problems with sensor networks which can be solved using distributed optimization algorithms. When these algorithm are synchronous, nodes periodically exchange state information which is clearly inefficient and, in fact, unnecessary since often the state of a node may not have changed much or may have only changed in a predictable way. We develop asynchronous optimization mechanisms in which a node communicates with others only when it considers it indispensable. We prove that such algorithms still guarantee convergence to an optimum under mild conditions, even in the presence of communication delays as long as these are bounded. We extend this framework so that all sensor nodes maintain continuous connectivity with a base station at all times. Finally, we provide experimental results showing that the proposed asynchronous method can substantially reduce communication costs while convergence performance is virtually indistinguishable from that of the synchronous method.

10:20-10:40 WeA4.3

Linear Iterative Strategies for Transmitting Streams of Values through Sensor Networks (I), pp. 106-111

Sundaram, Shreyas — Univ. of Illinois at Urbana-Champaign
Hadjicostis, Christoforos — Univ. of Cyprus

For any given fixed network of interconnected nodes, with some nodes designated as sources and some nodes designated as sinks, we investigate the problem of transmitting a stream of values from every source node to all of the sink nodes (possibly after some delay). We study linear iterative strategies for transmitting this information through the network, whereby at each time-step, each node in the network transmits a value that is a linear combination of the most recent transmissions of its neighbors. We show that this linear iterative strategy can be conveniently modeled as a linear dynamical system in state-space form. We then use

techniques from control theory pertaining to dynamic system inversion and structured linear systems to show that each sink node can reconstruct the data streams if and only if there are node disjoint paths in the network from the set of all source nodes to each sink node. Furthermore, this reconstruction can be accomplished after a delay of at most N-|mathcal{S}|+1 time-steps (where N is the number of nodes in the network, and |mathcal{S}| is the number of sources). This holds true for almost any choice of weights in the linear iteration.

10:40-11:00   WeA4.4

Intelligent Forklift Dispatching in Warehouses Using a Sensor Network (I), pp. 112-114

Paschalidis, Ioannis   Boston Univ.
Li, Keyong   Boston Univ.
Moazzez Estanjini, Reza   Boston Univ.
Lin, Yingwei   Boston Univ.
Guo, Dong   Boston Univ.

The paper describes the use of sensor networks in a warehouse where goods are stored and retrieved through the use of forklifts. Its first goal is to demonstrate that collecting vital information from the forklifts can be achieved inexpensively using state-of-the-art sensor network technology. Its second goal is to establish that the information collected can facilitate sophisticated, computer-aided decisions. To that end, we make use of a robust localization engine we have developed and an actor-critic-type policy optimization applied to the forklift dispatching problem. The improvements brought by our policy enhance the economic argument for the adoption of sensor networks.

11:00-11:20   WeA4.5

Distributed Collaborative Path Planning in Sensor Networks with Multiple Mobile Sensor Nodes (I),
pp. 115-120

Lambrou, Theofanis   Univ. of Cyprus
Panayiotou, Christos   Univ. of Cyprus

This paper presents an efficient distributed collaboration scheme for a team of autonomous mobile sensor nodes which enables them to navigate through a sparse sensor network with stationary nodes searching for events and improving area coverage. The mobile sensor nodes have limited communication and sensing ranges and autonomously plan their trajectories in order to enhance the probability of event detection. The main objective of this work is to investigate collaboration schemes between the sensor nodes such that each mobile samples areas not covered by the stationary or other mobile nodes. The aim is to reduce the amount of information that needs to be exchanged between nodes without significant loss of performance (in terms of area coverage).

11:20-11:40   WeA4.6

Evolutionary Dynamics of Collaborative Environments with Heterogeneous Agents (I), pp. 121-125

Somasundaram, Kiran   Univ. of Maryland
Baras, John S.   Univ. of Maryland

The seminal work of Maynard Prince and Price in 1973 laid the foundations in establishing the concept of evolutionary game stable strategies. It attempts to select strategies which are robust to evolutionary selection pressures. We observe that most of the literature as evolved is concentrated on single objective games. In this work we extend the notion of evolutionary stability to games with vector payoff functions. We illustrate that this notion of Multicriteria evolutionary stability, models a much larger class of interactions in social, economic and biological problems. Particular applications of interest are in autonomic wireless sensor networks and autonomic networked control systems. We present a multi-population replicator dynamics, which models the evolution of agent actions in a network with varying levels of selfishness. We observe that this model clearly demarks the regions of cooperation among these selfish agents. We provide analytical results on the dynamic stability of the replication. This clearly characterizes the aforementioned demarcations.

Nonlinear Systems I (Regular Session)

Chair: Menini, Laura   Univ. di Roma 'Tor Vergata'
Co-Chair: Balestrino, Aldo   Univ. of PISA

09:40-10:00   WeA5.1
R-Composition of Lyapunov Functions, pp. 126-131

Balestrino, Aldo   Univ. of PISA
Caiti, Andrea   Univ. of Pisa
Crisostomi, Emanuele   Univ. of Pisa
Grammatico, Sergio   Scuola Superiore Sant'Anna di Pisa

This paper introduces the use of R-functions to compose (R-composition) basic simple Lyapunov functions, like the conventional quadratic ones, to obtain a larger variety of functions. R-functions represent the natural extension of Boolean operators to real-valued functions and provide the basic tools to compute the analytic expression of intersection and union operations in a geometric setting. In the framework of Lyapunov approaches to prove stability of a dynamical system, the union of Lyapunov functions computed through the R-function approach is still a Lyapunov function. Moreover, as each Lyapunov function defines the shape and the orientation of a correspondent geometric Largest Estimate of the Domain of Attraction (LEDA), then the LEDA associated to the union of several Lyapunov functions corresponds to the union of the single LEDAs. R-composition of Lyapunov functions thus corresponds to a non-conventional Lyapunov function which can be used to improve the estimate of the Region of Asymptotic Stability (RAS) and at the same time to introduce more freedom in the choice of the shape of the correspondent level sets, that in general are non-convex. An example of the R-composition of Lyapunov functions is illustrated to solve a classic RAS estimation problem.

10:00-10:20   WeA5.2
Comparison of Standard and Modified Recursive State Estimation Techniques for Nonlinear Systems, pp. 132-138

Charalampidis, Alexandros   National Tech. Univ. of Athens
Papavassilopoulos, George P.   Univ. of Southern California

This paper deals with recursive state estimation for nonlinear systems. A new set of sigma-points for the Unscented Kalman Filter is proposed as well as a way to substitute a nonlinear output with a linear one. The importance of the function of the state which must be estimated is also illustrated and the need for taking it into account when designing the state estimator. All the proposed methods are compared with standard Extended Kalman Filter, Unscented Kalman Filter and Particle Filter with Sampling Importance Resampling using simulations. The results show that the modifications proposed in some cases lead to considerable reduction in estimation error.

10:20-10:40   WeA5.3
On the Use of Orbital Symmetries and Semi-Invariants for the Analysis of Planar Nonlinear Systems, pp. 139-144

Menini, Laura   Univ. di Roma 'Tor Vergata'
Tornambe, Antonio   Univ. Di Roma Tor Vergata

Semi-invariants can be used to study the trajectories of dynamical systems, and, in particular, to study the stability of the origin. The computation of semi-invariants can be based on orbital symmetries, which, in general, are hard to compute even for planar systems. The goal of this paper is to describe several classes of planar systems for which an orbital symmetries can be computed, and to illustrate what can be understood for such systems using the corresponding semi-invariants.

10:40-11:00   WeA5.4
Implementing Nonlinear Controllers Using Observer-Form Via Kernel Representations, pp. 145-150

Cha, Sung Han   RSISE, The Australian National Univ.
Dehghani, Arvin   The Australian National Univ.
Anderson, Brian D.O.   Australian National Univ.

We propose a connection between the state-space realization and 'observer-like' property of a nonlinear feedback system, consisting of an linear time-invariant (LTI) plant and a nonlinear controller by utilizing 'kernel representation' of dynamical systems. This connection is advanced by noticing that the kernel representation shares many properties with and is indeed a generalization of left fractional representations for nonlinear systems.

11:00-11:20 WeA5.5

Constructing Linear Parameter Varying Models through Adaptation for the Control of a Class of Nonlinear Systems, pp. 151-156

Kasnakoglu, Cosku — TOBB Univ. of Ec. and Tech.

In this paper a novel method is proposed for constructing linear parameter varying (LPV) system models through adaptation. For a class of nonlinear systems, an LPV model is built using its linear part, and its coefficients are considered as time-varying parameters. The variation in time is controlled by an adaptation scheme with the goal of keeping the trajectories of the LPV system close to those of the original nonlinear system. Using the LPV model as a surrogate, a dynamical controller is built by utilizing self-scheduling methods for LPV systems, and it is shown that this controller will indeed stabilize the original nonlinear system.

11:20-11:40 WeA5.6

Design Considerations for Piecewise Affine System Identification of Nonlinear Systems, pp. 157-162

Canty, Niel — Cork Inst. of Tech.
O'Mahony, Tom — Cork Inst. of Tech.

A PieceWise AutoRegressive eXogenous (PWARX) model for the AMIRA DR300 DC motor is identified using clustering techniques available in the Hybrid Identification Toolbox (HIT). The choice of design parameters like magnitude of the noise variance and size of the local dataset are discussed. These parameters influence the quality and performance of the PWARX model. The performance of the PWARX model is compared with that of a linear model. The results show superior performance of the PWARX model especially in the nonlinear regions.

WeA6 — Room 6
Distributed Parameter Systems I (Invited Session)

Chair: Demetriou, Michael A. — Worcester Pol. Inst.
Co-Chair: Daoutidis, Prodromos — Univ. of Minnesota
Organizer: Demetriou, Michael A. — Worcester Pol. Inst.

09:40-10:00 WeA6.1

On Stabilizing Strict-Feedback Linear Systems with Delayed Integrators (I), pp. 163-168

Bekiaris-Liberis, Nikolaos — Univ. of California, San Diego
Krstic, Miroslav — Univ. of California at San Diego

The problem of compensation of input delays for unstable linear systems was solved in the late 1970s. The systems with simultaneous input and state delay have remained a challenge, although exponential stabilization has been solved for systems that are not exponentially unstable, such as chains of delayed integrators and systems in the `feedforward' form. We consider a specially selected example of an exponentially unstable system with simultaneous input and state delays, which contains some key features that make the standard matrix exponential based predictor feedback design inapplicable. We construct an explicit feedback law, which contains distributed delay feedback of the input and the delayed state, and present a Lyapunov stability analysis.

10:00-10:20 WeA6.2

Multi-Scale Dynamics in Counter-Current Heat Exchangers (I), pp. 169-174

Jogwar, Sujit — U. Minnesota
Daoutidis, Prodromos — Univ. of Minnesota

In this paper, a class of high duty counter-current heat exchangers, which are typically used in energy integrated systems, is considered. The governing dynamic equations for such exchangers are stiff first order hyperbolic PDEs, and hence show a potential towards multi-scale dynamics. Using singular perturbations, a reduced non-stiff PDE model is derived, which captures the dynamics in the slow time scale. A simulation case study is considered to illustrate these results.

10:20-10:40 WeA6.3

Observer-Based Stabilization of an Unstable Parabolic PDE Using Pseudospectral Method and Sturm-Liouville Theory (I), pp. 175-180

Xu, Chao — Lehigh Univ.
Schuster, Eugenio — Lehigh Univ.

The stabilization of an unstable linear parabolic partial differential equation (PDE) system with both Neumann boundary control and interior control is considered in this work. Point output measurement is available at one end of the physical domain. The choice of a proportional output feedback boundary control is justified by Lyapunov analysis while the design of the interior control is carried out based on the Sturm-Liouville theory. A proportional state feedback is proposed for the interior control with a symmetric kernel function, and the

pseudospectral method is used to solve the stability conditions governed by the Sturm-Liouville systems. In addition, an observer is designed using the point measurement at one end of the physical domain, and used to propose an observer–based feedback controller for the PDE system. Both the controller and observer gains are designed numerically to make the eigenvalues of the associated Sturm-Liouville problems stable. Simulations show the effectiveness of the proposed controller.

10:40-11:00 WeA6.4

A Distributed Parameter Control Approach to Optimal Filtering and Smoothing with Mobile Sensor Networks (I), pp. 181-186

Burns, John A — Virginia Tech.
Cliff, Eugene M. — Virginia Tech.
Rautenberg, Carlos Nicolas — Virginia Tech.

In this paper we present a framework to address filtering and smoothing problems for distributed parameter systems when mobile (dynamic) sensors are used to provide system measurements. This framework can be used for systems governed by parabolic and hyperbolic partial differential equations and hence has application to a diverse set of problems such as estimating locations of biological and chemical sources, target tracking and estimation. We formulate the problems as hybrid systems on infinite dimensional spaces (coupled systems of partial, ordinary and delay differential equations) and use infinite dimensional theory to develop computational algorithms for the problems. A simple numerical example illustrates the approach.

11:00-11:20 WeA6.5

Scheduling of Static Sensor Networks and Management of Mobile Sensor Networks for the Detection and Containment of Moving Sources in Spatially Distributed Processes (I), pp. 187-192

Demetriou, Michael A. — Worcester Pol. Inst.
Gatsonis, Nikolaos A. — Worcester Pol. Inst.

In this paper we extend our previous work and consider two related problems: the first one proposes a method for the scheduling of static sensors in a network where it is assumed that an array of sensing devices is available to provide measurements on the state of a process governed by a partial differential equation. The second problem considers the guidance of a mobile sensor network used in a process governed by a partial differential equation. In the latter, it is assumed that the mobile sensors can move at discrete time instances, and hence the integrated sensor motion plus process can be modeled as a hybrid infinite dimensional system. It is shown that with the specific assumption made for the second problem, the two problems are essentially identical. The scheduling of static sensor network, or equivalently the guidance of mobile agents in a mobile sensor network, is subsequently used to address two tasks: (1) the improved estimation of the process state and (2) the detection of an intruder, which is modeled as a moving source. Such a moving source is used to model mobile contaminating chemical or biological sources in confined cavities. When the additional assumption of a joint sensor-and-actuator network, wherein the sensor network has actuating capabilities with the actuating devices collocated to the sensing devices, then the control problem becomes that of minimizing the effects of the mobile source on the process state. Such a control objective is essentially intruder containment and a simple and computationally efficient containment policy is proposed. Simulation results that demonstrate the effectiveness of mobile sensor-plus-actuator network in detecting and combating intruders are presented.

11:20-11:40 WeA6.6

Bounded Error Parameter Estimation for Models Described by Ordinary and Delay Differential Equations (I), pp. 193-198

Burns, John A — Virginia Tech.
Childers, Adam — Virginia Tech.

n this paper we focus on the problem of parameter identification for non-linear dynamical systems in the case when the number of data samples are too small for standard statistical analysis. The models are described by ordinary and delay differential equations with bounded errors. When the number of data samples is very small, standard validation methods are not applicable because classical statistical asymptotic theory relies on the behavior of the estimated parameter as the number of samples grows large. We present a new computational method that can be used to for solving this problem for a specific class of models. Although the assumptions lead to a restricted class of models, the new algorithm is computationally efficient for this class of problems. We introduce the basic ideas, provide some theoretical results needed for the convergence of the method and present numerical examples to illustrate the approach.

Chair: Syrmos, Vassilis L.   Univ. of Hawaii at Manoa
Co-Chair: Lesecq, Suzanne   UMR CNRS-INPG-UJF 5216

12:00-12:20   WeB1.1

Fuzzy Clustering Based Fault Diagnosis for Aircraft Engine Health Management, pp. 199-204

Babbar, Ashish   Univ. of Hawaii at Manoa
Ortiz, Estefan   Univ. of Hawaii at Manoa
Syrmos, Vassilis L.   Univ. of Hawaii at Manoa

Fault diagnosis plays a crucial role in aircraft health management for modern military and commercial aircrafts. Accurate detection and diagnosis of impending aircraft faults can lay the foundation to reduce maintenance turnaround times, operational costs and improve flight safety. Modern aircrafts are capable of generating massive amount of in-flight data and maintenance reports, which makes the task of developing a robust fault diagnosis scheme greatly challenging. Using flight parameters such as Exhaust Gas Temperature (EGT), Fuel Flow (FF), Engine Fan Speeds (N1 and N2), Total Air Temperature (TAT) decisions can be made on current and future health of aircraft engines. In this paper such flight parameters are used as the basis to develop a diagnostic scheme which can identify a fault and relate this information with the ground reports and maintenance data to allow the maintainer decide necessary maintenance procedures. The baseline values for the in-flight parameters are used as a reference for this evaluation. Any deviation from the baseline values can be considered as a system fault and has to be addressed by the maintenance crew. The data used for this analysis is obtained from flight data recorders. The final decision on a fault being accurately detected is taken by the ground maintenance crew or engineers. Once the fault has been accurately detected and identified Fault Isolation Manuals (FIM) are used to identify necessary maintenance actions required to repair the system or sub-system under fault. A robust fault diagnosis scheme combined with the maintenance actions can give the maintainer enhanced foresight in aircraft system health thus reducing unnecessary maintenance actions.

12:20-12:40   WeB1.2

An Improved Principal Component Analysis Scheme for Sensor Fault Detection and Isolation : Application to a Three Tanks System, pp. 205-210

Guerfel, Mohamed   National Engineering School of Tunis

In this paper a sensor fault detection and isolation procedure based on principal component analysis (PCA) is proposed to monitor a three interconnected tanks system. The PCA model is built to maximize fault detection sensitivity using a new index. The localization procedure is carried out using two methods. The first is based on the variables contribution to the fault index. The second is based on the reconstruction approach.

12:40-13:00   WeB1.3

Diagnosis of an Inertial Measurement Unit Based on Set Membership Estimation, pp. 211-216

Nguyen, Hoang Van   GIPSA-Lab.
Berbra, Cedric   UMR CNRS-INPG-UJF 5216
Lesecq, Suzanne   UMR CNRS-INPG-UJF 5216
Gentil, Sylviane   INPG/UJF/CNRS UMR 5216
Godin, Christelle   CEA
Barraud, Alain   CNRS-INPG-UJF UMR 5216

This paper compares two diagnostic techniques applied to MEMS sensors of an Inertial Measurement Unit (IMU). The sensors considered in this study are a triaxis accelerometer and a triaxis magnetometer. Note that rate gyros measurements are not considered here. The goal of the IMU is to sense the attitude of a rigid body on which it is embedded. The measurement equations are non-linear in the attitude parameters which are first estimated from five over six measurements. Then, each measurement equation together with the estimated parameters, provides an predicted measurement. Lastly, the residual is computed and analyzed with a signature table to detect and isolate the fault. Two estimation techniques are implemented. The first approach is based on parameter estimation with nonlinear optimization technique while the second one makes use of set membership estimation. Both techniques are applied to the detection of faults in the IMU fixed on a quadrotor in quasi-static mouvement.

State and Unknown Input Estimation for Nonlinear Systems Described by Takagi-Sugeno Models with Unmeasurable Premise Variables, pp. 217-222

Ichalal, Dalil	CENTRE DE RECHERCHE EN AUTOMATIQUE DE NANCY (CRAN), CNRS,UMR7039
Marx, Benoit	Centre de Recherche en Automatique de Nancy
Ragot, Jose	CRAN-INPL
Maquin, Didier	Inst. National Pol. de Lorraine

This paper presents a new method to synthesize observers for continuous time nonlinear systems described by Takagi-Sugeno (TS) model with unmeasurable premise variables. First, convergence conditions are established in order to guarantee the convergence of the state estimation error. These conditions are given in Linear Matrix Inequality (LMI) formulation. Secondly, a classical Proportional Integral Observer (PIO) is extended to the considered nonlinear systems in order to estimate the state and the unknown inputs (UI).

WeB2   Room 2
Adaptive Control II (Regular Session)

Chair: Kosmatopoulos, Elias	Tech. Univ. of Crete
Co-Chair: Xargay, Enric	Univ. of Illinois at Urbana-Champaign

Integration of the Stability Overlay (SO) with the Robust Multiple-Model Adaptive Control (RMMAC), pp. 223-228

Rosa, Paulo Andre Nobre	Inst. for Systems and Robotics - Inst. Superior
Shamma, Jeff S.	Univ. of California Los Angeles
Silvestre, Carlos	Inst. Superior Tecnico
Athans, Michael	Inst. Superior Tecnico

The Stability Overlay (SO) is a "safety net" that can be integrated with virtually any multiple-model adaptive control (MMAC) architecture, guaranteeing the stability of the closed-loop system. However, the arbitrary interconnection of the SO with a MMAC architecture can lead to severe performance deterioration. Thus, this paper proposes a systematic integration of the SO with the Robust Multiple-Model Adaptive Control (RMMAC), which provides stability guarantees, while maintaining the high levels of performance of the standard RMMAC observed in numerous simulations when the design assumptions are not violated.

Guaranteed Transient Performance with L1 Adaptive Controller for Nonlinear Strict Feedback Systems, pp. 229-234

Paranjape, Aditya	Univ. of Illinois at Urbana-Champaign
Xargay, Enric	Univ. of Illinois at Urbana-Champaign
Hovakimyan, Naira	UIUC
Cao, Chengyu	Virginia Pol. & State Univ.

This paper presents the L1 adaptive control architecture for nonlinear strict feedback systems in the presence of unknown high frequency gain and unknown time-varying nonlinearities, without restricting the rate of their variation. We prove that the L1 adaptive control architecture ensures guaranteed transient response for system's input and output signals simultaneously. Simulations of an airplane short period dynamics verify the theoretical findings and demonstrate the benefits of the method.

Robust Control for Uncertain Nonlinear Systems with Unknown and Changing Control Direction, pp. 235-239

Yang, Zaiyue	Hong Kong Pol. Univ.
Yam, S.C.P.	Hong Kong Pol. Univ.
Li, L.K.	Hong Kong Pol. Univ.
Wang, Yiwen	Hong Kong Univ. of Science and Tech.

This paper studies the robust control problem for uncertain nonlinear systems with unknown and changing control direction. The control direction is the multiplier of the control term, and is allowed to cross zero and change its sign for unlimited number of times. Based on the analysis of system dynamics at the points where the control direction is zero, a robust controller is proposed by integrating with a Nussbaum-type gain. Under the proposed controller, the system converges to zero if zero is accessible, or to the accessible point closest to zero if zero is not accessible by any control. The control performance is illustrated by the simulated example.

Self-Tuning Control of Nonlinear Servo System: Comparison of LQ and Predictive Approach, pp. 240-245

Bobal, Vladimir — Tomas Bata Univ. in Zlin
Kubalcik, Marek — Tomas Bata Univ.
Chalupa, Petr — Tomas Bata Univ. in Zlin
Dostal, Petr — Tomas Bata Univ. in Zlin

The majority of processes met in the industrial practice have stochastic characteristics and eventually they embody nonlinear behaviour. Traditional controllers with fixed parameters are often unsuitable for such processes because their parameters change. The changes of process parameters are caused by changes in the manufacturing process, in the nature of the input materials, fuel, machinery use (wear) etc. Fixed controllers cannot deal with this. One possible alternative for improving the quality of control for such processes is the use of adaptive control systems. Different approaches were proposed and utilized. One successful approach is represented by Self-tuning Controller (STC). The main idea of an STC is based on the combination of a recursive identification procedure and a selected controller synthesis. In this paper, the standard STC (non-predictive) approach is verified and compared with STC based on the Model Predictive Control (MPC). The verification of both methods was implemented by the real-time control of a highly nonlinear laboratory model, the DR300 Speed Control with Variable Load.

*An Observer-Based Recursive Delayed Feedback Control Using Neural Networks**

Yadmellat, P. — Amirkabir Univ. of Tech. (Tehran Pol.
Nikravesh, Kammaledin — Amirkabir Univ. of Tech.

WeB3 — Room 3
Robot Swarms (Regular Session)

Chair: Kosmatopoulos, Elias — Tech. Univ. of Crete
Co-Chair: Valavanis, Kimon — Univ. of Denve

Fuzzy Behavioral Control for Multi-Robot Border Patrol, pp. 246-251

Marino, Alessandro — Univ. degli Studi della Basilicata
Parker, Lynne E. — The Univ. of Tennessee
Antonelli, Gianluca — Univ. Di Cassino
Caccavale, Fabrizio — Univ. degli Studi della Basilicata

This paper deals with the problem of multi-robot border patrolling. The patrolling algorithm is designed by resorting to the behavioral control framework and is organized in a hierarchical structure. Several Elementary Behaviors are defined, which are the basis of the concept of Action, placed at a higher level of abstraction with respect to the behaviors. Each Action is obtained by properly combining multiple Elementary Behaviors via the Null-Space-Behavioral control framework. For the sake of robustness, the overall patrolling algorithm is fully decentralized, since explicit communication between robots is not needed. A a Fuzzy Inference System is designed to select the proper Action according to local sensor information only. The algorithm has been validated in simulation as well as experimentally on a setup composed by three Pioneer robots.

Coordination with the Leader in a Robotic Team without Active Communication, pp. 252-257

Cao, Ming — Univ. of Groningen
Yu, Changbin — Australian National Univ.
Anderson, Brian D.O. — Australian National Univ.

We propose a coordination algorithm for robotic multi-agent systems with leader-follower structures so that when a leader moves with a constant velocity, its followers can compute the leader's velocity after measuring their distances to the leader for a finite number of times. One feature of the proposed algorithm is that no active communication is needed, and as a result, the algorithm becomes advantageous in the application of robotic sensor networks where energy efficient algorithms are highly desirable to maximize network lifespan. The algorithm makes use of the Cayley-Menger determinant which is a powerful tool from distance geometry. It is shown that the proposed algorithm has the potential to be applied to robotic swarms in a challenging scenario where each robot is installed with only range sensors and cannot measure the position of a target directly.

12:40-13:00   WeB3.3

3-Cycle-Free Rigidity for Multi-Agent Control Systems, pp. 258-263

Eren, Tolga   Kirikkale Univ.

This paper is concerned with rigid formations of mobile autonomous agents. For the problem of relative formation stabilization, Nyquist-like criterion for formation stabilization is used in literature, where spectral properties of the Laplacian matrix play a role in evaluating desirable structural properties of formations. Establishing measures of near-periodicity would be useful in analyzing formation stability. In this paper, we analyze constructions to create non-3-periodic rigid formations, i.e., we study the constructions to create 3-cycle-free rigid formations. Central to the development of our analysis will be the use of tools from rigidity theory and graph Laplacians.

13:00-13:20   WeB3.4

A Unified Methodology for Multi-Robot Passive & Active Sensing, pp. 264-269

Kosmatopoulos, Elias   Tech. Univ. of Crete
Doitsidis, Lefteris   Tech. Univ. of Crete
Aboudolas, Konstantinos   Tech. Univ. of Crete

A major barrier preventing the wide employment of mobile networks of robots in tasks such as exploration, mapping, surveillance, and environmental monitoring is the lack of efficient and scalable multi-robot passive and active sensing (estimation) methodologies. The main reason for this is the absence of theoretical and practical tools that can provide with computationally tractable methodologies which can deal efficiently with the highly nonlinear and uncertain nature of multi-robot dynamics when employed in the aforementioned tasks.

In this paper, a new approach is proposed and analyzed for developing efficient and scalable methodologies for a general class of multi-robot passive and active sensing applications. Given the computational, communication, etc requirements of the particular multi-robot sensing application, the proposed methodology provides with an estimator design that meets the aforementioned requirements and, moreover, (a) guarantees {em stable and convergent performance} of the aforementioned estimator and (b) provides with an estimation accuracy that is inversely proportional to the {em complexity} of the aforementioned estimator (which, in turn, is proportional to either the computational capabilities of the robot's equipment or its memory storage capabilities). The proposed approach can handle constraints such as obstacle avoidance or maximum speed constraints and can treat both problems of passive and active sensing in a unified manner. The application of the proposed methodology to various multi-robot sensing tasks such as robot pose estimation using only inter-robot distance measurements, target tracking and simultaneous localization, mapping and exploration is discussed.

13:20-13:40   WeB3.5

Optimized Task Allocation in Cooperative Robot Teams, pp. 270-275

Tsalatsanis, Athanasios   Univ. of South Florida
Yalcin, Ali   Univ. of South Florida
Valavanis, Kimon   Univ. of Denve

This paper presents a novel task allocation methodology based on supervisory control theory applicable to cooperative robot teams. A team of heterogeneous robots with different sensory capabilities is considered. The overall team's mission is decomposed into multiple tasks which are assigned to one or more robots. An evaluation function is utilized to provide optimal task allocation. The proposed controller design methodology demonstrates flexibility in task assignments and robot coordination, and it is tolerant to robot failures and repairs. A warehouse patrolling application is used to demonstrate the implementation aspect of the proposed methodology.

WeB4	Room 4
Network Systems & Control (Regular Session)	

Chair: Beran, Jan   Brno Univ. of Tech.
Co-Chair: Iracleous, Dimitrios   IST Studies/ Univ. of Hertfordshire

12:00-12:20   WeB4.1

Fuzzy Tuned Gossip Algorithms in Mobile Ad Hoc Networks, pp. 276-279

Tsapanoglou, Athanasios   MSc student
Iracleous, Dimitrios   IST Studies/ Univ. of Hertfordshire

Mobile ad hoc networks (MANET) are modeled as agents that form communities without infrastructure, for a random period of time and with usually cooperative behavior. The nodes of MANET often carry information to disseminate. The dynamics of information delivery, mostly referred as average consensus, is a common problem in these networks. The gossip protocols are designed to implement this task. The standard algorithms that are used in these protocols exploit the network describing matrix, aka Laplacian, and exchange information

to all node neighbors. In static networks the problem can be considered as an output feedback problem but in the case of MANET the problem is getting complicated due to the continuous change of network topology. In this paper the fuzzy reasoning approach is proposed to tune and leverage the gossip protocol. Illustrative simulations are included to demonstrate the application of the method and to present comparative results in various cases.

12:20-12:40   WeB4.2

Distributed Power Control for QoS-Flexible Services in Wireless Communication Networks, pp. 280-285

Chaves, Fabiano de Sousa   School of Electrical and Computer Engineering, Univ. Camp
Abbas-Turki, Mohamed   Ec. Normale Supérieure de Cachan
Abou-Kandil, Hisham   Ec. Normale Sup. Cachan
Travasso, João Marcos   School of Electrical and Computer Engineering, Univ. of Cam

This paper proposes a distributed power control framework for wireless communication networks that is able to provide a flexible QoS with the introduction of a dynamic target QoS into a conventional (fixed) target tracking power control algorithm. The target QoS of individual terminals is automatically updated according to a given performance criterion. The distributed power control is formulated as a Linear Quadratic Regulator (LQR) problem, where system operating points are met according to channel quality and the choice of key parameters. Effectiveness of the LQR-based power control is analyzed and the influence of such parameters on the algorithm's performance is investigated with the help of computer experiments.

13:00-13:00   WeB4.3

Rate-Variable-Latency Service Curve As an Extension to Network Calculus, pp. 286-291

Beran, Jan   Brno Univ. of Tech.
Fiedler, Petr   Brno Univ. of Tech.
Zezulka, Frantisek   Tech. Univ. in Brno

The objective of our work is to provide industrial communication based on IP networks with an increased level of determinism and reliability compared to the office IP networks. Our approach is based on the established methods of Quality of Service used in telecommunication networks and verification of our approach by both empirical and analytical means. In this paper, we propose an extension of Network Calculus in form of Rate-Variable-Latency (RVL) service curve which is capable of modeling of step changes of latency during data congestion caused by flow aggregation. Furthermore, we introduce several properties of the RVL service curve. Finally, we provide a comparison of the outgoing port congestion simulation using the RVL service curve and our empirical measurements.

13:00-13:20   WeB4.4

Novel Index for the Best Node Selection Problem and Enhanced Technique for the Node's State Estimation, pp. 292-297

Lee, Seoung Kyou   Korea Univ.
Jeon, SeoHyun   Korea Univ.
Doh, Nakju   Korea Univ.
Yeon, Soo Yong   Korea Univ.

The best node selection problem, that distinguishes a node with the best state among multiply connected nodes, is one of the fundamental problem in robotics. However, a systematic solution has not been proposed by its ambiguity characteristics. To make the problem tractable, we reduce the scope of the original problem. Then, we suggest a novel index that systematically judges a required time step needed for a node to be the best. Furthermore, we suggest a new estimation technique that outperforms than previous approaches by4.94 times in its settling time.

13:20-13:40   WeB4.5

Bisection Algorithm of Increasing Algebraic Connectivity by Adding an Edge, pp. 298-301

Kim, Yoonsoo   Univ. of Stellenbosch

For a given graph (or network) G, consider another graph G' by adding an edge e to G. We propose a computationally efficient algorithm of finding e such that the second smallest eigenvalue (algebraic connectivity, lambda_2(G')) of G' is maximized. Theoretically, the proposed algorithm runs in O(4mnlog(d/eps)), where n is the number of nodes in G, m is the number of disconnected edges in G, d is the difference between lambda_3(G) and lambda_2(G), and eps > 0 is a sufficiently small constant. However, extensive simulations show that the practical computational complexity of the proposed algorithm, O(5.7mn), is nearly comparable to that of a simple greedy-type heuristic, O(2mn). This algorithm can also be easily modified for finding e which affects lambda_2(G) the least.

Chair: Kasnakoglu, Cosku   TOBB Univ. of Ec. and Tech.
Co-Chair: Alexandridis, Antonis   Univ. of Patras

12:00-12:20   WeB5.1

Input-Triggered Feedback for Resonance Tuning of Harmonic Oscillators, pp. 302-307

Aldrich, Jack   California Inst. of Tech.

Resonance tracking control of oscillatory plants whose natural frequency is unknown is investigated from a Lyapunov stability perspective. In particular, an event-triggered discrete-time system is investigated for this purpose. The proposed resonance tuner is time-synchronized with periodic sampling of the harmonic plant's output to ensure that an analytical relationship exists between the period of the driving squarewave and the tracking error. This relation defines a class of discrete-time nonlinear systems whose origin, is shown to be asymptotically stable.

12:20-12:40   WeB5.2

Enhancing Open-Loop Performance of Overhead Cranes by a Simple Energy-Based Hidden Control-Loop, pp. 308-313

Konstantopoulos, George   Univ. of Patras
Alexandridis, Antonis   Univ. of Patras

A new simple approach is proposed that improves the transient performance of an overhead crane. Particularly, the open-loop operation is substantially improved by adding a simple nonlinear hidden control-loop that needs measurements of only the carrier and angle velocities. This controller acts as a complementary part of the open-loop operation and it is implemented by a coupled-dissipation feedback term. Using energy-based techniques we prove that the proposed hidden controller increases the swing damping and the passivity of the system. Simulation tests under conventional open-loop operation indicate a decisive suppression of the angle oscillations and verify the effectiveness of the proposed scheme.

12:40-13:00   WeB5.3

Controlling Chaos in Arneodo System, pp. 314-319

Motallebzadeh, Farzaneh   Tarbiat Modares Univ.
Dadras, Sara   Tarbiat Modares Univ.
Motallebzadeh, Foroogh   Iran Univ. of Science and Tech.
Ozgoli, Sadjaad   Tarbiat Modares Univ.

In this paper, the problem of controlling chaos in Arneodo chaotic system is considered for the first time. Three different methods, feedback linearization, backstepping design and sliding mode control, are used to suppress chaos and regulate the system around one of its unstable equilibrium points. Simulation results show that all these three methods are efficient. We may also make the system robust to model uncertainties and external disturbances by applying the sliding mode approach.

13:00-13:20   WeB5.4

A Control Law for a Nonlinear Heat Conduction Problem on Nontrivial Domains Using FEM, pp. 320-323

Nabi, Mashuq-un-   Indian Inst. of Tech.
Guha, Paramita   Indian Inst. of Tech.

A modeling and control strategy is presented for a nonlinear problem of heating a domain of nontrivial geometry from an arbitrary initial to another arbitrary desired temperature profile. A large dynamic model of the nonlinear heat equation is obtained through finite element (FE), which is reduced using proper orthogonal decomposition. Finally, a nonlinear control law is proposed for the control problem and its stability proved through Lyapunov analysis. Results of numerical implementation are presented and possible extensions identified.

13:20-13:40   WeB5.5

Stabilization of a Class of Nonlinear Affine Fractional-Order Systems Using Generalizations of Bellman-Gronwall Lemma, pp. 324-329

N'Doye, Ibrahima   CRAN
Zasadzinski, Michel   CRAN
Radhy, Nour-Eddine   Lab. Physique et Matériaux Microélectonique, Automatique
Bouaziz, Abdellaq   Lab. Mécanique Productique et Génie Industriel (MPGI)

This paper presents a result of stabilization of nonlinear affine fractional-order systems using generalizations of Bellman-Gronwall lemma. Two case are treated : the nonlinear and the linear state feedback stabilization.

Chair: Vardulakis, Antonis   Aristotle Univ. of Thessaloniki
Co-Chair: Kalogeropoulos, Grigoris   Univ. of Athens

12:00-12:20   WeB6.1

Power Series Solutions for Linear Higher Order Rectangular Differential Matrix Control Systems,
pp. 330-335

Pantelous, Athanasios   City Univ. London
Karageorgos, Athanasios   Univ. of Athens
Kalogeropoulos, Grigoris   Univ. of Athens

This paper is concerned with the solution of linear higher order rectangular differential matrix systems which are appeared in many applications of optimal and filtering control theory. The classical power series method is employed to obtain the analytic solution of linear higher order rectangular (singular) differential matrix equations. In the present paper, the authors provide some preliminary results for solving linear singular matrix systems with the power series approach.

12:20-12:40   WeB6.2

Denominator Assignment, Invariants and Canonical Forms under Dynamic Feedback Compensation in Linear Multivariable Systems, pp. 336-341

Vardulakis, Antonis   Aristotle Univ. of Thessaloniki
Kazantzidou, Christina   Aristotle Univ. of Thessaloniki

A result originally reported in [1] for linear time invariant single input single output systems and concerning an invariant and a canonical form of the transfer function of the closed loop system under dynamic feedback compensation is generalized for LTI multivariable systems. This result leads to a characterization of the class of closed loop transfer function matrices which are obtainable under feedback through a proper dynamic compensator and gives rise to an algorithmic design procedure for the computation of a proper dynamic (feedback), internally stabilizing and denominator assigning compensator for non-minimum phase plants [1] Hammer, J. (1983), Linear dynamic output feedback: invariants and stability, IEEE Transactions on Automatic Control, Vol. AC-28, No. 4, April 1983, pp. 489-496

12:40-13:00   WeB6.3

Input-Output Finite-Time Stability of Linear Systems, pp. 342-346

Amato, Francesco   Univ. degli Studi Magna Graecia di Catanzaro
Ambrosino, Roberto   Univ. degli Studi di Napoli Parthenope
Cosentino, Carlo   Univ. degli Studi Magna Grćia di Catanzaro
De Tommasi, Gianmaria   Univ. degl Studi di Napoli
Montefusco, Francesco   Univ. degli Studi Magna Graecia di Catanzaro

When only the input-output behavior of a dynamical system is of concern, usually Bounded--Input Bounded--Output(BIBO) stability is studied, for which several results exist in literature. The present paper investigates the analogous concept in the framework of Finite Time Stability (FTS), namely the Input--Output FTS. A system is said to be IO finite time stable if, assigned a bounded input class and some boundaries in the output signal space, the output never exceeds such boundaries over a prespecified (finite) interval of time. FTS has been already investigated in several papers in terms of state boundedness, whereas this is the first work dealing with the characterization of the input-output behavior. Sufficient conditions are given, concerning the class of L_2 and mathcal L $_;$ input signals, for the analysis of IO--FTS and for the design of a static state feedback controller, guaranteeing IO--FTS of the closed loop system. Finally, the applicability of the results is illustrated by means of two numerical examples.

13:00-13:20   WeB6.4

Practical Stability and Stabilization of Linear Systems, pp. 347-352

Ben Mabrouk, Walid   école nationale d'ingenieurs de Monastir
Messaoud, Hassani   Ec. Nationale d'Ingénieurs de Monastir
Garcia, Germain   LAAS-CNRS

In this paper practical stability and stabilization of linear continuous systems, modeled in state space and subject to state norm constraints, are considered. First, we provide condition for practical stability using the norm of the transition matrix. Then we give conditions guaranteeing the existence and the synthesis of a state feedback controller and a static output feedback controller which practically stabilize the system with respect to state norm constraints. Conditions guaranteeing the design of a controller which ensures both practical and

asymptotic stability are then proposed. The latter conditions relative to simultaneous practical and asymptotic stability are extended to the case of uncertain systems.

WeC1	**Room 1**
Fault Diagnosis II (Regular Session)	

Chair: Maquin, Didier	Inst. National Pol. de Lorraine
Co-Chair: Boussalis, Helen	California State Univ.

16:20-16:40	WeC1.1

Simultaneous State and Unknown Inputs Estimation with PI and PMI Observers for Takagi Sugeno Model with Unmeasurable Premise Variables, pp. 353-358

Ichalal, Dalil	CENTRE DE RECHERCHE EN AUTOMATIQUE DE NANCY (CRAN), CNRS,UMR7039
Marx, Benoit	Centre de Recherche en Automatique de Nancy
Ragot, Jose	CRAN-INPL
Maquin, Didier	Inst. National Pol. de Lorraine

In this paper, a proportional integral (PI) and a proportional multiple integral observer (PMI) are proposed in order to estimate the state and the unknown inputs of nonlinear systems described by a Takagi-Sugeno model with unmeasurable premise variables. This work is an extension to nonlinear systems of the PI and PMI observers developed for linear systems. The state estimation error is written as a perturbed system. First, the convergence conditions of the state estimation errors between the system and each observer are given in LMI (Linear Matrix Inequality) formulation. Secondly, a comparison between the two observers is made through an academic example.

16:40-17:00	WeC1.2

Fault Detection and Isolation of a Segmented Telescope Testbed, pp. 359-364

Covarrubias, Jose D.	California State Univ. Los Angeles
Boussalis, Helen	California State Univ.
Torres, Christian	California State Univ. Los Angeles

Fault Detection and Isolation is one of the necessary requirements to guarantee the stability and performance of a control system under fault conditions. This scope of this paper will focus on the methods used to identify sensor and actuator failures. An observer based approach is used in conjunction with a sensor relationship on a segmented primary dish telescope testbed located at the NASA sponsored Structures Pointing And Control Engineering (SPACE) laboratory at California State University, Los Angeles. The use of a sensor relationship that is not dependent on the input of the system allows for a differentiation between actuator and sensor faults.

17:00-17:20	WeC1.3

Multiple Faults Diagnosability of Hybrid Systems, pp. 365-370

Fourlas, George K.	TEI of LAMIA

Many diagnosis approaches are based in the assumption of single faults. This assumption may result to erroneous diagnosis statement in case where multiple faults occurs. Thereby multiple fault diagnosis is a challenging task especially in the control of large scale complex systems that can be viewed as hybrid systems. This owed to the fact that multiple faults are hard to detect because there consequences can mask or compensate to each other. The goal is to detect multiple faults as early as possible and provide a timely warning. A key issue is to prevent local faults to be developed into system failures that may cause safety hazards, stop temporarily the production and possible detrimental environment impact. In this work we introduce the notion of multiple faults diagnosability of Hybrid Systems in the framework of Hybrid Input Output Automata (HIOA). We present a methodology for detection of multiple faults imposing the condition for a Hybrid System to be diagnosable. This approach is applicable to a wide rage of systems since Hybrid Systems involve both continuous and discrete dynamics. The proposed method is tested via a simple application to a two tank system.

17:20-17:40	WeC1.4

Combinational Fault Diagnosis in a Monitored Environment by a Wireless Sensor Network, pp. 371-376

Babazadeh, Mehrdad	Univ. of Bremen
Lang, Walter	Univ. of Bremen

This paper studies a combinational algorithm of a limit-trend checking, plausibility test and model-based method to attain a secure fault diagnosis in a wireless sensor network. It has been implemented based on a new theoretical identification method. The sensor nodes of the network have been distributed inside an intelligent container to monitor environmental parameters (temperature and relative humidity). It employs measured

parameters, residuals and a developed model of the environment to introduce a topology, applicable in several applications of fault diagnosis area.

17:40-18:00 WeC1.5

Fault Detection and Isolation for a Lipschitz Nonlinear System: Application to a Bank of Tanks, pp. 377-382

Kamel, Mohamed — National Engineering School of Sfax
Chaabane, Mohamed — Engineering school of Sfax, Tunisia
El Hajjaji, Ahmed — Univ. de Picardie-Jules Verne
Chadli, Mohammed — Univ. de Picardie-Jules Verne
Chaari, Abdessattar — National Engineering School of Sfax

this paper addresses the problem of fault detection and isolation (FDI) for a class of Lipschitz nonlinear systems with unknown inputs. We propose two new approaches based on unknown input observer design technique to detect, locate and estimate the additional fault. The observer design problem is formulated in LMI terms which can be solved easily using LMI Toolbox of Matlab software. An application of quadruple-tank process is presented to show the performance of the proposed approaches.

WeC2 Room 2

Classification Systems (Regular Session)

Chair: Koskimäki, Heli — Univ. of Oulu
Co-Chair: Mitrakis, Nikolaos — Aristotle Univ. of Thessaloniki

16:20-16:40 WeC2.1

An Evolutionary Fuzzy Classifier for Satellite Image Classification, pp. 383-388

Stavrakoudis, Dimitrios — Aristotle Univ. of Thessaloniki
Theocharis, John — Aristotle Univ. of Thessaloniki

A Boosted Genetic Fuzzy Classifier (BGFC) is presented in this paper for land cover classification from VHR multispectral images. The proposed system is constructed through a two stage process. The first stage incrementally generates a fuzzy rule base, through repeated invocations of an evolutionary rule extracting algorithm. A boosting algorithm is employed, forcing new rules to focus on uncovered regions of the feature space. Each fuzzy rule is allowed to choose the features that best describe the patterns its antecedent cover, thus implementing a local feature selection mechanism. The resulting rule base is further fine-tuned in a subsequent stage, namely the genetic tuning stage, through an evolutionary algorithm (EA), increasing the classification performance of the final model. The BGFC is tested using an IKONOS satellite image, in a lake-wetland ecosystem of international importance. The results demonstrate the proposed system's capabilities in handling complex multi-dimensional classification tasks.

16:40-17:00 WeC2.2

An Efficient Structure Learning Algorithm for a Self-Organizing Neuro-Fuzzy Multilayered Classifier, pp. 389-394

Mitrakis, Nikolaos — Aristotle Univ. of Thessaloniki
Theocharis, John — Aristotle Univ. of Thessaloniki

In authors' previous works, a novel self-organizing neuro-fuzzy multilayered classifier (SONeFMUC) was proposed. SONeFMUC is composed of small-scale interconnected fuzzy neuron classifiers (FNCs) arranged in layers. The structure of the classifier is revealed by means of the well known GMDH algorithm. In addition, the GMDH algorithm inherently implements feature selection, considering the most informative attributes as model inputs. However, previous simulation results indicate that the GMDH algorithm calculates a large number of FNCs with slightly higher or even the same classification capabilities than its parents. Hence, the computational cost of the GMDH is large without a direct impact to the classification accuracy. In this paper, a modified version of GMDH is proposed for an effective identification of the structure of SONeFMUC with reduced computational cost. To this end, a statistical measure of agreement of the generic FNCs in classifying the patterns of the problem is used. This measure is known as Proportion of Specific Agreement (Ps). Hence, only complementary FNCs are combined to construct a descendant FNC at the next layer and the total number of constructed FNCs is reduced. The proposed structure learning algorithm is tested on a well known classification problem of the literature, the forensic glass. Simulation results indicate the efficiency of the proposed algorithm.

On Training Radial Basis Function Neural Networks Using Optimal Fuzzy Clustering, pp. 395-400

Tsekouras, George   Univ. of the Aegean
Niros, Antonios   Univ. of the Aegean

The major issues in developing radial basis functions neural networks are the determination of the appropriate number of hidden nodes and the kernel parameter values. Both of them are directly related to the underlying structure of the training data. To discover this structure we propose a new training algorithm that uses, in sequence, hierarchical fuzzy clustering and optimal clustering. The result is a network topology with a small number of nodes without significant loss of the accurate modeling performance. To verify the efficiency of the method we test three well-known cluster validity indices. Finally, the simulation results demonstrate the modeling capabilities of the proposed method.

Activity Recognition Using a Wrist-Worn Inertial Measurement Unit: A Case Study for Industrial Assembly Lines, pp. 401-405

Koskimäki, Heli   Univ. of Oulu
Huikari, Ville   Univ. of Oulu
Siirtola, Pekka   Univ. of Oulu
Laurinen, Perttu   Univ. of Oulu
Röning, Juha   Univ. of Oulu

As wearable sensors are becoming more common, their utilization in real-world applications is also becoming more attractive. In this study, a single wrist-worn inertial measurement unit was attached to the active wrist of a worker and acceleration and angular speed information was used to decide what activity the worker was performing at certain time intervals. This activity information can then be used for proactive instruction systems or to ensure that all the needed work phases are performed. In this study, the selected activities were basic tasks of hammering, screwing, spanner use and using a power drill for screwing. In addition, a null activity class consisting of other activities (moving around the post, staying still, changing tools) was defined. The performed activity could then be recognized online by using a sliding window method to divide the data into two-second intervals and overlapping two adjacent windows by 1.5 seconds. Thus, the activity was recognized every half second. The method used for the actual recognition was the k nearest neighbor method with a specific distance boundary for classifying completely new events as null data. In addition, the final class was decided by using a majority vote to classifications of three adjacent windows. The results showed that almost 90 percent accuracy can be achieved with this kind of setting; the activity-specific accuracies for hammering, screwing, spanner use, power drilling and null data were 96.4%, 89.7%, 89.5%, 77.6% and 89.0%, respectively. In addition, in a case with completely new null events, use of the specific distance measure improved accuracy from 68.6% to 82.3%.

Detection and Identification of Human Actions Using Predictive Modular Neural Networks, pp. 406-411

Petridis, Vassilios   Aristotle Univ. of Thessaloniki
Deb, Briti   Aristotle Univ. of Thessaloniki
Syrris, Vassilis   Aristotle Univ. of Thessaloniki

Abstract—The aim of the present study is to validate a 2D kinematic model of human body in providing considerable features that they could be used for human actions classification. Human motion can be termed as a non-rigid, articulated motion, with body parts being piecewise rigid, held together by joints. The presented approach uses the fact that the human body has certain anthropometric proportion and uses the anatomical shape representation of the non-rigid and articulated human body contour. The body joints and the different body parts are detected with help of prior anatomical knowledge and extracted silhouette. The result of this kinematics based approach is a simple 2D human stick figure. Features are extracted from this 2D model and used to represent the human body. In the training phase, each training video is represented by a neural network, while in classification phase, the Predictive Modular Neural Network (PREMONN) time series classification algorithm is applied to classify the human actions.

Statistical Descriptors for Human Actions Classification, pp. 412-415

Syrris, Vassilis   Aristotle Univ. of Thessaloniki
Petridis, Vassilios   Aristotle Univ. of Thessaloniki

The objective of this study is to investigate alternative ways for representing suitably, with the fewest possible assumptions, the information derived from video recordings. It proposes a set of statistical descriptors capable of summarizing all the available information from each video frame. A sequence of such features expresses the

object motion implicitly without the need for object detection techniques and tedious pre-processing. A video application such as the human action recognition is then tackled as a time-series classification problem. Neural networks are used for the time-series learning; when they are simulated with a new human action video, their predictions constitute the input a typical classifier would require, in order for it to decide which model (from the known time-series) has possibly generated this video.

WeC3	**Room 3**
Swarm Robotics (Invited Session)	

Chair: Valavanis, Kimon	Univ. of Denve
Co-Chair: Longhi, Sauro	Univ. Pol. delle Marche
Organizer: Barnes, Laura	Univ. of Texas at Arlington
Organizer: Valavanis, Kimon	Univ. OF SOUTH FLORIDA
Organizer: Garcia, R.D.	Univ. of South Florida

16:20-16:40	WeC3.1

A Bar Magnet Approach to Controlling Multirobot Systems (I), pp. 416-421

Barnes, Laura	Univ. of Texas at Arlington
Fields, MaryAnne	U.S. Army Res. Lab.
Valavanis, Kimon	Univ. OF SOUTH FLORIDA

In this paper, we present a novel strategy for organizing groups of robots into a formation utilizing artificial potentials which behave like a bar magnet. A mathematical surface is defined that will "pull" the robots into formation controlling the overall geometry. Nonlinear limiting functions are defined to attract and hold members in a geometric formation. By adjusting control parameters, the shape and the extent of the formation is controlled. Formations can dynamically change and adapt accordingly by making the control parameters time varying. This approach is computationally efficient and scales well to large team sizes. Simulation studies are presented for ten robots in wedge, inverted 'vee', and column formations.

16:40-17:00	WeC3.2

Edge Contraction Based Maintenance of Rigidity in Multi-Agent Formations During Agent Loss (I), pp. 422-427

Fidan, Baris	Australian National Univ.
Hendrickx, Julien M.	Massachusetts Inst. of Tech.
Anderson, Brian D.O.	Australian National Univ.

This paper proposes a systematic approach to the problem of restoring rigidity after loss of an agent, for two-dimensional rigid multi-agent formations based on a particular graph operation, the edge contraction operation. A rigidity maintenance method is proposed, for the cases where an agent is lost in an arbitrary two-dimensional rigid formation, to restore rigidity by transferring all links to which this agent was incident on to one of its neighbors. From a graph theoretical point of view, this corresponds to contraction of a certain edge incident to the vertex representing the agent being lost.

17:00-17:20	WeC3.3

Formation Control of Marine Veihicles Via Real-Time Networked Decentralized MPC (I), pp. 428-433

Vaccarini, Massimo	Univ. Pol. delle Marche
Longhi, Sauro	Univ. Pol. delle Marche

Traditional ocean research and exploration usually require a lot of time, funds and, in general, resources. In the last years, mainly thanks to the GPS technology, unmanned small vehicles have been proposed for marine exploration and investigation. In this paper, a cooperation scheme (either for surface and underwater vehicles) is outlined for a multi-robot framework with a certain mission. The objective is translated into a formation control problem and the coordination is achieved through underwater sonar communication. A real-time implementable formation control strategy based on Networked Decentralized MPC is presented that drive each single vehicle. MPC allows to take into account for constraints, nonlinearities and exchanged information about future behaviours of the single agents. The decentralized strategy makes use of either local and received information for computing the best behaviour that optimises some objective function. A reconfigurable hierarchical structure is assumed for managing the formation. The real-time implementability is achieved using Multiplexed MPC and/or stochastic optimization algorithms for reducing computation times. Simulation results are provided for comparing the presented algorithms.

17:20-17:40 WeC3.4

A Grid Forming Target Allocation Strategy for Multi Robot Systems. (I), pp. 434-439

Lionis, Grigoris National Tech. Univ. of Athens
Kyriakopoulos, Kostas J. National Tech. Univ. of Athens

In this paper we investigate a class of algorithms for solving a target allocation problem for a team of mobile robots. The problem solved concerns the concurrent solution of the target allocation problem and the motion planning problem, and it is solved for a specific class of targets. Specifically we are studying the solution of the target allocation problem when the targets are structured on a full grid structure. The problem is solved decentralized, with each agent having information regarding its position and its immediate vicinity. The main idea is to transform the problem from a 2D problem in a 1D problem. Time bounds for convergence are also given.

17:40-18:00 WeC3.5

Cooperative Multi-Target Tracking Via Hybrid Modeling and Geometric Optimization (I), pp. 440-445

Tolic, Domagoj Univ. of New Mexico
Fierro, Rafael Univ. of New Mexico
Ferrari, Silvia Duke Univ.

In this paper, we present a stochastic hybrid model of mobile networks able to encompass a large variety of multiagent problems and phenomena. The model is applied to a case study where a heterogeneous mobile sensor network cooperatively detects and tracks mobile targets in the plane based on intermittent observations. When these observations form a satisfactory target trajectory, a mobile sensor is switched to pursuit mode and deployed to capture the target in minimum time. The mobile sensor network consists of a set of robotic sensors modeled as hybrid systems with processing capabilities. Since the sensors are installed on robotic platforms and have limited range, the geometry of the mobile sensors' field-of-view plays a critical role in motion planning and obstacle avoidance. The cost of operating the sensors is determined from the geometric properties of the network, its workspace and the probability of target detection. Simulation results verify the validity of the developed model and tracking methodology.

WeC4 Room 4
Secure Wireless Sensor Networks (Invited Session)

Chair: Selmic, Rastko R. Louisiana Tech. Univ.
Co-Chair: Phoha, Vir Louisiana Tech. Univ.
Organizer: Selmic, Rastko R. Louisiana Tech. Univ.
Organizer: Phoha, Vir Louisiana Tech. Univ.

16:20-16:40 WeC4.1

Coverage Control for Camera Sensor Networks: Its Implementation and Experimental Verification (I), pp. 446-451

Hatanaka, Takeshi Tokyo Inst. of Tech.
Ibuki, Tatsuya Tokyo Inst. of Tech.
Gusrialdi, Azwirman Tech. Univ. of Munich
Fujita, Masayuki Tokyo Inst. of Tech.

In this paper, we investigate coverage control for robotic camera sensor networks. The main objective is to establish a camera sensor network system in practice and to perform an experiment of coverage control. However, the camera sensor is one of the typical anisotropic sensors and we cannot apply most conventional algorithms assuming isotropic sensors. We thus employ the algorithm in [9] which is one of our previous works, and demonstrate the effectiveness of our algorithm through an experiment.

16:40-17:00 WeC4.2

Detecting Coverage Holes in Wireless Sensor Networks (I), pp. 452-457

Kanno, Jinko Louisiana Tech. Univ.
Buchart, Jack Louisiana Tech. Univ.
Selmic, Rastko R. Louisiana Tech. Univ.
Phoha, Vir Louisiana Tech. Univ.

Wireless sensor network coverage completeness is an important Quality of Service measure. It is frequently assumed that events occurring in the sensor field will always be detected. However, this is not necessary the case, particularly if there are holes in the sensor network coverage. This paper introduces a novel method for detection and relative localization of sensor network coverage holes in coordinate-free networks assuming availability of a network communication graph. We identify sensor nodes that bound coverage holes, called

"hole boundary nodes", by processing information embedded in a communication graph, which is non-planar in general. We create a hole-equivalent planar graph preserving a number and position of holes. Finally, we build a planar simplicial complex, called maximal simplicial complex, which contains the information regarding coverage holes. The proposed method is applicable for both coordinate-available and coordinate-free networks. Two implementation strategies for hole detection are provided, and they are each analyzed to compare runtime and accuracy. Simulation results show effectiveness of the hole detection algorithms.

17:00-17:20 WeC4.3

Game Theory Model for Selective Forward Attacks in Wireless Sensor Networks (I), pp. 458-463

Reddy, Brahmananda   Grambling State Univ.
Srinivasagopalan, Srivathsan   Louisiana State Univ.

The problem of detecting malicious nodes in wireless sensor networks is considered. Since current security mechanisms are inadequate for wireless sensor networks, we must develop a new framework to detect malicious nodes using Zero-Sum game approach and selective node acknowledgements in the forward data path. The first few sections of the paper provide a game model with probability of cost required to defend the nodes and the subsequent sections derives the model to detect malicious nodes using the probability of acknowledgment at source.

17:20-17:40 WeC4.4

Container Communities: Anti-Tampering Wireless Sensor Network for Global Cargo Security (I), pp. 464-468

Bian, Jiang   Univ. of Arkansas at Little Rock
Seker, Remzi   Univ. of Arkansas at Little Rock
Ramaswamy, Srini   Univ. of Arkansas at Little Rock
Yilmazer, Nuri   Texas A&M Univ. - Kingsville

U.S. Immigration and Customs Enforcement is overwhelmed with the number of containers entering U.S.A. on a regular basis. Although containers are pre-screened and inspected at the time of shipment, it does not necessarily address all security risks. Containers stay en-route for long enough time that their contents can be tempered with or altered according to the procedures/needs of a terrorist attack. Moreover, considering the huge amount of shipments entering U.S. board daily, it is not practical to inspect every container again upon arriving U.S. ports. There is a urgent need to develop a protection system, such that the integrity of the containers can be persevered or at least the intrusion can be detected and properly handled. This paper proposes a design of a comprehensive solution that would monitor containers' integrity from the originating port to the destination port and report any intrusion event if it has taken place so the intruded container can be handled in an appropriate way. More important, the system itself needs to be secure and intrusion resistant. In the proposed system, intrusion detection sensors are deployed on each container, and form a Wireless Sensor Network (WSN) to report intrusion incidents. A secure and reliable communication protocol has been developed to ensure not only the integrity but also the authenticity of the communication conducted among among sensor nodes. With in the proposed system, not only the intrusions can be identified and properly handled, but also the system itself is attack resistant by utilizing Wireless Sensor Networks in a smart fashion.

WeC5   Room 5
Robust Control (Regular Session)

Chair: Gershon, Eli   Tel Aviv Univ.
Co-Chair: Lupu, Ciprian   Pol. Univ. of Bucharest

16:20-16:40 WeC5.1

A Set-Theoretic Approach to Dependable Control of Uncertain Linear Systems, pp. 469-474

de Leon Canton, Plinio   Ruhr-Univ. Bochum
Lunze, Jan   Ruhr-Univ. Bochum

This paper concerns the feedback control of discrete-time systems subject to disturbances and uncertainties in both model parameters and signal measurements. The main result is a new approach to design a feedback control keeping the system state in a target set. Techniques on invariant polyhedra are extended in order to incorporate the assumption of unknown-but-bounded uncertainties and disturbances. The method is illustrated by a mobile robot experiment.

Static H_infty Output-Feedback of Retarded Linear Continuous-Time Systems with Stochastic Uncertainties, pp. 475-479

Gershon, Eli   Tel Aviv Univ.
Shaked, Uri   Tel-Aviv Univ.

A linear parameter varying approach for designing a constant output feedback controller for a linear time-invariant retarded system with stochastic multiplicative Wiener-type noise, that achieves a minimum bound on the hinf performance level is introduced. The stochastic uncertainties appear in the dynamic matrices, which correspond to the delayed and non-delayed states of the system,and in the measurement matrix of the system.

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

Robust Control Solutions for Some Classes of Hysteretic Processes, pp. 480-485

Lupu, Ciprian   Pol. Univ. of Bucharest
Udrea Andreea, Andreea   Pol. Univ. of Bucharest
Popescu, Dumitru   Pol. Univ. of Bucharest

The paper proposes a combined feedforward - feedback control scheme with nonlinear compensator as a solution for some classes of hysteretic processes. This is developed using the nonlinear geometric characteristic of the process and a classical robust control algorithm. The design methods for the components of the proposed structure are based on experimental tests, classic identification and closed loop pole placement methods. The applicability of the proposed method and of other recent methods is proved using a real-time structure implementation based on a RST control algorithm. A comparison between them and the analysis on advantages and disadvantages was made. In the end, its software implementation and the obtained results are also showed and commented.

Discrete Time Minimax Tracking Control with State and Disturbance Estimation II: Time-Varying Reference and Disturbance Signals, pp. 486-491

Bauer, Peter   Computer and Automation Res. Inst.
                                                                HungarianAcademy of
Kulcsar, Balazs   Tech. Univ. of Delft
Bokor, Jozsef   Hungarian Acad. of Sciences

The paper characterizes the properties of discrete time minimax tracking control problem in the case of time varying reference respectively estimated disturbance signal. Hereunder, a multi step tracking control synthesis is suggested for Linear Time Invariant (LTI) plants when the reference signal could be time dependent. Moreover, instead of directly rejecting the effect of the (time varying) disturbance signal, an intermediate estimation and centering step is proposed. This step eliminates the main part of the disturbance by its unbiased estimate. The solution combines the state and disturbance estimation with linear quadratic and optimal minimax tracking design. The resulted unified control solution is LQ optimal on infinite horizon with constant references and disturbances and sub-optimal on large horizons with timevarying references and disturbances. The paper clarify the effect of the time varying signals on the stability and performance criteria. The multi step procedure is illustrated via an ascending spiral trajectory tracking simulation of a quadrotor helicopter.

Distributed Parameter Systems II (Invited Session)

Chair: Demetriou, Michael A. — Worcester Pol. Inst.
Co-Chair: El-Farra, Nael H. — Univ. of California, Davis
Organizer: Demetriou, Michael A. — Worcester Pol. Inst.

16:20-16:40 WeC6.1

Stability-Based Actuator Scheduling in Distributed Processes with Control and Communication Constraints (I), pp. 492-497

Ghantasala, Sathyendra — Univ. of California, Davis
El-Farra, Nael H. — Univ. of California, Davis

This work focuses on control of distributed processes modeled by linear parabolic partial differential equations (PDEs) with constrained and quantized control inputs. Using a suitable finite-dimensional model that captures the PDE's dominant dynamics, we first characterize the inherent conflict in the control design objectives when both control constraints and quantization are simultaneously present, and the implications of this conflict for the spatial placement of the control actuators. At the heart of this conflict is the fact that control constraints limit the set of initial conditions starting from where stability can be achieved, while quantization constrains the set of terminal states that the system can be steered to. Using Lyapunov-based techniques, we explicitly characterize both the stability and terminal regions in terms of the control constraints, the quantization levels and the actuator spatial locations. The analysis reveals that the actuator configuration with the largest stability region also possesses the largest terminal region. This implies that steering the closed-loop state from large initial conditions to arbitrarily small terminal sets may not be possible using a single actuator configuration. To resolve this conflict, we devise an actuator scheduling strategy that orchestrates a finite number of transitions between different actuator configurations based on where the closed-loop state is with respect to the stability and terminal regions at any given time. The theoretical results are illustrated using a diffusion-reaction process example.

16:40-17:00 WeC6.2

Robust Control of Dissipative PDE Systems in the Presence of Uncertainty Using Adaptive Model Reduction (I), pp. 498-503

Pitchaiah, Sivakumar — The Pennsylvania State Univ.
Armaou, Antonios — The Pennsylvania State Univ.

The problem of robust feedback control of spatially distributed processes described by highly dissipative partial differential equations (PDEs) is considered. Typically, this problem is addressed through model reduction where finite dimensional approximations to the original {PDE} system are derived. A common approach to this task is the Karhunen-Loeve expansion combined with the method of snapshots. To circumvent the issue of *a priori* availability of a sufficiently large ensemble of {PDE} solution data, we focus on the recursive computation of eigenfunctions as additional data from the process become available. Initially, an ensemble of eigenfunctions is constructed with a relatively small number of snapshots. The dominant eigenspace of this ensemble is then identified to compute the empirical eigenfunctions required for model reduction. This dominant eigenspace is reevaluated with the addition of new snapshots the dominant eigenspace is reevaluated and its dimensionality may increase or decrease. Because this dimensionality is typically small the computational burden is also small. This approach is applied to a representative example of dissipative PDEs, to demonstrate the effectiveness of the approach to design robust controllers.

17:00-17:20 WeC6.3

Scanning Control for the String Equation (I), pp. 504-509

Tucsnak, M. — Univ. of Nancy
Tenenbaum, Gerald — Nancy 1

It is well known that for pointwise control problems we generally have a lack of robustness with respect to the location of the actuator. More precisely, any open subset of the considered domain contains points for which controllability fails. A remedy which has been proposed in the literature is to consider an actuator which moves according to a prescribed law. Our main results yield wellposedness and approximate controllability for a string with moving pointwise actuator.

17:20-17:40 WeC6.4

An Equation-Free, Variable-Free Approach to Systems-Level Computation in Complex/Multiscale Distributed Systems (I)*

Kevrekidis, Yannis — Princeton Univ.

On Iterative Learning Control of Parabolic Distributed Parameter Systems, pp. 510-515

Xu, Chao — Lehigh Univ.
Reza, Arastoo — Lehigh Univ.
Schuster, Eugenio — Lehigh Univ.

The Iterative Learning Control (ILC) technique is extended to distributed parameter systems governed by parabolic partial differential equations (PDEs). ILC arises as an effective method to approach constrained optimization problems in PDE systems. We discuss both P-type and D-type ILC schemes for a distributed parameter system formulated as a general linear system Sigma(A,B,C,D) on a Hilbert space, in which the system operator A generates a strongly continuous semigroup. Under the assumption of identical initialization condition (IIC), conditions on the learning parameters are obtained to guarantee convergence of the P-type and D-type ILC schemes. Numerical simulations are presented for a 1D heat conduction control problem solved using ILC based on semigroup analysis. The numerical results show the effectiveness of the proposed ILC schemes.

ThA1 Room 1
Advanced Methods in FDI and FTC (Invited Session)

Chair: Georges, Jean-Philippe — Nancy-Univ.
Co-Chair: Aubrun, Christophe — Univ. Henri Poincaré
Organizer: Aubrun, Christophe — Univ. Henri Poincaré
Organizer: Theilliol, Didier — Nancy Univ.

09:40-10:00 ThA1.1

Hybrid Priority Scheme for Networked Control Quadrotor (I), pp. 516-521

Berbra, Cedric — UMR CNRS-INPG-UJF 5216
Gentil, Sylviane — INPG
Lesecq, Suzanne — UMR CNRS-INPG-UJF 5216

This paper deals with the design and analysis of different priority schemes (static or hybrid), which can be used for the message scheduling in a networked control system. These policies are illustrated with a network controlled mechatronic system, namely a quadrotor. The quadrotor is controlled by an embedded microprocessor through a CAN network. The paper focuses on the problem of overload in the network and illustrates the results with Matlab/Simulink and Truetime simulations.

10:00-10:20 ThA1.2

Fault-Tolerant Control Design Using LPV Admissible Model Matching: Application to a Two-Degree of Freedom Helicopter (I), pp. 522-527

Saul, Montes de Oca — UPC
Puig, Vicenc — Univ. Pol. de Catalunya
Theilliol, Didier — CRAN - Nancy
Tornil-Sin, Sebastian — Univ. Pol. de Catalunya (UPC)

In this paper, a new approach to design a Fault-Tolerant Control (FTC) based on Linear Parameter Varying (LPV) Admissible Model Matching (AMM) is proposed. The suggested strategy is an active technique that requires the fault to be detected and estimated by the FDI scheme and the controller redesigned accordingly. In this work, faults are expressed as a change in the system dynamics (in particular, in the model parameters). The main contribution of the proposed approach is to consider the fault as a scheduling variable in the LPV model that allows the controller reconfiguration. In this controller, the scheduling variables are the fault magnitude estimations as well as the system operating point, and allow to specify a set of admissible models. The effectiveness and performances of the method have been illustrated in a two degree of freedom helicopter.

10:20-10:40 ThA1.3

Networked Control System with Intermittent Observations: FDI/FTC Design Based on Interacting Multiple Model Approach (I), pp. 528-533

Georges, Jean-Philippe — Nancy-Univ.
Theilliol, Didier — CRAN - Nancy
Ponsart, Jean-Christophe — Univ. Henri Poincare, Nancy I
Aubrun, Christophe — Univ. Henri Poincaré

This paper presents a FTC approach based on sensor masking principle in the special case of control system integrating a wireless sensor network. In the presence of sensor faults, the faulty measurements corrupt directly the behaviour of the closed-loop systems. With wireless transmission, packet losses are acting as additional

sensor faults. Since the controller aims at cancelling the error between the measurement and its reference input, the real outputs will in such networked control system deviate from the desired value and may drive the system to its physical limitations or even to instability. The proposed method makes possible the faults compensation based on a classical Interacting Multiple Model developed in the framework of multiple sensors failures. The IMM involved in Networked Control system provides simultaneously on-line packet losses detection, and isolation and also a suitable state estimation. Based on particular knowledge on packet losses, sensor fault-tolerant controls are obtained by computing a new control law using a fault-free estimation of the faulty element to avoid faults to develop into failures and to minimise the effects on the system performance and safety.

10:40-11:00　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　ThA1.4

Active Fault Tolerant Control Scheme for a General Aviation Aircraft Model (I), pp. 534-539

Bonfe, Marcello　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　Univ. di Ferrara
Castaldi, Paolo　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　Univ. of Bologna
Simani, Silvio　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　Univ. of Ferrara

This paper addresses the development of a novel active fault tolerant control scheme. The methodology is based on a fault detection and diagnosis procedure relying on adaptive filters designed via the nonlinear geometric approach. The controller reconfiguration exploits a further control loop, depending on the on-line estimate of the fault signal. One of the advantages of this strategy is that, for example, a structure of logic-based switching controller is not required. The active fault tolerant control scheme is therefore applied to a PA-30 aircraft simulator in several flight conditions, in the presence of actuator faults, turbulence, measurement noise, and modelling errors. The achieved results in faulty conditions show the enhancement of the flying quality, the asymptotic fault accommodation, and the control objective recovery.

ThA2	Room 2
New Trends in Neuro-Fuzzy Adaptive Control - 1 (Invited Session)	

Chair: Christodoulou, Manolis A.　　　　　　　　　　　　　　　　　　　　　　Tech. Univ. of Crete
Co-Chair: Boutalis, Yiannis　　　　　　　　　　　　　　　　　　　　　Democritus Univ. of Thrace
Organizer: Christodoulou, Manolis A.　　　　　　　　　　　　　　　　　　　Tech. Univ. of Crete
Organizer: Boutalis, Yiannis　　　　　　　　　　　　　　　　　　　　Democritus Univ. of Thrace

09:40-10:00　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　ThA2.1

A Multilayer Neural Network Based Identification and Control Scheme for a Class of Nonlinear Discrete-Time Systems with Asymptotic Stability Guarantees (I), pp. 540-545

Thumati, Balaje　　　　　　　　　　　　　　　　　　　　Missouri Univ. of Science and Tech.
Jagannathan, Sarangapani　　　　　　　　　　　　　　　　Missouri Univ. of Science and Tech.

In this paper, a new multi-layer neural network (MNN) based system identification scheme in discrete-time is proposed for a general class of nonlinear discrete-time systems with guaranteed asymptotic convergence of the identification error. Then, a MNN based direct adaptive MNN controller design is introduced for a different class of nonlinear discrete-time systems. The unique aspect of the proposed method is the asymptotic stability assurances of the system identification and tracking errors in the presence of MNN reconstruction errors by using an auxiliary robust term which is a function of the outer-layer NN weights. Finally, simulation examples are presented to illustrate the MNN based estimation and control scheme.

10:00-10:20　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　ThA2.2

Decentralized Fault Accommodation of a Class of Interconnected Nonlinear Systems Using an Adaptive Approximation Approach (I), pp. 546-551

Panagi, Panagiotis　　　　　　　　　　　　　　　　　　　　　　　　　　　Univ. of Cyprus
Polycarpou, Marios M.　　　　　　　　　　　　　　　　　　　　　　　　　Univ. of Cyprus

This paper presents a decentralized adaptive approximation design for the fault tolerant control of interconnected subsystems. We consider faults that occur in the subsystems local dynamics as well as in the interconnection effects. Linearly parameterized neural networks are used to adaptively approximate the unknown interconnection effects and the unknown changes in model dynamics due to failures. An adaptive bounding method is introduced for addressing stability and robustness issues in the presence of residual approximation errors. A simulation example is presented to illustrate the proposed control design methodology.

Discrete-Time Decentralized Neural Backstepping Controller for a Five DOF Robot Manipulator (I), pp. 552-557

Garcia, Ramon   Centro de Investigación y de Estudios Avanzados del Inst. Po
Sanchez, Edgar N.   CINVESTAV
Saad, Maarouf   Ec. de Tech. Superieure
Bayro-Corrochano, Eduardo   Centro de Investigacion y de Estudios Avanzados del Inst. Po

This paper deals with adaptive trajectory tracking for a five DOF robot manipulator, A high order neural network (HONN) is used to approximate a decentralized control law designed by the backstepping technique as applied to a block strict feedback form (BSFF). The HONN learning is performed online by an Extended Kalman Filter (EKF) algorithm. The applicability of the proposed scheme is illustrated via simulations.

Direct Adaptive Control of Unknown Nonlinear Systems with Robustness Analysis Using a New Neuro-Fuzzy Representation and a Novel Approach of Parameter Hopping (I), pp. 558-563

Theodoridis, Dimitrios   Democritus Univ. of Thrace
Christodoulou, Manolis A.   Tech. Univ. of Crete
Boutalis, Yiannis   Democritus Univ. of Thrace

EXTENDED ABSTRACT Nonlinear dynamical systems can be represented by general nonlinear dynamical equations of the form $x\mathring{U}; = f(x, u)$ (1) The mathematical description of the system is required, so that we are able to control it. Unfortunately, the exact mathematical model of the plant, especially when this is highly nonlinear and complex, is rarely known and thus appropriate identification schemes have to be applied which will provide us with an approximate model of the plant. It has been established that neural networks and fuzzy inference systems are universal approximators [1], [2], [3],i.e., they can approximate any nonlinear function to any prescribed accuracy provided that sufficient hidden neurons and training data or fuzzy rules are available. Recently, the combination of these two different technologies has given rise to fuzzy neural or neuro fuzzy approaches, that are intended to capture the advantages of both fuzzy logic and neural networks. Numerous works have shown the viability of this approach for system modeling [4] - [9]. Recently [10], [11], high order neural network function approximators (HONNFs) have been proposed for the identification of nonlinear dynamical systems of the form (1), approximated by a Fuzzy Dynamical System. This approximation depends on the fact that fuzzy rules could be identified with the help of HONNFs. The same rationale has been employed in [12], where a neuro-fuzzy approach for the indirect control of unknown systems has been introduced. In this paper HONNFs are also used for the neuro fuzzy direct control of nonlinear dynamical systems with modeling errors. In the proposed approach the underlying fuzzy model is of Mamdnani type. The structure identification is also made off-line based either on human expertise or on gather

Model Reference Circuits for Mitosis Control (I), pp. 564-569

Sotiriadis, Paul   Johns Hopkins Univ. EPP-APL & Sotekco LLC
Newcomb, Robert   Univ. of Maryland

After a review of different sets of equations covering mitosis we give a simulink realization of a basic set and from that we design some transistor circuits for their implementation. These can serve for a model reference for control of mitosis.

Adaptive Control with Neuro-Adaptive Disturbance Rejection (I), pp. 570-575

Levin, Jason   Univ. of Southern California
Ioannou, Petros A.   Univ. of Southern California

This paper presents an adaptive disturbance rejection scheme which makes use of a neural model of the disturbance. Unknown disturbances may account for the reduction in the performance of a control system where precise tracking is required. These disturbances may be nonlinear and dynamic making the rejection problem difficult for traditional methods. Also the plant being controlled may be unknown, as the model may be inaccurate or the parameters may vary over time. Classical controllers may not be able to stabilize the system and meet performance requirements under these conditions. For this purpose, the scheme presented employs an adaptive controller in conjunction with an adaptive disturbance rejector which is based on a neural model of the unknown disturbance. Numerical simulations are included to show the benefit of the scheme in terms of tracking performance.

Aerospace Control (Regular Session)

Chair: Kasnakoglu, Cosku   TOBB Univ. of Ec. and Tech.
Co-Chair: Papanikolopoulos, Nikos   Univ. of Minnesota

09:40-10:00   ThA3.1

Obtaining Regional Dynamical Models for Flow Control Using Wavelet Transform, pp. 576-581

Erbil, Turker Nazmi   TOBB Univ. of Ec. and Tech.
Kasnakoglu, Cosku   TOBB Univ. of Ec. and Tech.

In this paper, we utilize wavelet transform to obtain dynamical models describing the behavior of fluid flow in a local spatial region of interest. First, snapshots of the flow are obtained from experiments or from computational fluid dynamics (CFD) simulations of the governing equations. A wavelet family and decomposition level is selected by assessing the reconstruction success under the resulting inverse transform. The flow is then expanded onto a set of basis vectors which are constructed from the wavelet function. The wavelet coefficients associated with the basis vectors capture the time variation of the flow within the spatial region covered by the support of basis vectors. A dynamical model is established for these coefficients by using subspace identification methods. The approach developed is applied to a sample flow configuration on a square domain where the input affects the system through the boundary conditions. It is observed that there is good agreement between CFD simulation results and the predictions of the dynamical model. A controller is designed based on the dynamical model and is seen to be successful in regulating the velocity of a given point within the region of interest.

10:00-10:20   ThA3.2

Estimation of Longitudinal and Lateral Velocity of Vehicle, pp. 582-587

Jaballah, Belgacem   Univ. Paul Cézanne (France) & Univ. deMonastir(Tunisie
M'Sirdi, Kouider Nacer   LSIS -CNRS UMR 6168
Naamane, Aziz   Univ. Aix-Marseille (U3)
Messaoud, Hassani   Ec. Nationale d'Ingénieurs de Monastir

In this paper, we compare three observers and methods for estimation of the longitudinal and lat´eral velocity of the vehicle. These methods are based on the First Order Sliding Mode (FOSM), Second Order Sliding Mode (SOSM) and on the use of algebraic approach ALIEN. Their performance are studied using a 16 DoF dynamic simulator.

10:20-10:40   ThA3.3

Frequency Constrained Control of Oscillations in Flow Problems, pp. 588-593

Kasnakoglu, Cosku   TOBB Univ. of Ec. and Tech.

In this paper we investigate the control of flow problems where the control objective is to reduce the oscillation amplitude while keeping the frequency of oscillation between predefined limits at all times. The governing equations are simplified to obtain the oscillatory mode dynamics, after which the conditions that the control parameters must satisfy in order to achieve the desired objective are derived in detail. The results obtained are illustrated on a physical application example, namely cavity flow control, where it is seen that the controller is successful in achieving the control goal.

10:40-11:00   ThA3.4

New Control Laws for Angular Velocity and Line-Of-Sight Stabilization of Under-Actuated Rigid Spacecraft, pp. 594-599

Zargarzadeh, Hassan   Iran Univ. of Science and Tech.
Jahed Motlagh, Mohammad Reza   Iran Univ. of Science and Tech.

This paper proposes a novel general Lyapunov-based line-of-sight (LOS) controller design for rigid spacecraft by means of two torques. Then, the approach is developed in order to simultaneously stabilize the angular velocity and LOS, while the LOS axis is unactuated. As a feature of the introduced controller, it is shown that the total closed loop system's stability is robust against any unpredefined intrinsic saturability of actuators.

11:00-11:20   ThA3.5

Miniature Rotorcraft Platform for Aerial Teleoperation Experiments, pp. 600-605

Mettler, Bernard   Univ. of Minnesota
Andersh, Jonathan   Univ. of Minnesota
Papanikolopoulos, Nikos   Univ. of Minnesota

This paper describes the hardware and software systems that make up an experimental architecture developed to facilitate teleoperation research for miniature rotorcraft. One objective in developing this platform is to place the minimum required sensors and electronics onboard a miniature helicopter with limited payload. The

onboard hardware resources must be sufficient to simplify the teleoperation task for the operator. While being developed, the onboard system is coupled with the infrastructure at the Interactive Guidance and Control Lab at the University of Minnesota to allow for a systematic approach to the investigation of onboard control and guidance augmentations. The overall architecture integrates components that allow a variety of estimation, control and guidance algorithms to be conveniently implemented and tested. In the lab environment, a Vicon tracking system is used to accurately determine a helicopter's pose and orientation and evaluate algorithms on stationary computers. This accurate information is used to develop the necessary metrics and evaluate the performance of different algorithms before transition to real-world situations.

11:20-11:40 ThA3.6

Angular Acceleration Estimator for a Flight Motion Simulator: Design and Performance Comparison, pp. 606-609

Ma, Jie — Harbin Inst. of Tech.
Yao, Yu — Harbin Inst. of Tech.

Angular acceleration feedback will help improve dynamic transparency and reduce non-linear behavior of flight motion simulator axes motions. FIR and Kalman angular acceleration estimator design method are investigated in this paper. A detailed performance comparison is proposed and the results indicate the angular acceleration estimators present an effective routine to produce the high fidelity flight motion simulator.

ThA4	**Room 4**
Networked Control Systems I (Regular Session)	

Chair: De Persis, Claudio — Sapienza Univ. of Rome
Co-Chair: Sauter, Dominique — Nancy Univ.

09:40-10:00 ThA4.1

Stabilization of Networked Control Systems with Uncertain Time-Varying Delays, pp. 610-615

Dilaneh, Imane — ENSEA
Laval, Laurent — ENSEA

This paper deals with the stabilization problem of a Networked Control System, by means of an observer-based state feedback control approach. In particular, this paper focuses on a closed-loop Master-Slave setup with a TCP network as communication media, in case of uncertain, time-varying, non-symmetric transmission delays affecting both the control input and measured output. First, we establish some asymptotic stability criteria for the closed-loop NCS, regarding to a Lyapunov--Krasovskii functional derived from a descriptor model transformation. These stability conditions are given in terms of Linear Matrix Inequalities which are used, afterwards, to design the observer and state feedback controller gains. Finally, the proposed stabilizing approach is illustrated through numerical and simulation results, related to the remote control of a ``ball and beam" system.

10:00-10:20 ThA4.2

Quantized Controllers Distributed Over a Network: An Industrial Case Study, pp. 616-621

De Persis, Claudio — Sapienza Univ. of Rome
Kallesře, Carsten Skovmose — Grundfos Management A/S

We consider the problem of regulating pressures across large-scale hydraulic networks. We investigate the use of a class of piece-wise constant control laws which take value in a finite number of values and whose transition from one value to another occurs when the measurements cross certain thresholds. We show that a special class of these controllers, namely binary controllers, allow to achieve set-point pressure regulation from any arbitrarily large set of initial conditions. The use of this class of controllers is motivated by the need to exchange information among controllers over a network.

10:20-10:40 ThA4.3

Adaptive Stabilization of Networked Control Systems with Delays and State-Dependent Disturbances, pp. 622-627

H. Tahoun, A. — Huazhong Univ. of Science and Tech.
Fang, Huajing — Huazhong Univ. of Science and Tech.

This paper addresses the adaptive stabilization problem of linear networked control systems with network-induced delay in the presence of state-dependent disturbances. The case of state feedback is treated in which a new adaptive model of networked control system in the presence of network-induced delays and state-dependent disturbances is proposed. Based on Lyapunov stability theory, new delay-dependent stability criteria for the system are derived. To illustrate the effectiveness of the proposed method, a numerical example is provided for the design approach.

In this paper we study performance-related aspects for plants in a networked control setting, employing an approach known as Model-Based Networked Control Systems (MB-NCS) with Intermittent Feedback. Model-Based Networked Control Systems use an explicit model of the plant in order to reduce the network traffic while attempting to prevent excessive performance degradation. Intermittent Feedback consists of the loop remaining closed for some time interval, then open for another interval. We begin by investigating the behavior of the system while tracking a reference input. We provide the full response of the system and a condition for stability. We then shift our attention to controller design for MB-NCS. We use dynamic programming techniques to design an optimal controller to optimize an LQ-like performance index.

The fault detection problem is studied in this paper for a class of linear Networked Control Systems (NCS) with communication delays. Aim is to generate residual signals which, in the fault free case, are supposed to be identically zero. In practice, this condition is not satisfied due to various factors such as measurements noises, model uncertainties, and in particular for NCS communication induced delays. The effect of unknown networked induced delays on conventional observed based residual generator is studied. It is shown that the detection performances may be deteriorated due to the sensitivity of the residuals to the delays. Two approaches for robustness enhancement are proposed : one is based on robust residual generation making use of an adaptive Kalman filter, the other relies on adaptive residual evaluation.

ThA5   Room 5
Modeling & Simulation I (Regular Session)

In a system using PAMs, a big research effort has been carried out to solve the control problem, in which the nonlinear dynamics of a PAM were left behind as a disturbance to that system. The inherent dynamics in a PAM is due to its constitutional materials which cause hysteresis during cyclic contraction/extension. Prior knowledge of the hysteresis behavior in a PAM may simplify the associated control system. In this paper, the hysteretic behavior of a PAM is investigated and the results show much similarity to the presliding regime in the friction of mechanical contacting elements. The PAM hysteresis is thus generalized and represented by a lumped- parameter model, which is useful for control design.

A novel design approach for the centrifugal compressor blade is proposed in this paper. It is set up based on the offset theory and line geometry. The designed blade surface is represented as a tool path, which consists of two guide curves. It can be manufactured by flank milling method with a cylindrical cutter. The drive surface is a ruled surface that is derived by approximating the offset surface of the original design surface. This approach integrates the manufacture requirements into the design phase, which reduces the developing cycle time.

Field Validation of the Intelligent Asphalt Compaction Analyzer, pp. 651-656

Commuri, Sesh — Univ. of Oklahoma
Mai, Anh — Univ. of Oklahoma

The Intelligent Asphalt Compaction Analyzer (IACA) is a device based on Neural Network Technology that can measure the density of an asphalt pavement continuously in real-time during its construction. It was shown during limited field trials that the IACA could, in real-time, measure the density of an asphalt pavement during its construction with accuracy comparable to existing point-wise measurement technologies. In this paper, the validation of the performance of the IACA, i.e. accuracy of density measurements, is addressed. The results demonstrate that the IACA can be used to determine the density of the asphalt mat during compaction with an accuracy needed for quality control operations in the field.

ThA6 — Room 6
Predictive Control (Regular Session)

Chair: Kahng, Byungik — Univ. of Minnesota
Co-Chair: Attarwala, Fakhruddin T — Unified Control Tech. Corp.

Predictive Control of the Heat Exchanger Using Local Model Network, pp. 657-662

Novak, Jakub — Tomas Bata Univ.
Bobal, Vladimir — Tomas Bata Univ. in Zlin

The paper deals with the problem of modeling and control of nonlinear processes using the Local Model Network (LMN). The idea is based on development of the local linear models for the whole operating range of the controlled process. The nonlinear plant is then approximated by a set of locally valid sub-models, which are smoothly connected using the validity function. For saving the computational load, linear model is obtained by interpolating these linear models at each sample instant and then used in Model Predictive Control (MPC) framework to calculate the future behavior of the process. The approach is verified in a real-time control of Multifunction Process Control Teaching System (MPCTS) – the Armfield PCT 40.

Positive Invariance of Multiple Valued Iterative Dynamical Systems in Disturbed Control Models, pp. 663-668

Kahng, Byungik — Univ. of Minnesota

It is well known that a classical non-linear discrete-time control dynamical system can be reduced to an iterative dynamical system of one endomorphism in the phase space. In this paper, we study the similar reduction in the presence of disturbance, via multiple valued iterative dynamics. This reduction raises some intriguing problems in the invariant set theory of the disturbed control dynamical systems. The multiple valuedness of our system necessitates us to consider two distinct types of predecessor operations, strong and weak, where each type generates its own invariant set theory. A natural question that follows is, how the strong and the weak invariant set theories of the multiple valued iterative dynamical systems differ. The purpose of this paper is to answer this question and discuss its implications in modeling the disturbed control dynamical systems.

Modular Robust Model Predictive Control, pp. 669-675

Attarwala, Fakhruddin T — Unified Control Tech. Corp.

This paper presents a method of combining model predictive control (MPC) with explicitly defined stability criteria for improved robust performance. The stability criteria is fundamental in its basis and can be applied universally to a process of any size. The stability criteria is independent variables based and can be used with linear or non-linear process; when used with linear process it imparts a quasi-linear optimal closed loop behavior. The stability criteria determines speed of optimization. A braking action can be included in conjunction with the stability criteria to permit a complete cycle control involving startup, normal operation and shutdown. The stability criteria supports both hierarchical and distributed MPC implementation consistently; that allows for the formation of a hierarchical and distributed MPC system within a process while permitting it to be connected to neighboring processes as part of a unified control system for an entire production chain involving a network of modular robust MPCs. Intrinsically, the stability criteria makes a MPC both robust and modular.

10:40-11:00   ThA6.4

Real-Time Control of a Sewer Network Using a Multi-Goal Objective Function, pp. 676-681

  Fiorelli, David   Public Res. Centre Henri Tudor
  Schutz, Georges   Public Res. Centre Henri Tudor

The present work investigates the use of a multi-goal objective function and a simple linear model for the minimizing of combined sewage overflow (CSO) in a sewer network during rain events. The model is based on a linear description of the transfer phenomena in the conduits and in the storage tanks. The objective function used, tries to distribute the hydraulic load homogenously over the network while keeping the inflow to the wastewater treatment plant as close as possible to constant value. The chosen description allows for a linear formulation of the optimisation problem. The approach has been tested on a simulator developed for a 24 retention reservoirs sewer network planed for the north-western region of the Grand Duchy of Luxembourg. Furthermore the positive and negative effects of each criterion and the influence of varying the weighting of the different subgoals are analysed. Additionally, the implementation of the real time control to be realised is discussed. The benefits of the proposed approach are shown for a series of different rain events.

11:00-11:20   ThA6.5

*Robust MPC Based on Symmetric Low-Complexity Polytopes**

  Barjas Blanco, Toni   Katholieke Univ. Leuven
  De Moor, Bart L.R.   Katholieke Univ. Leuven

11:20-11:40   ThA6.6

Discrete Output-Prediction Based Proportional Switching Controller, pp. 682-687

  Shaukat, Mansoor   Univ.
  Munawar, Khalid   Univ.

This paper introduces a novel control law that is generic in nature and stabilizes linear and a class of non-linear systems. The parameters of the proposed controller give the same flexibility of tuning the transient response of a system as the standard PID does. The superiority of the Output-Prediction based Proportional Switching (OPPS) controller lies in the fact that it addresses the fundamental implementation problems of the PID such as integrator windup, high frequency gain of the derivative term and especially sacrifice of rise-time as system damping is further enhanced using the derivative term. Extensive simulation results are presented implementing OPPS on different linear and non-linear systems that show its generic nature and strength. Finally OPPS is implemented to stabilize a 2-DOF platform stabilization scheme and results are compared with those of a PID.

ThB1	Room 1
Fault Tolerant Control (Regular Session)	

  Chair: Zolotas, Argyrios   Loughborough Univ.
  Co-Chair: Commuri, Sesh   Univ. of Oklahoma

12:00-12:20   ThB1.1

Detection and Identification of Actuator Failures in Robotic Systems Based on Multiple-Model Nonlinear State Estimation, pp. 688-693

  Hsiao, Tesheng   National Chiao Tung Univ.
  Haung, Huei-jyun   National Chiao Tung Univ.

Modern robotic systems perform elaborate tasks in a complicated environment and have close interactions with humans. Therefore fault detection and isolation (FDI) systems must be carefully designed and implemented on robots in or-der to guarantee safe and reliable operations. In addition, many high performance robotic controllers require full state feedback; hence it is essential to implement state estimators whenever not all state variables are measurable. Moreover, the state estimator must work properly despite the presence of failures so that the robot is fault tolerable. In this paper, we propose an algorithm for state estimation, fault detection, and fault identification of a robotic system. All failures in consid-eration are associated with a set of exclusive failure modes. Then a multiple-model nonlinear state estimator is applied to estimate not only the state but also the failure mode of the robot at each time step. Furthermore all failure modes are organized in a hierarchical structure to alleviate the computa-tion load. Simulations show that state estimation is accurate even in the event of actuator failures, and that the occurrence of faults is detected immediately. The computational advan-tage of the proposed hierarchical structure is also demon-strated by the simulations.

Fault detection capability tends to become an integral part of control system design procedures for practical engineering systems. It is thus desirable fault diagnosis/tolerance functions to also be included in the controller design. In this context, we develop a generic observer-based feedback controller where the observer-part can also generate a residual signal for fault detection purposes. The design objectives is a mixture of H-infinity control and H-infinity fault detection and isolation. This multi-objective optimization problem is then formulated using Bilinear Matrix Inequalities (BMI) and a sub-optimal solution is achieved via transformation to Linear Matrix Inequalities (LMI). The developed approach and algorithm are verified in study of an application to a railway suspension system of ride quality maintenance.

Unmanned Aerial Vehicles (UAVs) are playing an important role both in military as well as civilian applications. However, their role in civilian applications is hampered by the lack of adequate guidelines and operational requirements. In this paper a set of flight, operational and performance requirements for the use of UAVs in civilian applications are collated from several resources in the public domain. The application of these requirements to the flight control of an unmanned fixed-wing aircraft is also addressed in this paper. A robust controller is designed to maintain the stability and the desired performance of the system in the presence of modeling uncertainty and measurement noise. A neural network based Fault Detection and Identification (FDI) scheme is then developed to estimate the effectiveness of control inputs. Finally, a reconfigurable controller is designed to compensate for the degradation of the actuation on the occurrence of a fault. Monte Carlo simulation is used to validate the capability and performance of the designed controller.

This paper deals with freezing fault reconfiguration in a small four-rotor helicopter (Drone). This fault may be because of network faults such as packet loss or long delay in one actuator. In case of the fault occurrence in one actuator (motor) different strategies were proposed to compensate the fault effects on Drone. These approaches are based on the minimisation of criterion related to flight condition performance and satisfying to safety conditions.

The paper presents a method to recover the performance of an EMS (Electromagnetic suspension) under faulty air gap measurement. The controller is a combination of classical control loops, a Kalman estimator and analytical redundancy (for the air gap signal). In case of a faulty air gap sensor the air gap signal is recovered using the Kalman filter and analytical redundancy. Simulations verify the proposed sensor Fault Tolerant Control (FTC) method for the EMS system.

Adaptive Systems (Regular Session)

Chair: Schoukens, Johan   Vrije Univ. Brussels
Co-Chair: Stergiopoulos, John   Univ. of Patras

12:00-12:20   ThB2.1
Model Based Nonlinear Iterative Learning Control: A Constrained Gauss-Newton Approach, pp. 718-723

Volckaert, Marnix Luc Joan   K.U.Leuven
Van Mulders, Anne   Vrije Univ. Brussel
Schoukens, Johan   Vrije Univ. Brussels
Diehl, Moritz   KU Leuven
Swevers, Jan   K. U. Leuven

A new method is proposed to solve the model inversion problem that is part of model based iterative learning control (ILC) for nonlinear systems. The model inversion problem consists of finding the input signal corresponding to a given output signal. This problem is formulated as a nonlinear dynamic optimization problem in time domain and solved efficiently using a constrained Gauss-Newton algorithm. A nonlinear ILC algorithm based on this model inversion approach is validated numerically and experimentally. The considered application is an electric circuit described by a polynomial nonlinear state-space model. The nonlinear ILC algorithm shows fast convergence and accurate tracking control.

12:20-12:40   ThB2.2
Behavior Categorization Using Correlation Based Adaptive Resonance Theory, pp. 724-729

Yavas, Mustafa   METU
Alpaslan, Ferda Nur   METU

This paper presents a new method of categorizing robot behavior, which is based on a variation of Correlation Based Adaptive Resonance Theory (CobART) learning. CobART is a type of ART 2 network and its main contribution is the usage of correlation analysis methods for category matching. This study uses derivation based correspondence and Euclidian distance as correlation analysis methods for behavior categorization. Tests show that the proposed method generates better results than ART 2 categorization even when a priori SOM (Self-Organizing Map) categorization is combined with ART 2 categorization.

12:40-13:00   ThB2.3
Experimental Verification of an Adaptive Input Shaping Scheme for Hoisting Cranes, pp. 730-735

Stergiopoulos, John   Univ. of Patras
Konstantopoulos, George   Univ. of Patras
Tzes, Anthony   Univ. of Patras

The aim of this paper is the presentation of an adaptive input shaping technique suitable for overhead cranes with hoisting mechanism. The main goal is the minimization of the remaining oscillations when the motion of the trolley and the hoisting of the load are performed simultaneously. While standard input shaping theory can be applied in its standard form in classical cranes, the shaper configuration when the load is hoisted is not profound. The adaptive version proposed calculates the parameters of the shaper online depending on the updated linearized model and the current rope length. Experimental results show the benefits of the proposed controller contrary to standard input shaping and to unshaped responses.

13:00-13:20   ThB2.4
Introducing Adaptive Neurofuzzy Models with Recursive Incremental Learning Algorithm for System Identification of Nonlinear Time Varying Processes, pp. 736-741

Mirmomeni, Masoud   Control and Intelligent Processing Center of Excellence, School of Elect
Lucas, Caro   Univ. of Tehran
Araabi, Babak Nadjar   Department of Electrical & Computer Engineering

Several methods have been introduced for identification of nonlinear processes via locally or partially linear models. Unfortunately, most of these methods have a training phase which should be done offline. There are phenomena that possess time varying behavior. Furthermore, the amount, distribution and/or quality of measurement data that is available before the model is put to operation may be insufficient to build a model that would meet the specification. One of the most popular learning methods in nonlinear system identification is Locally Linear Model Tree (LoLiMoT) algorithm as an incremental learning method which needs to be carried out by an offline data set. This paper introduces a recursive version of this algorithm called Recursive Locally Linear Model Tree algorithm (RLoLiMoT) for time varying and online applications. The proposed method also eliminates some of the LoLiMoT restrictions in tuning premise parameters of the Locally Linear Models (LLMs).

Two case studies are considered to test the performance of the proposed method. The results depict the power of the proposed method in online system identification of nonlinear time varying systems.

13:20-13:40 ThB2.5

CobART: Correlation Based Adaptive Resonance Theory, pp. 742-747

Yavas, Mustafa METU
Alpaslan, Ferda Nur METU

This paper introduces a new type of ART 2 network that performs satisfactory categorization for a domain where the patterns are constructed from consecutive analog inputs. The main contribution relies on the correlation analysis methods used for category-matching. The resulting network model is named as Correlation Based Adaptive Resonance Theory (CobART). Correlation waveform analysis and Euclidian distance methods are used to elicit correlation between the learned categories and the data fed to the network.

ThB3	Room 3
Robotics I (Regular Session)	

Chair: Papadopoulos, Evangelos National Tech. Univ. of Athens
Co-Chair: Conte, Giuseppe Univ. delle Marche

12:00-12:20 ThB3.1

Minimum-Time Constrained Velocity Planning, pp. 748-753

Lini, Gabriele Univ. di Parma
Consolini, Luca Univ. of Parma
Piazzi, Aurelio Univ. of Parma

This paper proposes a method for minimum-time velocity planning with velocity, acceleration and jerk constraints and generic initial and final boundary conditions for the velocity and the acceleration. This minimum-time planning problem is relevant in the context of robotic autonomous navigation, where the iterative steering supervisor periodically replans the future mobile robot motion starting from current position, velocity and acceleration conditions. The problem is faced through discretization and its solution is based on a sequence of linear programming feasibility checks, depending on motion constraints and boundary conditions.

12:20-12:40 ThB3.2

A Parametric Study on the Rolling Motion of Dynamically Running Quadrupeds During Pronking, pp. 754-759

Chatzakos, Panagiotis National Tech. Univ. of Athens
Papadopoulos, Evangelos National Tech. Univ. of Athens

This paper examines the passive dynamics of straight-ahead level ground quadrupedal running and explores its use in formulating design guidelines that would: a) reduce steady-state roll and b) self-stabilize the rolling motion, thus making the control of the robot more straightforward. To study the effect of mechanical design in the rolling motion, a simple bounding-in-place (BIP) template is introduced as a candidate frontal plane model that captures the targeted steady-state behavior of a straight-ahead level ground running quadruped robot. This model is parametrically analyzed and local stability analysis shows that the dynamics of the open loop passive system alone can confer stability of the motion! These results might explain the success of simple, open loop running controllers on existing experimental robots and can be further used in developing control methodologies for legged robots that take advantage of the mechanical system.

12:40-13:00 ThB3.3

An Application of E-Field Sensors in Industrial Robotics, pp. 760-765

Conte, Giuseppe Univ. delle Marche
Scaradozzi, David Univ. Pol. delle Marche
Rosettani, Matteo Univ. Pol. delle Marche

This paper investigates the possibility of constructing touch and proximity sensory systems for industrial robots by means of low cost electric field sensors. The interest in this application is motivated by the possibility of implementing new modalities of interaction and cooperation between man and robot in industrial environments, according to the revised ISO standards on Robots for industrial environments. The use of two E-field sensors, having different architecture, for the realization of an artificial skin on robot links is considered and studied. Prototypes of the sensory system are developed and tested on a simple, reduced-scale model of an anthropomorphic manipulator, showing the feasibility of the proposed solution and its suitability to reduce the risk of dangerous collisions between humans and robot in a shared workspace.

13:00-13:20   ThB3.4

Design, Control, and Experimental Performance of a Teleoperated Robotic Fish, pp. 766-771

  Papadopoulos, Evangelos   National Tech. Univ. of Athens
  Apostolopoulos, Efthymios   National Tech. Univ. of Athens
  Tsigkourakos, Petros   National Tech. Univ. of Athens

Fish-like propulsion is a challenging alternative to propellers in small underwater vehicles. This paper presents the analysis, the design stages, the development and the experimental evaluation of a small low-cost teleoperated underwater robotic fish, driven by an oscillating foil. The main principles for the development of efficient thrust by oscillating foils are presented, and implemented. Essential mechatronic subsystems of the robot, including the tail's motion control system, the wireless communication system, and the autonomous power system are described. Design equations are provided, evaluation experiments are executed and performance results are presented.

13:20-13:40   ThB3.5

Stereo-Vision Based Motion Stabilization of a Humanoid Robot for the Environment Recognition by Type-2 Fuzzy Logic, pp. 772-777

  Kang, Tae-Koo   Korea Univ.
  Zhang, Huazhen   Korean Univ.
  Park, Gwi-Tae   Korea Univ.

This paper presents an efficient method of ego-motion compensation of a humanoid robot by using stereo vision and type 2 fuzzy logic. A humanoid robot should have the ability to autonomously recognize its surroundings and make right decisions under unknown environment. To solve this problem, we suggest the ego-motion compensation method which can eliminate the motion of a humanoid robot causing error of the environment recognition. The method uses the disparity map obtained from the stereo-vision and can be divided into three modules - segmentation module, feature extraction module, compensation module. In the segmentation module, we extract the objects analyzed by type-2 FCM. Features are extracted by using wavelet level set extraction and least square ellipse approximation in the feature extraction module. So, we estimate the displacement for the rotation and translation by tracking the least square ellipse and correlation coefficient by the FNCC in the compensation module. From the results of experiments, we can know that the proposed method can be applied to a humanoid robot effectively.

ThB4   Room 4

Networked Control Systems II (Regular Session)

  Chair: Pohjola, Mikael   Helsinki Univ. of Tech.
  Co-Chair: Dritsas, Leonidas   Univ. of Patras

12:00-12:20   ThB4.1

Robust Stability Bounds for Networked Systems with Varying Delays, pp. 778-783

  Dritsas, Leonidas   Univ. of Patras
  Tzes, Anthony   Univ. of Patras

This paper is concerned with Networked Controlled Systems (NCS) with uncertain, varying, bounded transmission delays and asynchronous discrete–time static control laws. It is first shown that the delay variation gives rise to a discrete–time uncertain NCS model; robust stability analysis is carried out via a linear matrix inequality approach which, when combined with a directed parameter search, yields an estimate of robust stability bounds against any variations of the maximum allowable delay (constrained within one sampling period) that the closed–loop system can tolerate. The derived bounds are compared with other techniques relying on the singular values of the perturbed NCS model. The presented simulation results prove the efficacy of the proposed control scheme.

12:20-12:40   ThB4.2

Adaptive Control Speed Based on Network Quality of Service, pp. 784-789

  Pohjola, Mikael   Helsinki Univ. of Tech.

The adaptive control speed algorithm, developed in this paper, adapts the control performance according to the communication quality of service in a networked control system. The adaptive control speed algorithm is distributed among several control loops, all sharing a bandwidth limited network. The target is to adjust the control speed and sampling interval of all the control loops, such that the network is fully utilized, while not congesting the network, but maintaining a specified network quality of service. The control speed is developed according to the internal model control principle. Bumpless changing the sampling time of the controller is also proposed. The adaptice control speed algorithm is demonstrated with the network and control co-simulator PiccSIM.

This paper addresses the bilateral teleoperation of a car-like planetary rover under communication delay. The teleoperation platform is built up between the rover and a haptic device, which provides the human operator a forcefeedback mechanism describing the environmental conditions, based on the relative distances and speeds between the rover and the obstacles. Therefore, obstacle avoidance can be achieved independent of the visualization of the environment, which, on the other hand, will reduce the communication burden. A virtual-mass model extended to the application on a carlike rover is introduced, so that wave-variable method can be implemented on this teleoperation system to overcome the timedelay problem. This control strategy is compared with another proposed sliding-mode based impedance control through a set of experiments, which also prove the feasibility of both teleoperation schemes.

This paper describes a switching visual servoing control scheme designed for an underwater vehicle with nonholonomic constraints. The objective of the proposed control methodology is to provide a human tele-operator the capability to move the vehicle without loosing a visual target from the vision system's optical field. Target tracking and vehicle pose are obtained using a Laser Vision System (LVS). Using a Lyapunov based switching controller design, the resulting controller has analytically guaranteed stability and convergence properties, while its applicability and performance have been experimentally verified using a small non-holonomic Remotely Operated Vehicle (ROV), in a test tank.

The Kalman filter is a powerful state estimation algorithm which incorporates noise models, process model and measurements to obtain an accurate estimate of the states of a process. Implementation of conventional Kalman filter algorithm requires a central processor that harvests measurements from all the sensors in the field. Central algorithms have some drawbacks such as reliability, robustness and high computation which result in a need for non-central algorithms. This study takes optimality in Decentralized Kalman Filter (DKF) as its focus and derives the Optimal Decentralized Kalman Filter (ODKF) algorithm, in case the network topology is provided to every node in the network, by introducing Global Kalman Equations. ODKF sets a lower bound of estimation error in least squares sense for DKF.

ThB5   Room 5
Nonlinear Systems III (Regular Session)

This paper deals with the problem of stabilizing a bilinear system with unstable open-loop part by means of state feedback control. The implicit objective is to provide an estimate of the region of stability of the closed-loop system. The proposed procedure can be decomposed into two convex optimization problems described in

terms of LMIs: i) Given a polytope which bounds the values of the state, containing the origin, find a stabilizing state feedback control law and an associate region of stability as large as possible inside the polytope. ii) For a solution of the first problem, find the largest polytope containing the ellipsoid such that the stability conditions hold. By iterating these two steps, constructive conditions are given to compute a state feedback control that maximizes the estimate of the region of stability. The results are illustrated by means of examples.

12:20-12:40   ThB5.2

Robust LPV Controller Synthesis with Uncertainty Modelling, pp. 815-820

Rödönyi, Gábor   Comp. and Automation Res. Inst.
Gaspar, Peter   Computer & Automation Inst. of HAS
Bokor, Jozsef   Hungarian Acad. of Sciences

The paper presents an iterative uncertainty modelling and robust controller synthesis method for linear parameter-varying (LPV) systems in linear fractional transformation (LFT) form. The goal of the method is to improve robust performance by exploiting modelling freedom in the structured uncertainty descriptions while ensuring model consistency with respect to measurement data. The proposed iterative algorithm consists of three steps: robust LPV controller synthesis, tuning of the uncertainty model and performing closed-loop experiments for new validation data.

12:40-13:00   ThB5.3

Robust Controller Design for Linear Fractional-Order Systems with Nonlinear Time-Varying Model Uncertainties, pp. 821-826

N'Doye, Ibrahima   CRAN
Zasadzinski, Michel   CRAN
Radhy, Nour-Eddine   Lab. Physique et Matériaux Microélectonique, Automatique
Bouaziz, Abdellaq   Lab. Mécanique Productique et Génie Industriel (MPGI)

In this article, a robust linear controller design in the time domain is presented for linear fractional-order systems with nonlinear model uncertainties. The Gronwall-Bellman lemma is employed to investigate the robust stability conditions which are based on the upper norm-bounds of the uncertainties. The parameters of a dynamic controller are selected to satisfy the requirements of robust stability under plant uncertainties.

13:00-13:20   ThB5.4

Stabilization of the Cart-Pendulum System Using Normalized Quasi-Velocities, pp. 827-830

Herman, Przemyslaw   Poznan Univ. of Tech.

A globally stabilizing controller in terms of the normalized quasi-velocities (NQV) for the cart-pendulum system is considered in this note. Introducing the NQV vector together with generalized coordinates leads to first-order differential equations with the identity mass matrix of the system. The proposed NQV controller, based on an energy approach, ensures balancing the inverted pendulum and bringing it to its upper equilibrium position. At the same time the cart displacement tends to zero. Some differences between the modified controller and the classical one given by Lozano et al. (2000) were discussed too.

13:20-13:40   ThB5.5

Sliding Mode Control with Integral Corrector: Design and Experimental Application to an Interconnected System, pp. 831-836

Benayache, Rabiâ   Univ. de Picardie Jules Verne

In this paper, a solution is proposed in order to solve the chattering avoidance problem in variable structure control for a class of uncertain non linear systems with external disturbances. This approach is based on sliding mode control (SMC) with integral corrector in the boundary layer to synthesize a robust control system. The stability and the performances of the closed-loop system are proven analytically using the Lyapunov synthesis approach. The proposed methods attenuate the effect of both uncertainties and external disturbances; moreover it attenuates the chattering phenomenon introduced by classical sliding-mode control. The application of this method to the two-tanks system illustrates the validity and the performances of this approach. The experimental results are presented and compared in this paper.

ThB6 — Linear Systems II (Regular Session)

Chair: Puerta, Xavier   Univ. Pol. de Catalunya
Co-Chair: Olivier, Philip D   Mercer Univ.

12:00-12:20   ThB6.1

Interaction Evaluation and Decoupler Design Using Index of Interaction, pp. 837-842

Teng, F C   Pol. Univ. of Puerto Rico

Index of Interaction (IoI) proposed in [10] is a novel measure that connects the dynamic interaction of discrete time multivariable systems to the energy level of the discrete signals. In this paper, two objective measures of interaction called diagonal dominance and the worst case IoI are proposed. In comparison with the previously proposed measure [12], current measures provide a more comprehensive interaction evaluation scheme. In addition, IoI can be used for the design of approximate decouplers which require only the solution of linear equations thereby making it much simpler to implement. Several examples are included to illustrate the ideal of interaction evaluation scheme and the design of an approximate decoupler based on diagonal dominance concept. Simulation study confirms that substantial improvement in dynami

12:20-12:40   ThB6.2

On the Lipschitz Stability of (A; B)-Invariant Subspaces, pp. 843-845

Puerta Sales, Ferran   ETSEIB - UPC
Puerta, Xavier   Univ. Pol. de Catalunya

We give necessary and sufficient conditions for the Lipschtz stability of a wide class of (AB)- invariant subspaces.

12:40-13:00   ThB6.3

PID Controller Design Using Laguerre Series, pp. 846-851

Olivier, Philip D   Mercer Univ.

A new technique for designing (i.e. tuning) PID controllers based on Laguerre series representations of the plant model and the desired response is presented. The technique allows tradeoffs between response matching, noise/disturbance rejection, and economic operation.

13:00-13:20   ThB6.4

Mediant Dynamical Systems and Diagram Coefficient Method, pp. 852-855

Balestrino, Aldo   Univ. of PISA
Zini, Giancarlo   Univ. of PISA

In anology with mediant fractions, mediant dynamical systems are introduced and their properties are analyzed. The Diagram Coefficient Method for assessing the stability of these systems is compared to classical root locus techniques.

13:20-13:40   ThB6.5

A Multi-Variable Disturbance Observer for Model Predictive Control, pp. 856-861

Tange, Yoshio   Fuji Electric Advanced Tech. Co., Ltd.
Nakazawa, Chikashi   Fuji Electric Advanced Tech. Co., Ltd.
Matsui, Tetsuro   Fuji Electric Advanced Tech. Co., Ltd.

In this paper, a new method for disturbance rejection suitable for dynamic matrix control (DMC) is proposed. DMC has been widely used in many practical engineering fields as a very useful control method. Despite its usefulness and achievements, it has been pointed out that DMC gives poor performance with respect to disturbance rejection for some kinds of disturbances such as ramp-like disturbances. To overcome this weakness, we developed an easy-to-implement disturbance observer, which only requires step response models of plants. Illustrative examples are provided to show its effectiveness for the case where a ramp-like disturbance is acting on a plant.

New Trends in Neuro_; Fuzzy Adaptive Control 2 (Invited Session)

Chair: Christodoulou, Manolis A.	Tech. Univ. of Crete
Co-Chair: Boutalis, Yiannis	Democritus Univ. of Thrace
Organizer: Christodoulou, Manolis A.	Tech. Univ. of Crete
Organizer: Boutalis, Yiannis	Democritus Univ. of Thrace
Organizer: Jagannathan, Sarangapani	Missouri Univ. of Science and Tech.

16:20-16:40   ThC1.1

Robust Adaptive Fuzzy Control of Non-Affine Systems Guaranteeing Transient and Steady State Error Bounds (I), pp. 862-867

Bechlioulis, Charalampos	Aristotle Univ. of Thessaloniki
Rovithakis, George A.	Aristotle Univ. of Thessaloniki

We consider the tracking problem of Single Input Single Output, unknown, nonaffine systems with guaranteed prescribed performance in the presence of additive input disturbances. By prescribed performance we mean that the tracking error should converge to a predefined arbitrarily small residual set, with convergence rate no less than a prespecified value, exhibiting a maximum overshoot less than a sufficiently small preassigned constant. An output error transformation is incorporated to produce a transformed system the boundedness of which is proven to be sufficient to solve the problem. A fuzzy system is utilized to approximate the unknown system nonlinearities and consequently a smooth robust adaptive fuzzy controller is designed to achieve the boundedness of the transformed system as well as of all signals in the closed loop. System performance is independent of controller gains, while no almost perfect fuzzy modeling is required. Simulation studies clarify and verify the approach.

16:40-17:00   ThC1.2

Real-Time Output Tracking for Induction Motors by Recurrent High-Order Neural Network Control (I), pp. 868-873

Alanis, Alma Y.	Univ. of Guadalajara
Sanchez, Edgar N.	CINVESTAV
Loukianov, Alexander G.	CINVESTAV de IPN, Unidad Guadalajara

This paper deals with the discrete-time adaptive output trajectory tracking for induction motors in presence of bounded disturbances. A recurrent high order neural network structure is used to design a nonlinear observer and based on this model, a discrete-time control law is derived, which combines discrete-time block control and sliding modes techniques. The paper also includes the respective stability analysis, for the whole system with a strategy to avoid specific adaptive weights zero-crossing. Applicability of the scheme is illustrated via experimental results in real-time for a three phase induction motor.

17:00-17:20   ThC1.3

Control of Unknown Nonlinear Systems with Efficient Transient Performance Using Concurrent Exploitation and Exploration (I), pp. 874-879

Kosmatopoulos, Elias	Tech. Univ. of Crete

Learning mechanisms that operate in unknown environments should be able to efficiently deal with the problem of controlling unknown dynamical systems. Many approaches that deal with such a problem face the so-called exploitation-exploration dilemma where the controller has to sacrifice efficient performance for the sake of learning ``better" control strategies than the ones already known. In this paper we show that, in the case where the control goal is to stabilize an unknown dynamical system by means of state feedback, exploitation and exploration can be concurrently performed. This is made possible through an appropriate combination of recent results developed by the author in the areas of adaptive control and adaptive optimization and a new result on the convex construction of Control Lyapunov Functions (CLF) for nonlinear systems. The resulting scheme guarantees arbitrarily good performance outside the regions where the system is uncontrollable. Theoretical analysis as well as simulation results on a particularly challenging control problem verify such a claim.

Trajectory Control of Unmanned Aerial Vehicle Using Neural Nets with a Stable Learning Algorithm (I),
pp. 880-885

Topalov, Andon Venelinov — Tech. Univ. Sofia, campus in Plovdiv
Kaynak, Okyay — Bogazici Univ.
Nikolova, Severina Mitkova — Tech. Univ. Sofia, campus in Plovdiv
Shakev, Nikola Georgiev — Tech. Univ. Sofia, campus in Plovdiv
Seyzinski, Dobrin Todorov — Tech. Univ. - Sofia, branch Plovdiv

A neuro-adaptive trajectory control approach for unmanned aerial vehicles is proposed. The aerial robot's altitude and latitude-longitude is controlled by three neuro-adaptive controllers that are used to track the desired altitude, airspeed and roll angle of the vehicle. Each intelligent control module consists of a conventional and a neural network feedback controller. The former is provided both to guarantee global asymptotic stability in compact space and as an inverse reference model of the response of the controlled system. Its output is used as an error signal by a stable on-line learning algorithm to update the parameters of the neurocontroller. In this way the latter is able to eliminate gradually the conventional controller from the control of the system. The proposed learning algorithm makes direct use of the variable structure systems theory and establishes a sliding motion in term of the neurocontroller parameters, leading the learning error toward zero. The performance of the proposed trajectory control scheme is evaluated with time based diagrams under MATLAB's standard configuration and the Aeronautical Simulation Block Set.

Robust Adaptive Controller Scheduling Using Mixing (I), pp. 886-891

Kuipers, Matthew — Univ. of Southern California
Ioannou, Petros A. — Univ. of Southern California

The performance of an identifier-based adaptive controller depends on the properties of its certainty equivalence control law and the choice for the design parameters of its estimator. The adaptive control literature has largely focused on model-following and pole-placement control objectives, which may not capture the true control objective as effectively as LTI robust control designs, e.g., mu-synthesis. Moreover, the rigorous analysis of adaptive systems have focused on qualitative results of signal boundedness and convergence, not on how to choose the design variables. In this paper we focus on these practical issues of designing adaptive controllers. The recently proposed adaptive mixing control approach addresses the first issue, in so much as the entire suite of LTI tools are available to design the underlying parameterized control law, assuming the unknown plant parameter belongs to a compact set. We examine the factors that dictate the choice of design variables. We also examine a modification of the adaptive mixing scheme that is capable of maintaining stability for cases when none of the off-line designed candidate controllers can. This is done by mixing in a conventional adaptive controller. Numerical simulations are presented to illustrate the results.

ThC2 Room 2
Unmanned Systems (Regular Session)

Chair: Fierro, Rafael — Univ. of New Mexico
Co-Chair: Sultan, Cornel — Virginia Tech.

Adaptive Kalman Filter with the Filter Gain Correction Applied to UAV Flight Dynamics, pp. 892-897

Soken, Halil Ersin — Istanbul Tech. Univ.
Hajiyev, Chingiz — Istanbul Tech. Univ.

In normal operation conditions of an UAV (Unmanned Aerial Vehicle), Optimal Kalman Filter gives sufficiently good estimation results. However, in case, where measurements are faulty, filter outputs become inaccurate and even the filter may fail. This study, introduces an Adaptive Kalman Filter algorithm with the filter gain correction for the case of measurement malfunctions. By the use of a defined variable named as the adaptive factor, faulty measurements are taken into consideration with small weight and the estimations are corrected without affecting the characteristic of the accurate ones. Efficiency of the presented algorithm is tested by the simulations for implementation on a UAV platform. Behavior of the filter algorithm is investigated for various types of measurement errors.

16:40-17:00 ThC2.2

Integrated Identification Modeling of Rotorcraft-Based Unmanned Aerial Vehicle, pp. 898-903

Budiyono, Agus — Konkuk Univ.
Yoon, Kj — Konkuk
Daniel, Finley David — Bandung Inst. of Tech.

Developing an autonomous rotorcraft-based unmanned aerial vehicle presents higher level and difficult challenges than most of the robots in general. A miniature rotorcraft, with four control inputs and six degrees of freedom, has an inherently multivariable behavior that exhibits coupling effects among the different axes of motion. The dynamics of this type of aerial vehicle is characterized by instability, high-order and sensitivity to disturbance. For rotorcraft to function as a stable mobile platform in changing flight conditions, therefore, its dynamics must be understood and modeled as the basis for controlling such a vehicle. The paper presents a development of linear model of a small scale helicopter using multi input multi output time domain identification system. The results from first principle approach are used as initial condition in the Prediction Error Minimization scheme to achieve convergence. It is demonstrated that the proposed technique can enhance the accuracy of dynamics model obtained from the first principle prediction. Using the technique, the establishment of global helicopter linear model can be achieved for a practical design of linear control laws.

17:00-17:20 ThC2.3

Development of an Autonomous ATV for Real-Life Surveillance Operations, pp. 904-909

Beainy, Fares — The Univ. of Oklahoma
Commuri, Sesh — Univ. of Oklahoma

Mobile robots are becoming an essential participant in perimeter security, reconnaissance missions and search & rescue operations. Most mobile robots available for the surveillance are not designed for outdoor use and have limited payload capability. In this paper, the Zoiros-kinito-Mati (smart-mobile-eye/ZKM-1) using off the shelf components with high load capability and off-road navigation is introduced. ZKM-1 is built on a modified ATV platform and is capable of autonomous as well as remote controlled operations. ZKM-1 is built for outdoor demonstration purposes. A sub-meter GPS receiver is used for position updates and an electronic magnetic compass used for obtaining heading information. ZKM-1 has an onboard network for connecting different modules. This network can be connected wirelessly to other networks or computers. A network camera mounted on a pan-tilt platform with a built-in microphone is installed on the ATV for video and audio feedback. ZKM-1 can also be remotely operated using a regular gaming joystick over the network. In this paper, design, development and deployment of the ZKM-1 are presented in details.

17:20-17:40 ThC2.4

Vision Based Autonomous Navigation and Landing of an Unmanned Aerial Vehicle Using Natural Landmarks, pp. 910-915

Cesetti, Andrea — Univ. Pol. delle Marche (Univ.
Frontoni, Emanuele — Univ. Pol. delle Marche
Mancini, Adriano — Univ. Pol. delle Marche
Zingaretti, Primo — Univ. Pol. delle Marche
Longhi, Sauro — Univ. Pol. delle Marche

This paper presents the design and implementation of a vision-based landing and navigation algorithm for an autonomous helicopter. The vision system allows defining a target area from an high resolution aerial or satellite images to define the waypoints of the navigation trajectory or the landing area. The helicopter is required to navigate from an initial position to a final position in a partially known environment based on GPS and vision, locate a landing target (a helipad of a known shape) and land on it. The vision based approach, using a feature based image matching algorithm find the area, analyze, in case of landing, if the area is flat and proper for landing (i.e. enough flat) and give feedbacks to the control system for autonomous landing. We use vision for precise target detection and recognition. The helicopter updates its landing target parameters based on vision and uses an on board behaviour-based controller to follow a path to the landing site. Results show the appropriateness of the vision based approach that does not require any artificial landmark (i.e. helipad) and is quite robust to occlusions, lightness variations and seasonal changes (i.e. brown or green leaves).

17:40-18:00   ThC2.5
Marine Vehicles' Line Following Controller Tuning through Self-Oscillation Experiments, pp. 916-921

  Miskovic, Nikola   Lab. for Underwater Systems and Tech. Faculty of E
  Bibuli, Marco   CNR - ISSIA
  Caccia, Massimo   CNR - ISSIA
  Bruzzone, Gabriele   CNR - ISSIA
  Vukic, Zoran   Univ. of zagreb, Faculty of Electrical Engineering and Comp

This paper demonstrates the use of self-oscillation identification experiments for tuning line following controllers for marine vehicles. Two approaches are described: first, when the controller output is yaw rate and second when controller output is reference heading. In the first case, low level controller is yaw rate while in the second it is heading controller. The identification by use of self-oscillations (IS-O) has been applied to identify the steering equation (for the case of the first controller) and it was used to identify the heading closed loop (for the case of the second controller). The second controller has been tested on different inner loop structures in order to prove the functionality of the method. The IS-O method has been chosen because of its simplicity and applicability in the field (effects of external disturbances are minimized). The methodology was applied to autonomous catamaran Charlie. The results are presented in the paper and demonstrate that the proposed method for identification as well as the developed algorithms give satisfactory performance. All algorithms and results presented here are a result of a joint work of researchers at the Consiglio Nazionale delle Ricerche, Genova and the University of Zagreb.

18:00-18:20   ThC2.6
Robust Feature Extraction and Correspondence for UAV Map Building, pp. 922-927

  Nemra, Abdelkrim   EMP
  Aouf, Nabil   Cranfield Univ.

In this paper, a technique to design a robust feature extractor and descriptor for visual map building is proposed. The extracted features are required to be computationally attractive and invariant to image rotation, scale change and illumination. We adapted the Scale Invariant Features Transform (SIFT) algorithm for Map Building applications. Our main contributions are: firstly, we introduce of an adaptive version of the SIFT algorithm suitable for different visual perceptual environments. Secondly, we use of the L-infinity norm as a criterion for feature matching, which ensures more robustness against noises and uncertainties. Finally, we propose a new criterion to select the most stable features in order to improve the visual map building performances. Results based on real images shows the good performance obtained with the proposed approach.

ThC3	Room 3
Robotics II (Regular Session)	

  Chair: Papanikolopoulos, Nikos   Univ. of Minnesota
  Co-Chair: Lazarevic, Mihailo   Univ. of Belgrade, Faculty of Mechanical Engineering

16:20-16:40   ThC3.1
A Novel Energy Pumping Strategy for Robotic Swinging, pp. 928-933

  Papadopoulos, Evangelos   National Tech. Univ. of Athens
  Papadopoulos, Georgios   MIT

In this work we show that an Acrobot can be made to behave as a robotic swing. This is achieved by controlling the first joint, provided that a given condition is satisfied. When this condition is not satisfied, the system undergoes through singular points. Even when this happens, we are again able to make the system behave as a swing by controlling the second joint and employing a new Energy Pumping strategy. This strategy presents important advantages compared to previously proposed strategies, as it is the only one that can start the system from rest and drive it to large heights. Moreover, it is fast and requires very small torques.

16:40-17:00   ThC3.2
Optimal Motion Planning for Robotic Manipulators with Dynamic Obstacles Using Mixed-Integer Linear Programming, pp. 934-939

  Ding, Hao   Tech. Univ. Muenchen
  Zhou, Mingxiang   Tech. Univ. Muenchen
  Stursberg, Olaf   Univ. of Kassel

The task of motion planning for robotic manipulators means to drive an end-effector between designated points in the work area while obstacles are not hit. This contribution investigates the case of dynamic obstacles (like human operators) and the consideration of a performance criterion to be maximized for the motion. The

proposed approach maps the dynamics of the manipulator and the obstacles into the C ×T space (spanned by the configuration C and the time T). Within this space, an (sub-)optimal sequence of configurations in the collision-free subspace is determined by mixed-integer linear programming. To achieve sufficient computational efficiency, the optimization task is approached by employing the principles of model predictive control. The paper describes the approach based on the example of a two-link robot interacting with a human operator.

17:00-17:20   ThC3.3

Path Planning Using a Lazy Spatial Network PRM, pp. 940-945

Gasparri, Andrea	Univ. degli Studi Roma Tre
Panzieri, Stefano	Univ. degli Studi Roma Tre
Oliva, Gabriele	Univ. degli Studi Roma Tre

Motion planning is an important step in any complex robotic motion task. Many algorithms deal with this problem and a lot of effective approaches makes use of random generation of roadmaps or motion commands. In this paper, a novel algorithm for random roadmap generation is proposed. This approach, which addresses the planning problem with a resilience philosophy, relies on a network model with some particular topological properties. These properties of robustness against random faults and intentional attacks are functional to devising a suitable solution for the planning problem. Comparative simulations against several algorithms have been performed to show the effectiveness of the proposed approach.

17:20-17:40   ThC3.4

Experiments in Object Reconstruction Using a Robot-Mounted Laser Range-Finder, pp. 946-951

Tokekar, Pratap	Univ. of Minnesota
Bhatawadekar, Vineet	Univ. of Minnesota
Fehr, Duc	Univ. of Minnesota, Minneapolis
Papanikolopoulos, Nikos	Univ. of Minnesota

This paper presents a methodology to estimate the 2D reconstruction of an object on a given horizontal plane using a laser range-finder mounted on a mobile robot. To complete the reconstruction process, scans of the object from all sides are required and hence the robot must go around the object in a full circle. Since no a priori information about the object is available, the path planning for the robot must be done in an online fashion as more and more of the object is seen. Techniques for such trajectory planning to obtain all round views in a smooth fashion are put forth in this paper. As the object is being seen in parts, these parts must be registered together to form a consistent reconstruction. Scan matching using Iterative Closest Point (ICP) is used to stitch together the scans obtained from various viewpoints to form the required reconstruction. Experimental results for the reconstruction are provided in this paper. The 2D reconstruction can provide information about the area projected onto the ground by the object, thus giving cues about the shape of the object. This provides motivation for further work in the 3D reconstruction of moving objects.

17:40-18:00   ThC3.5

Detecting Static Occlusion Edges Using Foreground Patterns, pp. 952-957

Miller, Grant	UMN
Atev, Stefan	UMN
Papanikolopoulos, Nikos	Univ. of Minnesota

Static occlusions are a common impediment to successful object tracking in many realistic scenes. Knowledge about the locations of occlusions in the field of view of video cameras can allow tracking algorithms to successfully handle occlusion events. We present a simple and efficient rule-based method for finding large, rigid occluders in a scene by analysis of images from a single camera. Pixels along occlusion edges are identified through specific spatiotemporal patterns occurring in the binary foreground segmentation masks obtained from the input video. The final output of our algorithm is a binary mask indicating the locations of static occluders in the scene. We present experimental results from several outdoor scenes and compare the performance of the algorithm with a previously proposed method.

18:00-18:20   ThC3.6

Biologically Inspired Optimal Control of Robotic System: Synergy Approach, pp. 958-963

Lazarevic, Mihailo	Univ. of Belgrade, Faculty of Mechanical Engineering
Obradovic, Aleksandar	Univ. of Belgrade, Faculty of Mechanical Engineering
Joka, Marko	Univ. of Belgrade,Faculty of Mechanical Engineering
Bucanovic, Ljubisa	RTB, Bor

This paper suggests a new optimal control of robotic system based on a biologically inspired control principle-synergy, which allows resolving actuator redundancy. The redundancy control problem has been discussed in the framework of optimal control problem which it is solved by Pontryagin's maximum principle. It is suggested joint

actuator synergy approach which is established by optimization law at coordination level, where it is introduced a central control as suggested Bernstein in [1]. In that way, one may obtain a specific constraint(s) on the control variables. Finally, the effectiveness of suggested biologically inspired optimal control is demonstrated with a suitable robot with three degrees of freedom and four control variables as the illustrative example.

ThC4 — Room 4
Sensor-Actuator Networks (Regular Session)

Chair: Tzes, Anthony	Univ. of Patras
Co-Chair: Koutsoukos, Xenofon	Vanderbilt Univ.

16:20-16:40   ThC4.1

A Hybrid Scheme for Video Transmission Over Wireless Multimedia Sensor Networks, pp. 964-969

Kandris, Dionisis	Tech. Educational Inst. (T.E.I.) of Athens,Greece
Tsagkaropoulos, Michail	Univ. of Patras
Politis, Ilias	Univ. of Patras
Tzes, Anthony	Univ. of Patras
Kotsopoulos, Stavros	Univ. of Patras

The introduction of multimedia capable sensors has posed new challenges for classic Wireless Sensor Networks that are henceforth required to provide both power and quality efficient routing. This paper proposes an innovative protocol for power and perceived QoS aware routing of multimedia content over Wireless Multimedia Sensor Networks. The proposed scheme comprises the advantages of both energy efficient hierarchical routing and video packet scheduling according to the packet's importance. The hierarchical routing algorithms are often utilized for bandwidth efficiency and power control over Wireless Sensor Networks. In addition, packet scheduling is widely adopted as an effective rate adaptation technique in wireless multimedia communications. Both these techniques are combined in a proposed scheme which firstly, utilizes nodes with the highest residual energy and low power-cost paths, in order to perform the routing and secondly, predicts the distortion of video packets and selects to either drop them or transmit them according to the current channel bandwidth limitations. The simulation results prove the efficiency of the proposed combined scheme in terms of power consumption and received video distortion (PSNR).

16:40-17:00   ThC4.2

Optimal Performance for Detection Systems in Wireless Passive Sensor Networks, pp. 970-975

Tantawy, Ashraf	Vanderbilt Univ.
Koutsoukos, Xenofon	Vanderbilt Univ.
Biswas, Gautam	Vanderbilt Univ.

Passive wireless sensors have emerged as a new technology to measure a vast majority of phenomena in our daily life. Passive sensors require no power source, and therefore their application domains are numerous, including health care, infrastructure protection, and national security, among many others. The deployment of wireless passive sensors and their readers has changed how detection needs to be performed. Passive sensors cannot pre-process the measurements as they have limited computational power. Therefore, no local decision is taken. Also, the reader polls the information from multiple sensors at the same time, and this causes collisions and hence packet drops and delays. In this paper, we formulate the detection performance, with non-ideal channels, in a probabilistic way, and compare with classical detection performance. We design an optimal adaptive Neyman-Pearson detector, given the channel probabilistic model, by formulating and solving a constrained optimization problem.

17:00-17:20   ThC4.3

Developing a Control Algorithm for CEN Indoor Environmental Criteria – Addressing Air Quality, Thermal Comfort and Lighting, pp. 976-981

Mitsios, Ioannis	National Tech. Univ. of Athens
Kolokotsa, Dionissia	Tech. Educational Inst. Branch of Chania
Stavrakakis, George	Tech. Univ. of Crete
Kalaitzakis, Konstantinos	Tech. Univ. of Crete
Pouliezos, Anastasios	Tech. Univ. of Crete

In this specific paper a control algorithm for serving CEN's indoor environmental input parameters in building energy management systems is presented. In the proposed control system, techniques of natural ventilation and daylight penetration are exploited. Electric lighting as well as mechanical cooling and heating are used supplementary to the techniques mentioned above. This fairly simple controller works quite satisfactory on the given input levels reducing the need for high-energy solutions.

17:20-17:40   ThC4.4
Instrumentation Design of N-Linear Sensor Network, pp. 982-986

Wailly, Olivier   CNRS UMR 6134
Heraud, Nicolas   Univ. of Corsica
Malasse, Olaf   ENSAM

The authors investigate the problem of the structural observability. This work is based on a Groëbner basis algorithm. The applicability of the algorithm is illustred by applying it on an example used by Bagajewicz. The first part gives an overview on Groëbner bases. The second part develops the concept of observability bases and in the third part we show how to use these bases to make optimal the disponibility of the system by studying the reliability. Strategies for optimally locating sensors based on reliability and cost-minimization are developed.

17:40-18:00   ThC4.5
System Identification of a Domestic Residence Using Wireless Sensor Node Data, pp. 987-992

Carmody, Cheryl   Cork Inst. of Tech.
O'Mahony, Tom   Cork Inst. of Tech.

This paper focuses on the system identification of the thermal dynamics of a domestic dwelling and the aim of the modelling process is to design an efficient control scheme that minimises energy usage and, consequently, fuel bills. Existing software packages for thermal modelling of structures are based on physical models or finite element analysis and use real data for comparative purposes only. In contrast, in this study a wireless sensor network was used to measure actual temperature variations and this data was used to identify a process model. By successfully twinning wireless technology and system identification techniques, an overall model structure of the heat characteristics of a domestic residence is presented in this paper.

ThC5   Room 5
Modeling & Simulation II (Regular Session)

Chair: Ippoliti, Gianluca   Univ. Pol. delle Marche
Co-Chair: Dr.-Ing. Sourkounis, Constantinos   Ruhr-Univ. Bochum

16:20-16:40   ThC5.1
Modal and Harmonic Experimental Validation of the Vibration Model of an Elastic Structure, pp. 993-998

Ciabattoni, Lucio   Univ. Pol. delle Marche
Grisostomi, Massimo   Univ. Pol. delle Marche
Ippoliti, Gianluca   Univ. Pol. delle Marche
Longhi, Sauro   Univ. Pol. delle Marche

In this paper it is shown that the problem of applying active control to a simple elastic plate structure can be introduced in a form which allows the application of optimal control theory. In particular, a modal model for the vibration of an elastic structure and the state space realization of this model are given. In the first part of the paper a modal analysis of the structure is introduced and the natural frequencies are computed both in analytic form and by a set of experimental tests. In the second part an harmonic analysis is performed and the output of the model is developed and compared with experimental results. This shows that the introduced model is a good description of the real process and an optimal active control of the elastic plate structure is feasible.

16:40-17:00   ThC5.2
Parametric Modelling of Flexible Plate Structures Using Real-Coded Genetic Algorithms, pp. 999-1004

Julai, Sabariah   The Univ. of Sheffield
Tokhi, M.O.   Univ. of Sheffield

This paper presents parametric modelling of flexible plate structures using real-coded genetic algorithms (RCGA). The global optimization technique of RCGA is utilized to obtain a dynamic model of a flexible plate structure based on one-step-ahead (OSA) prediction. The structure is subjected to three different disturbance signal types, namely random, pseudo random binary sequence (PRBS), and finite duration step. The fitness function for the RCGA optimization is the mean-squared error (MSE) between the measured and estimated outputs of the plate. The validation of the algorithm is presented in both time and frequency domains. The developed RCGA modelling approach will be used for active vibration control systems design and development in future work.

17:00-17:20   ThC5.3
A New Algorithm for the ARMA Model Order Via Pivot-Neighbors Comparisons, pp. 1005-1008
    Alqawasmi, Khaled   Al Al-Bayt Univ.

This paper presents a new algorithm for the determination of the ARMA model orders based on a rounding approach which is implemented to deal with the precision of binary words. The rounding approach uses the floor and the ceiling functions. The proposed algorithm is based on selecting a sequence of pivot cells values from the well known minimum eigenvalue (MEV) method developed by Liang et. al. [6]. It uses the floor and the ceiling functions of the pivot cells values and the values of its neighbors to search for the corner that contains the estimates of the true orders. The observed sequence may be contaminated by additive Gaussian noise. Simulation examples are given to illustrate the effectiveness of the proposed technique for different signal to noise ratios.

17:20-17:40   ThC5.4
Prediction of Stochastically Fluctuating Values Using the Example of Road Surface Roughness,
pp. 1009-1013
    Richter, Florian   Ruhr-Univ. Bochum
    Dr.-Ing. Sourkounis, Constantinos   Ruhr-Univ. Bochum
    Ni, Bingchang   Ruhr-Univ. Bochum

The prediction of stochastically fluctuating values is very interesting for the control of systems with stochastically fluctuating input values. In this paper a prediction method for road surface distortion is presented. If a high prediction quality can be assured, this information can be very useful for the control of a road vehicle's active damping. In the frame of this paper, different prediction methods were introduced and tested for their average prediction error. The most interesting prediction method is the one which is based on short term statistics.

17:40-18:00   ThC5.5
On the Robustness of AVS Controller to Sensor Actuator Noncollocation, pp. 1014-1019
    Peled, Irit   Tech. - Israel Inst. of Tech.
    Halevi, Yoram   Tech.

This paper considers the problem of controlling flexible systems, such as rotating shafts, whose dynamics is described by the wave equation. In previous works, infinite dimension transfer functions were introduced. Their special structure lead to the Absolute Vibration Suppression (AVS) linear collocated controller that results in a low order plus delay closed loop transfer function, hence eliminates the infinite number of poles. In this paper, the robustness problem of small, unintentional noncollocation between the control and the measurement is investigated for both conservative and non-conservative (damped) systems. It is shown that the loop can be robustly stabilized only if the load end of the structure contains damping. The use of Robust AVS controller (RAVS) to overcome the problem of noncollocation is discussed and a tuning algorithm for it is suggested. Its improved performance is shown by means of an example.

ThC6	Room 6
Optimization (Regular Session)	
Chair: Bujorianu, Luminita Manuela	Univ. of Manchester
Co-Chair: Šelmi_;, Milica	Univ. of Belgrade

16:20-16:40   ThC6.1
Scheduling Independent Tasks: Bee Colony Optimization Approach, pp. 1020-1025
    Davidovi_;, Tatjana   Searbian Acad. of Sciences and Arts
    Šelmi_;, Milica   Univ. of Belgrade
    Teodorovi_;, Dušan   Univ. of Belgrade

The problem of static scheduling of independent tasks on homogeneous multiprocessor systems is studied in this paper. The problem is solved by the Bee Colony Optimization (BCO). The BCO algorithm belongs to the class of stochastic swarm optimization methods. The proposed algorithm is inspired by the foraging habits of bees in the nature. The BCO algorithm was able to obtain the optimal value of objective function in all small to medium size test problems. The CPU times required to find the best solutions by the BCO are acceptable.

16:40-17:00   ThC6.2
Stochastic Reachability As an Exit Problem, pp. 1026-1031
    Bujorianu, Luminita Manuela   Univ. of Manchester
    Blom, Henk A.P.   National Aerospace Lab. NLR

For stochastic hybrid systems, safety verification methods are very little supported mainly because of complexity and difficulty of the associated mathematical problems. The key of the methods that succeeded in

solving various instances of this problem is to prove the equivalence of these instances with known problems. In this paper, we apply the same pattern to the most general model of stochastic hybrid systems. Stochastic reachability problem can be treated as an exit problem for a suitable class of Markov processes. The solutions of this problem can be characterized using Hamilton Jacobi theory.

17:00-17:20   ThC6.3
Performance Evaluation of an Input/output Selection Criterion Via Normalized LQG Closed-Loop Comparison, pp. 1032-1037

Hemedi, Mark   Vienna Univ. of Tech.
Schirrer, Alexander   Vienna Univ. of Tech.
Westermayer, Christian   Vienna Univ. of Tech.
Kozek, Martin   Vienna Univ. of Tech.

One essential task in control system design is the optimal selection of inputs and outputs (I/O). In this paper a new concept for solving the I/O selection problem is proposed. It is based on normalized comparison of LQG closed loops, which are designed for each potential actuator/sensor separately. The LQG controller is iteratively tuned to obtain a prescribed and fixed value of a suitable system norm quantity. The proposed placement criterion is applied to flexible structures and demonstrated for an academic example and for a largescale blended-wing-body (BWB) passenger aircraft pre-design model. Comparison to a state-of-the-art open-loop I/O selection method from literature verifies the proposed approach, but also shows that the closed-loop approach provides additional system insight and highly flexible applicability.

17:20-17:40   ThC6.4
Control During Feedback Failure: Characteristics of the Optimal Solution, pp. 1038-1043

Chakraborty, Debraj   Indian Inst. of Tech. Bombay
Hammer, Jacob   Univ. of Florida

The problem of keeping performance errors within bounds while controlling a perturbed open loop linear system is considered. The objective is to maximize the time during which performance errors remain acceptable, given that the controlled system is within a specified neighborhood of its nominal parameter values. It is shown that the optimal solution is associated with a switching function z(t) which has the following feature: the optimal input signal is a bang-bang signal when z(t) is not the zero function.

17:40-18:00   ThC6.5
Optimising Home Automation Systems: A Comparative Study on Tabu Search and Evolutionary Algorithms, pp. 1044-1049

Morganti, Gianluca   Univ. Pol. delle Marche
Perdon, Anna Maria   Univ. Pol. delle Marche
Conte, Giuseppe   Univ. delle Marche
Scaradozzi, David   Univ. Pol. delle Marche
Brintrup, Alexandra   Univ. of Cambridge

We use the Multi Agent System paradigm to model and analyse Home Automation System performance in exploiting limited resources such as electricity and hot water. In this paper we evaluate several approaches to the optimisation of Home Automation System performance using Tabu Search, and Single and Multi-objective Genetic Algorithms. The results show that the Genetic Algorithms achieve faster convergence than Tabu Search. Multi-objective Genetic Algorithm provides a diverse set of solutions for the decision maker.

18:00-18:20   ThC6.6
Investigation on the Choice of the Initial Temperature in the Simulated Annealing: A Mushy State SA for TSP, pp. 1050-1055

Shakouri, Hamed   Univ. of Tehran, Tehran, Iran
Shojaee, Kambiz   Univ. of Tehran, Tehran, Iran
Behnam T, Mojtaba   Pol. di Torino, Torino, Italy.

It is a long time that the Simulated Annealing (SA) procedure is introduced as a non-derivative based optimization for solving NP-hard problems. Improvements from the original algorithm in the recent decade mostly concentrate on combining its initial algorithm with some heuristic methods. This is while modifications to the method are rarely happened to the initial conditions from which the annealing schedule starts. There are several parameters in the process of annealing the adjustment of which affects the overall performance. This paper focuses on the initial temperature and proposes a lower temperature with low energy to speed up the process. Such an annealing indeed starts from a mushy state rather than a quite liquid molten material. The mushy state characteristics depends on the problem that SA is being applied to solve. In this paper the Mushy State Simulated Annealing (MSSA) is applied to the Traveling Salesman Problem (TSP). The mushy state may

be obtained by some simple methods like crossover elimination. A very fast version of The Wise Experiencing Traveling Salesman is also applied to initiate SA by a low-energy-low-temperature state. This fast method results in quite accurate solutions compared to other recent novel methods.

ThEPL Plenary Room
Plenary Session: Michael Athans and Ioan Landau, Adaptive and Robust Control Methods & Philosophy (Plenary Session)

Chair: Antsaklis, Panos J. Univ. of Notre Dame
Co-Chair: Valavanis, Kimon Univ. of Denve

18:30-20:30 ThEPL.1
Adaptive Regulation - Rejection of Unknown Multiple Narrow Band Disturbances, pp. 1056-1065

Landau, Ioan Dore E.N.S.I.E.G.
Constantinescu, Aurelian Ec. de Tech. superieure
Alma, Marouane Univ. joseph fourier

The paper presents a methodology for feedback adaptive control of active vibration systems in the presence of time varying unknown multiple narrow band disturbances. A direct adaptive control scheme based on the internal model principle and the use of the Youla-Kucera parametrization is proposed. This approach is comparatively evaluated with respect to an indirect adaptive control scheme based on the estimation of the disturbance model. The evaluation of the methodology is done in real time on an active suspension system and on an active vibration control system using an inertial actuator.

FrA1 Room 1
Power Systems I (Regular Session)

Chair: Andersen, Palle Aalborg Univ.
Co-Chair: Rasmussen, Henrik Aalborg Univ.

09:40-10:00 FrA1.1
Coal Moisture Estimation in Power Plant Mills, pp. 1066-1071

Andersen, Palle Aalborg Univ.
Bendtsen, Jan Dimon Aalborg Univ.
Pedersen, Tom S. Aalborg Univ.
Mataji, Babak Elsam Engineering a/s

Knowledge of moisture content in raw coal feed to a power plant coal mill is of importance for efficient operation of the mill. The moisture is commonly measured approximately once a day using offline chemical analysis methods; however, it would be advantageous for the dynamic operation of the plant if an online estimate were available. In this paper we such propose an on-line estimator (an extended Kalman filter) that uses only existing measurements. The scheme is tested on actual coal mill data collected during a one-month operating period, and it is found that the daily measured moisture content agrees with the estimates.

10:00-10:20 FrA1.2
Nonlinear Superheat and Capacity Control of a Refrigeration Plant, pp. 1072-1077

Rasmussen, Henrik Aalborg Univ.
Larsen, Lars Finn Sloth Danfoss A/S

This paper proposes a novel method for superheat and capacity control of refrigeration systems. A new low order nonlinear model of the evaporator is developed and used in a backstepping design of a nonlinear controller. The stability of the proposed method is validated theoretically by Lyapunov analysis and experimental results shows the performance of the system for a wide range of operating points. The method is compared to a conventional method based on a thermostatic superheat controller.

10:20-10:40 FrA1.3
Avoiding Fold Bifurcations with the Help of New Proximity Indices, pp. 1078-1083

Altanis, Giorgos National Tech. Univ. of Athens
Maratos, Nikos National Tech. Univ. of Athens

This work studies the problem of monitoring and avoiding fold (saddle-node) bifurcations of equilibria without solving any difficult optimization problems, such as the closest bifurcation problem. New scalar indices are proposed to monitor the proximity to fold bifurcations. These indices are based on the QR factorization of the Jacobian matrix, and they are directionally differentiable in the interior of the feasibility boundary. This allows us to compute steepest descent directions in the uncontrollable parameter space and steepest ascent directions in

the controllable parameter space. The former are used to estimate the distance to the feasibility boundary, while the latter are used by a simple algorithm which designs the controllable parameters in a way that the proximity indices maintain values above a certain threshold, thus avoiding the feasibility boundary. One of the proposed indices is asymptotically linear with respect to the distance to the bifurcation value being approached, resulting in accurate estimates of the distance to the bifurcation.

Index Terms - Nonlinear systems, Bifurcation, System analysis and design, Robustness, Power systems.

10:40-11:00	FrA1.4

Genetic Algorithms Based Dynamic Search Spaces for Global Power System Stabilizer Optimization,
pp. 1084-1089

Alkhatib, Hasan	Univ. Paul Cézanne - Aix Marseille III
Duveau, Jean	Univ. Paul Cézanne - Aix Marseille III
Pasquinelli, Marcel	Univ. Paul Cézanne - Aix Marseille III

Genetic algorithms (GAs) are powerful optimization techniques. The optimization performance depends highly on the determination of optimized parameter search spaces, which remain unchanged during GA running. Hence, the objective function evolution may decelerate or even stabilize well before attaining the optimal solution. This article proposes an approach of GAs based dynamic search spaces. It focuses on improving the search space boundaries and allowing GAs to discover new search spaces which are not accessible initially. A GA using this approach is developed and validated to the optimization of power system stabilizer parameters within a multimachine system (16-generator and 68-bus). The obtained results are evaluated and compared with those of ordinary GAs and literature. They show significant improvement in terms of optimization performance and convergence rate.

11:00-11:20	FrA1.5

A Nonlinear Robust Adaptive Stabilizing Controller in Interconnected AC/DC Power Systems*

| El-Kashlan, S.A. | AAST, Ain-Shams Univ. |

11:20-11:40	FrA1.6

Decentralized Self-Tuning Pole Placement Controller for Load Frequency Control in KHOZESTAN Area*

| Hamedrahmat, Ehsan | Power and Water Univ. of Tech. |
| Yazdizadeh, Alireza | Shahid Abbaspour Univ. of Tech. |

FrA2   Room 2
Discrete Event Systems (Regular Session)

| Chair: Kezic, Danko | Maritime Faculty in Split, Univ. in Split |
| Co-Chair: Su, Rong | Eindhoven Univ. of Tech. |

09:40-10:00	FrA2.1

Adding Two Level Supervisory Control in the Hybrid Petri Net Methodology for Production Systems,
pp. 1090-1095

| Tsinarakis, George | Tech. Univ. of Crete |
| Tsourveloudis, Nikos | Tech. Univ. of Crete |

This work extends the Hybrid Petri Net (HPN) methodology introduced in [1] to study multi-operational production systems, by adding two level supervisory control. In the controller implemented, the first control level refers to the internal function of the models of the fundamental subsystems while the second one describes the interaction between them while forming the overall system model. The supervisory control is implemented with Hybrid Petri nets and is added to the structure of the model, so that it's communication and cooperation with the model is faster and more accurate. This comprises one of the first efforts to apply supervisory control concepts in continuous or Hybrid Petri nets.

10:00-10:20	FrA2.2

P – Invariant Based Petri Net Traffic Controller, pp. 1096-1101

Kezic, Danko	Maritime Faculty in Split, Univ. in Split
Matic, Petar	Maritime Faculty in Split, Univ. in Split
Racic, Nikola	Maritime Faculty in Split, Univ. in Split

This paper deals with the automatic traffic control of vessels moving through the marine canal traffic system. To avoid dangerous situations which may occur in case of vessels' irregular moving through the system such as conflicts and deadlocks, the vessels' traffic is controlled by traffic lights. The goal is to design maximally permissive controller which stops vessels only in the case of dangerous situation. The paper uses a method for P-invariant based Petri net controller design. The marine traffic system is modeled as a MRF1 class of Petri net

with disjoint sets of resource and job places. The authors describe a method for calculating control places which control conflicts and restrict the set of reachable states to avoid first and second level deadlocks. The controller is tested using computer simulation.

10:20-10:40   FrA2.3

On Pole-Zero Patterns of Non-Negative Impulse Response Discrete-Time Systems with Complex Poles and Zeros, pp. 1102-1107

Liu, Yuzhe   Univ. of Notre Dame
Bauer, Peter   Univ. of Notre Dame

This paper presents a new set of sufficient conditions on complex poles and zeros to ensure the non-negativity of the impulse response of an arbitrary-order discrete-time system. Different from previous work, this set of sufficient conditions expose an interesting geometric pole-zero pattern --- poles and zeros are evenly distributed on different concentric circles centered at origin. By controlling the number of poles/zeros on each circle and using pole-zero cancellation to de-regularize the pole-zero distribution, the class of pole-zero patterns known to exhibit a non-negative impulse response (NNIR) are significantly expanded. And this set of sufficient conditions can be easily employed for designing NNIR filters.

10:40-11:00   FrA2.4

Synthesize Nonblocking Distributed Supervisors with Coordinators, pp. 1108-1113

Su, Rong   Eindhoven Univ. of Tech.
van Schuppen, Jan H.   CWI
Rooda, J.E.   Eindhoven Univ. of Tech.

In supervisor synthesis achieving nonblockingness is a major computational challenge when a target system consists of a large number of local components. To overcome this difficulty, for a distributed system consisting of a set of nondeterministic finite-state automata and a collection of deterministic specifications, we propose a synthesis approach that computes nonblocking distributed supervisors with coordinators by using a novel automaton abstraction technique.

11:00-11:20   FrA2.5

Advanced Methods for Modeling of Monitoring Functions in Hierarchical Systems, pp. 1114-1119

Minca, Eugenia   Univ. Valahia din Targoviste
Dragomir, Otilia   Univ. Valahia din Targoviste
Dragomir, Florin   Univ. Valahia din Targoviste
Istudor, Ion   Valahia Univ. of Targoviste, Electrical EngineeringFaculty

A new tool for non-autonomous hierarchical systems modelling is proposed in this article. This tool is used for the modelling of monitoring functions and integrates the fuzzy logic in the temporal aspect of the events occurrence. The tool is also suited for the development of the hierarchical and distributed typologies structures and in modelling of recurrent functions. The proposed systems are structured on hierarchical levels. On each level there are events with equal probabilities of occurrence/detection. The proposed typologies ensure a recurrent behaviour to the horizontal firing of the networks, which allows the detection of the occurrence/persistence of the monitored external events. In this context, the Recurrent Synchronized Fuzzy Petri Nets (PNetSinFREC) are well adapted to detection/decision modelling of the functions by a temporal fuzzy transition approach in hierarchical systems

11:20-11:40   FrA2.6

An Algorithm for Computing Supremal Nonblocking State-Normal Supervisors for Nondeterministic Systems, pp. 1120-1125

Su, Rong   Eindhoven Univ. of Tech.
van Schuppen, Jan H.   CWI
Rooda, J.E.   Eindhoven Univ. of Tech.

Recently supervisor synthesis for nondeterministic systems has gained more and more attention, owing to the potential computational advantage of using nondeterministic automata in modular/distributed synthesis. It is well known that, in the Ramadge/Wonham language-based supervisory control paradigm, the supremal nonblocking normal supervisor always exists (although may be empty) and is computable. In this paper we will show that, for a nondeterministic plant model and a deterministic specification, a similar entity called the supremal nonblocking state-normal supervisor also exists, which coincides with the supremal nonblocking normal supervisor when the plant model becomes deterministic. We then present a concrete algorithm to compute such a supervisor and analyze the relevant computational complexity.

Biomedical Engineering I (Regular Session)

| Chair: Papadopoulos, Evangelos | National Tech. Univ. of Athens |
| Co-Chair: Costa, B.Andrade | Inst. Superior Tecnico - Tech. Univ. of Lisbon |

09:40-10:00 FrA3.1

A Recommender System for Detection of Leukemia Based on Cooperative Game, pp. 1126-1130

Torkaman, Atefeh	Tarbiat Modarres Univ.
Moghadam Charkari, Nasrollah	Tarbiat Modares Univ.
Aghaeipour, Mahnaz	Iranian Blood Transfusion Res. Center
Hajati, Esmerdis	Iranian Blood Transfusion Res. Center

Cancer is a term used for diseases in which abnormal cells divide without control and invade other tissues. Cancer types can be grouped into broader categories including Leukemia, Carcinoma, Sarcoma, Lymphoma and Myeloma, Central nervous system cancers among them, Leukemia is a form of serious cancers that starts in blood tissue such as the bone marrow where all the blood is made. It is one of the leading causes of death in the world. So, the importance of diagnostic techniques is manifested. Application of these techniques would be able to decrease the mortality rate from leukemia. In this paper, an automatic system for classifying leukemia based on game theory is presented. The aim of this research is to apply game theory in order to classify leukemia into eight classes. In other words, cooperative game is used for classification according to different weights assigned to the markers. Through out this paper, we work on real data (304 samples) taken from different types of leukemia that have been collected at Iran Blood Transfusion Organization (IBTO). The modeling system can be used to model and classify a population according to their contributions. In the other words, it applies equally to other groups of data. The results show that the highest classification accuracy (98.44%) is obtained for the proposed model. So, it is hoped that game theory can be directly used for classification in the other cases.

10:00-10:20 FrA3.2

Experimental Tissue Parameter Identification for Use in Endoscopic Urological Haptic Simulators, pp. 1131-1136

Dimopoulos, Athanasios	National Tech. Univ. of Athens
Papadopoulos, Evangelos	National Tech. Univ. of Athens
Iagnemma, Karl	MIT

A method is developed for obtaining parameters for tube-like soft-tissues, to be used in urological haptic simulators. A device was designed and built that allows the acquisition of forces and displacements during endoscope insertion in a tube-like soft tissue. The device consists of a mechatronic ball screw mechanism, with a 6 DOF force/ torque sensor attached to it. The steel shaft representing the endoscope, is commanded to follow desired trajectories with micrometric accuracy under the application of an IPD controller, implemented on a dSpace 1103 system. The experimental data acquired is fitted to polynomials to yield a tissue model that can be used to predict insertion forces required for haptic simulator feedback.

10:20-10:40 FrA3.3

Neuromuscular Blockade Nonlinear Model Identification, pp. 1137-1142

Costa, B.Andrade	Inst. Superior Tecnico - Tech. Univ. of Lisbon
Silva, Margarida M.	Univ. do Porto
Mendonça, Teresa	Univ. do Porto
Lemos, Joao M.	Inesc-id

This paper presents a methodology for parameter estimation of a nonlinear neuromuscular blockade dynamic model to be used as a predictive model for automated control, in general anesthesia. The neuromuscular blockade dynamic model comprises two blocks connected in series, a pharmacokinetic model and the pharmacodynamic model. The pharmacokinetic model is a second order linear dynamic model and describes the redistribution of the drug in the body. The pharmacodynamic model is a nonlinear function, named as the Hill equation, and it describes the interaction between the concentration of the drug in the effect site and the measured patient's muscle paralysis state. The identification methodology uses four data points taken from the neuromuscular blockade response obtained with the administration of the first bolus. The four data points are chosen to avoid the identification difficulties caused by the presence of the nonlinear behavior of the Hill equation. This approach enables the identification of the pharmacokinetic dynamics, that is, the two poles of the second order linear dynamic model followed by the estimation of the normalized parameters of the Hill equation.

Computer simulations show that the proposed identification methodology is able to provide good results even when the pharmacokinetic dynamics has an order higher that two. This suggests that the methodology may be

employed in neuromuscular blockade automated control as a predictive model, to help the initial tuning of the controller parameters or in adaptive control to get a first model that can be improved with online identification using some recursive minimization techniques to adjust the adaptive controller or as an advising mechanism to help the anesthesiologist during the anesthesia.

10:40-11:00   FrA3.4

An Optimal Model Predictive Control Model for Human Postural Regulation, pp. 1143-1148

Li, Yao   Uinversity of Maryland at Coll. Park
Levine, William S.   Univ. of Maryland

A series of convex optimal control problems is proposed as mathematical models of human postural control during quiet standing. The human body is modeled as a two-segment inverted pendulum controlled by a joint torque. Several performance criteria that are quartic in the state and quadratic in the control are utilized. The discrete-time approximation to each of these problems is a convex programming problem. These problems can be solved by the Newton-KKT method. The solutions exhibit many of the experimentally observed postural control phenomena, especially, greater sway than would occur with a linear feedback control without delay.

11:00-11:20   FrA3.5

Total Mass TCI Driven by Parametric Estimation, pp. 1149-1154

Silva, Margarida M.   Univ. do Porto
Sousa, Cláudia   School of Education Jean Piaget - Piaget Inst.
Sebastiao, Raquel   Univ. do Porto
Gama, Joao   Univ. Porto
Mendonça, Teresa   Univ. do Porto
Rocha, Paula   Univ. of Porto
Esteves, Simao   Hospital Geral Santo Antonio

This paper presents the Total Mass Target Controlled Infusion algorithm. The system comprises an On Line Algorithm for Recovery Detection (OLARD) and an identification scheme based on sparse measurements of the accessible signal which aims to minimize a Bayesian cost function. To design the drug dosage profile, two algorithms are here proposed. During the transient phase, an Input Variance Control (IVC) algorithm is applied. It is based on the concept of TCI and aims to steer the drug effect to a predefined target value within an textit{apriori} fixed interval of time. When the steady state phase is reached the drug dose regimen is controlled by a Total Mass Control (TMC) algorithm, robust even in the presence of parameter uncertainties. The whole system feasibility have been evaluated for the case of Neuromuscular Blockade (NMB) level and was tested both in simulation and in real clinical cases.

11:20-11:40   FrA3.6

A Bio-Inspired Filtering Framework for the EMG-Based Control of Robots, pp. 1155-1160

Artemiadis, Panagiotis   Massachusetts Inst. of Tech.
Kyriakopoulos, Kostas J.   National Tech. Univ. of Athens

There is a great effort during the last decade towards building control interfaces for robots that are based on signals measured directly from the human body. In particular electromyographic (EMG) signals from skeletal muscles have proved to be very informative regarding human motion, and therefore they are usually incorporated in control interfaces for robots that are either remotely operated or being worn by humans, i.e. arm exoskeletons. However, this kind of interface demands an accurate decoding technique for the translation of EMG signals to human motion, in order to efficiently command the teleoperated robot. This paper presents a methodology for estimating human arm motion using EMG signals from muscles of the upper limb, using a decoding method and an additional filtering technique based on a probabilistic model for arm motion. The decoding method can estimate, in real-time, arm motion in 3-dimensional (3D) space using only EMG recordings from 11 muscles of the upper limb. Then, the probabilistic model realized through a Bayesian Network, filters the decoder's result in order to tackle the problem of the uncertainty in the motion estimates. This method results to a robust human-robot control interface that can be used in many different kinds of robots (i.e. teleoperated robot arms, arm exoskeletons, prosthetic devices). The proposed methodology is assessed through real-time experiments in controlling a remote robot arm in random 3D movements using only EMG signals recorded from able-bodied subjects. The experimental results show that the filtering approach significantly improves the performance of the decoding, while providing robust motion estimates in cases where the decoder fails to track the user's movement with enough accuracy.

Embedded Control Systems (Regular Session)

Chair: Economakos, George   National Tech. Univ. of Athens
Co-Chair: Dobra, Petru   Tech. Univ. of Cluj

09:40-10:00   FrA4.1

Design and Development of an Embedded Control System of a DC/DC Power Converter for a Fuel Cell,
pp. 1161-1165

Kontonikolas, Kostantinos   Centre for Res. and Tech. Hellas (CERTH)
Ziogou, Chrisovalantou   Centre for Res. and Tech. Hellas (CERTH)
Stergiopoulos, Fotis   Centre for Res. and Tech. Hellas (CERTH)
Papadopoulou, Simira   Alexander Tech. Educational Inst. of Thessaloniki
Voutetakis, Spyridon   Centre for Res. and Tech. Hellas (CERTH)

The non-linear behavior of the Voltage-Current (V-I) fuel cells' output curve is one of the major issues the scientific community deals with, in order to improve fuel cell technology and expand its use to both domestic and industrial applications. Many power conditioning topologies of a fuel cell's output electrical energy have been presented in the past years, but the DC/DC Interleaved Boost Converter (IBC) topology seems to be one of the most attractive solutions. Therefore, IBC control schemes become a key factor in fuel cell energy systems and the use of Embedded Systems is highly indicated for efficient and reliable real-time control. The traditional methods of programming microcontrollers via "C" or Assembly language, may take a respectable amount of time to develop, significantly slowing down the procedures for system development and validation. This paper presents a new model-based rapid prototyping method for programming Embedded Systems using Matlab/Simulink® models. The Embedded Control System (ECS) is designed to control the input current of an IBC connected to a fuel cell, by suitably varying the switching signals which drive the Power Switches on the IBC.

10:00-10:20   FrA4.2

A Unifying Logic for Environments of Cyber-Physical Systems, pp. 1166-1171

Bujorianu, Marius Constantin   Univ. of Manchester
Barringer, Howard   Univ. of Manchester
Bujorianu, Luminita Manuela   Univ. of Manchester

The varieties of possible interaction between computational systems and physical environments is at the heart of a new modeling paradigm called cyber-physical systems. In order to model and control these interactions it necessary to present the fundamental properties of physical environments in a formalism compatible with the computational structures, usually in a formal logic or an algebraic calculus. In this paper, we propose a model as a step towards reasoning about the problems of uncertainty and surprise in the context of cyber-physical systems operating under mixed human/autonomous control. In controlling embedded devices, human operators are, in most cases, assisted by automated controllers (like driving assistance systems and automatic pilots). A new issue appeared in many applications is to model the automatic controllers which are user centric, i.e. the controllers are carrying a runtime monitoring of the system behavior in its environment, they inform and warn the user on safety hazardous situation and they take action only when the user fails to react. A robust controller should be able to operate in open, random environments and to assist the human operator in case of appearance of surprising, possible catastrophic situations.

10:20-10:40   FrA4.3

An Architectural Exploration Framework for Efficient FPGA Implementation of PLC Programs,
pp. 1172-1177

Economakos, Christoforos   Halkis Inst. of Tech.
Economakos, George   National Tech. Univ. of Athens

This paper presents an automated framework for obtaining high-performance FPGA implementations of industrial automation and control algorithms coded as PLC programs. The proposed method is mainly targeting demanding applications, requiring lots of numerical computations. Based on previous experience, the proposed framework exploits Electronic System Level modeling methodologies and tools for high-level hardware synthesis. Since most of these tools are not compatible with PLC development environments, custom translating software built by using standard compiler techniques, can be employed for converting PLC programs to a form that can be understood by the selected tools. Furthermore, the translating software uses different coding templates to support microarchitectural level design trade-offs. Experimental results involving three well-known industrial control algorithms show that appropriate coding styles can offer 2x performance improvements, being simple and syntactically similar to Statement List code.

Low-Cost Embedded Solution for PID Controllers of DC Motors, pp. 1178-1183

Dobra, Petru   Tech. Univ. of Cluj
Dumitrache, Daniel   Tech. Univ. of Cluj-Napoca
Tomesc, Liviu   Tech. Univ. of Cluj-Napoca
Duma, Radu   Tech. Univ. of Cluj-Napoca
Trusca, Mirela   Tech. Univ. of Cluj

Proportional Integral Derivative (PID) control is the most common control algorithm used in industry today. The popularity of PID controllers can be attributed to their effectiveness in a wide range of operating conditions, their functional simplicity and how easily engineers can implement them using current computer technology. This article discusses PID control and practical implementations and provides a brief overview on how to tuning parameters of PID controllers.

11:00-11:20   FrA4.5
Motion Control of the SOFIA Cavity Door Drive System, pp. 1184-1189

Jayaraman, Ganga   Woodward MPC Inc.

This paper describes the architecture and modeling of the motion control system for the cavity door drive system developed by MPC Products Corporation for the SOFIA aircraft. We also describe some of the fault tolerance features in the system architecture designed to meet the safety requirements. Finally, simulation results are presented that demonstrate the tracking capabilities of the door drive control system.

11:20-11:40   FrA4.6
Modeling and Design of an Autothrottle Speed Control System, pp. 1190-1195

Jayaraman, Ganga   Woodward MPC Inc.

This paper describes the architecture and modeling of an autothrottle servo drive system developed by Woodward MPC Corporation for a typical midsize business jet aircraft. The autothrottle speed control system automatically adjusts the throttle lever position in response to changes in thrust level demands, thus providing speed control and thrust management for the aircraft. The autothrottle servo drive system implements a speed control loop that drives the throttle lever in response to speed commands from the autothrottle speed control system. Simulation results are presented that demonstrate the accuracy and dynamic performance of the speed control system

FrA5	Room 5
Process Control (Regular Session)	

Chair: Dostal, Petr   Tomas Bata Univ. in Zlin
Co-Chair: Zanoli, Silvia Maria   Univ. Pol. delle Marche

09:40-10:00   FrA5.2
A DCS Supervisory Control of a Centrifugal Compessor for Oxygen Consumption Optimization, pp. 1196-1202

Zanoli, Silvia Maria   Univ. Pol. delle Marche
Barboni, Luca   api raffineria di Ancona

In this paper, a supervisory control system for oxygen consumption optimization on a Syngas Manufacturing Process Plant is proposed. A grey-box multivariable parametric identification of the oxygen compressor system is first performed. Consequently, by means of dynamic simulations the structure of an optimal control system has been determined, also reflecting the implementation constraints linked with the use of a DCS. Finally, operating results of the system implemented on the real process are shown which confirmed the expected results obtained

10:00-10:20   FrA5.3
Performance Optimization for Linear Stochastic Systems with Probabilistic Parametric Uncertainties, pp. 1203-1208

Taflanidis, Alexandros   Univ. of Notre Dame
Scruggs, Jeffrey   Duke Univ.

This study discusses the robust performance optimization of controlled systems with probabilistically described parametric uncertainty. Focus is placed on linear, time invariant systems with stochastic disturbances. Incorporation of probabilistic uncertainty in classical control approaches as well as a design based on the concept of the reliability of the system response output are discussed. Analysis and synthesis methodologies based on recently developed stochastic simulation techniques are presented. The design approach is applied in

a structural control example. The results illustrate the significance of adopting a probabilistic description for model uncertainty and the existence of differences between the various probabilistic characterizations.

10:20-10:40   FrA5.4

Adaptive Temperature Control in a Tubular Chemical Reactor, pp. 1209-1214

Dostal, Petr   Tomas Bata Univ. in Zlin
Bobal, Vladimir   Tomas Bata Univ. in Zlin
Vojtesek, Jiri   Tomas Bata Univ. in Zlin

The paper deals with adaptive control of a tubular chemical reactor. As a part of the control design, preliminary steady-state and dynamic analysis of the process is incorporated. A nonlinear model of the process is approximated by a continuous-time external linear model with parameters estimated using a corresponding delta model. The controller design is based on the polynomial approach. The adaptive control is tested on the nonlinear model of the tubular chemical reactor with a consecutive exothermic reaction.

10:40-11:00   FrA5.5

Design and Implementation of Sliding-Mode Controller with Varying Boundary Layer for a Coupled Tanks System, pp. 1215-1220

Benayache, Rabiâ   Univ. de Picardie Jules Verne

In this paper, the nonlinear sliding mode control (SMC) with varying boundary layers is implemented to improve the tracking performance of a nonlinear system. The key feature of the control scheme is the use of varying boundary layers instead of fixed boundary layers, which are usually employed in conventional sliding mode control. The experimental results strongly suggest that the proposed control scheme is capable of improving the tracking precision without causing any chattering. In addition, the new control scheme seems to be very robust against various set point conditions.

11:00-11:20   FrA5.6

Hybrid Intelligent Control for a Wastewater Treatment Prototype, pp. 1221-1226

Carrasco, Rocio   CINVESTAV
Sanchez, Edgar N.   CINVESTAV
Cadet, Catherine   Lab. d'Automatique de Grenoble

This paper presents a hybrid intelligent control based on nonlinear PI controller and a recurrent high order neural network (RHONN) identifier. This control scheme is applied to a wastewater treatment prototype. The hybrid intelligent control and neuronal identification performance is illustrated via simulations.

FrA6	Room 6
Advances in Rotorcraft Modeling and Control (Invited Session)	

Chair: Sultan, Cornel   Virginia Tech.
Co-Chair: Fierro, Rafael   Univ. of New Mexico
Organizer: Sultan, Cornel   Virginia Tech.
Organizer: Bogdan, Stjepan   Univ. of Zagreb
Organizer: Fierro, Rafael   Univ. of New Mexico

09:40-10:00   FrA6.1

Nonlinear Backstepping Control Design for Miniature Helicopters Using the Rotation Matrix (I), pp. 1227-1232

Raptis, Ioannis   Univ. of South Florida
Valavanis, Kimon   Univ. of Denve
Moreno, Wilfrido   Univ. of South Florida

This paper presents a backstepping control design for small scale helicopters. The objective is for the helicopter to autonomously track predefined position and yaw trajectories. The position reference trajectories are arbitrary, possibly aggressive, with some constraints in their higher order time derivatives. The main idea of the algorithm is to control the direction and magnitude of the thrust vector appropriately in order to stabilize the position dynamics. In contrast with most control schemes that use Euler angles or quaternions for the control of the attitude dynamics, this design use the elements of the rotation matrix. The intermediate pseudo controls related with the directional dynamics are enhanced with terms that guarantee that the helicopter will not overturn while tracking the position reference signals.

10:00-10:20   FrA6.2

Design and Implementation of a Structured Flight Controller for a 6DoF Quadrotor Using Quaternions (I), pp. 1233-1238

  Stingu, Emanuel   Univ. of Texas at Arlington
  Lewis, Frank L.   Univ. of Texas at Arlington

This paper describes a practical implementation of simple control algorithms on a 6DoF quadrotor flying in an uncontrolled environment and being equipped with inexpensive sensors. A significant number of control algorithms that apply dynamic inversion or backstepping techniques on simplified state variable models of the vehicle dynamics are present in the literature, but they are only tested in simulations where real-life issues like sensor noise and precision, vibrations, measurement reference frames, and modeling errors are not included completely or even partially. Here it is shown that if the practical implementation is done correctly, even simple PD controllers can ensure the stability of the quadrotor platform in hover.

10:20-10:40   FrA6.3

Hybrid Control of Quadrotor (I), pp. 1239-1244

  Orsag, Matko   Univ. of Zagreb, Faculty of Electrical Engineering and Comp
  Bogdan, Stjepan   Univ. of Zagreb

In the last couple of years, quadrotor aircrafts have been a subject of extensive research in the field of autonomous control systems. Various control algorithms, like PID regulators, fuzzy control and LQ regulators have been proposed. Research presented in this paper focuses on discrete automaton that, in combination with classical PID controllers, creates a hybrid control system. The practical side of the decision to use hybrid control system lies in the fact that, in reality, quadrotor's propulsion system has limited amount of energy. Proposed hybrid control system uses finite automaton with predefined states, thus providing a mechanism for dividing every change of position and orientation into combination of moves that keep propulsion system safe of saturation. Academic research done so far usually neglected this realistic problem. The other reason for choosing this control is because the propulsion system is nonlinear due to nonlinear rotor characteristic. Lift and drag forces that each rotor renders depend not only on rotor speed but also on quadrotor's speed and direction. This nonlinear rotor characteristic has been studied in detail on large scale helicopters. In this paper we successfully implemented these studies into a nonlinear dynamic model of small quadrotor aircraft. Nonlinear model used in this research takes into consideration different inflow models in hover, forward flight and quadrotor descent, along with In-ground effect. The simulation results show that the system is stable and at the same time safe of saturation. Experimental results show consistency and agreement with the proposed mathematical model.

10:40-11:00   FrA6.4

Vision Aided Navigation for Unmanned Helicopters (I), pp. 1245-1250

  Katzourakis, Diomidis   TUDelft
  Vitzilaios, Nikos   Tech. Univ. of Crete
  Tsourveloudis, Nikos   Tech. Univ. of Crete

The development of a vision system to aid the autonomous navigation of an unmanned helicopter, primarily based on inertial sensors and GPS data, is presented. An unmanned helicopter has been equipped with appropriate sensors and a vision system fitted on a custom pan-tilt mechanism. Robust software, based on the Open Computer Vision Library (OpenCV), has been developed for handling images and video from a camera. Our implementation involves real time object recognition, histogram matching for real time video streaming, pattern matching and object tracking. Software implemented in C++ interacts with Matlab in order to aid the autonomous navigation of the helicopter.

11:00-11:20   FrA6.5

Nonlinear Modeling and Output Feedback Control Design for a Small-Scale Helicopter (I), pp. 1251-1256

  Palunko, Ivana   Univ. of New Mexico
  Fierro, Rafael   Univ. of New Mexico
  Sultan, Cornel   Virginia Tech.

This paper presents a helicopter dynamic model controlled by a nonlinear output feedback controller. Particular emphasis is placed on the mathematical modeling of the main rotor dynamics, i.e., modeling the individual dynamics of the blades and the dynamics of the main rotor stabilizing bar. Since the derived model is highly nonlinear, an output feedback controller that uses a nonlinear observer is derived and used for both stabilization and trajectory tracking. The effectiveness of the proposed control scheme is verified through numerical simulations.

Chair: Iribas, Mikel   CENER
Co-Chair: Leithead, William   Univ. of Strathclyde
Organizer: Iribas, Mikel   CENER

12:00-12:20   FrB1.1
A Novel Approach to Structural Load Control Using Intelligent Actuators (I), pp. 1257-1262

Leithead, William   Univ. of Strathclyde
Neilson, Victoria   Univ. of Strathclyde
Dominguez, Sergio   MLS
Dutka, Arkadiusz   MLS UK

The recent trend towards large multi-MW wind turbines resulted in the role of the control system becoming increasingly important. The extension of the role of the controller to alleviate structural loads has motivated the exploration of novel control strategies, which seek to maximise load reduction by exploiting the blade pitch system. The reduction of blade fatigue loads through individual blade pitch control is one of the examples. A novel approach to reduction of the unbalanced rotor loads by pitch control is presented in this paper. Each blade is equipped with its own actuator, sensors and controller. These local blade control loops operate in isolation without a need of communication with each other. The single blade control approach to regulation of unbalanced rotor loads presented in this paper has an important advantage of being relatively easy to design and tune. Furthermore, it does not affect the operation of the central controller and the latter need not be re-designed when used in conjunction with the single blade controllers. Their performance is assessed using BLADED simulations.

12:20-12:40   FrB1.2
Identification for Control Design Purposes of Pitch Model in Closed Loop Operation of Wind Turbines. (I), pp. 1263-1268

Iribas, Mikel   CENER
Landau, Ioan Dore   E.N.S.I.E.G.

In order to design a model based controller availability of a linear model of the system to be controlled is mandatory. Open loop identification is a very well known and extended used technique which provides reliable linear models for control design purposes. However, classical open loop identification techniques can not be applied to the case of wind turbines for several reasons: operating in open loop could render the system unstable, the aerodynamics are non-linear, the wind input disturbance can not be measured and it has an important stochastic component and finally, the measured data are normally corrupted by disturbances and noise. This article presents a procedure allowing wind turbine identification in closed loop operation with time varying controllers. A set of reliable linear models for control design of the pitch loop are obtained

12:40-13:00   FrB1.3
The Importance of Control in Wind Turbine Design and Loading (I), pp. 1269-1274

Bossanyi, Ervin   Garrad Hassan and Partners Ltd
Ramtharan, G   Garrad Hassan & Partners Ltd
Savini, Barbara   Garrad Hassan & Partners

The importance of the controller in determining the design loads of a wind turbine has been recognised for many years. This paper will discuss this topic from the following perspectives:

Approaches to the design and tuning of closed loop controllers: fatigue loading can be reduced by using advanced control methods, sometimes dramatically. Classical design methods currently predominate, although there may also be a role for other approaches such as model-based methods.

Interactions between closed loop and supervisory control: supervisory control events such as shut-downs can be a source of design-driving loads, although these can often be mitigated by careful consideration of the details of the shut-down control and how it may interact with the closed loop control. Also the advanced closed-loop methods may themselves have consequences for extreme loads, sometimes requiring careful consideration of shutdown strategies. The distinction between controlled shutdowns and safety system shutdowns is very important to consider.

Network faults: The response of wind turbines to network faults such as voltage dips are of increasing concern for turbine designers and network operators, and modifications to the control system may be required in order to minimise the probability of turbine shut-down following a short-duration network fault, as well as to minimise the loading consequences of such events. Advanced simulation tools capable of dealing with these events are required so that the most appropriate strategies can be devised.

Field Testing Controls to Mitigate Fatigue Loads in the Controls Advanced Research Turbine (I),
pp. 1275-1282

Alan Wright, Alan Wright   National Renewable Energy Lab.
Lee Fingersh, Lee J. Fingersh   National Renewable Energy Lab.
Karl Stol, Karl Stol   Univ. of Auckland

In this paper we show field-test results of wind turbine advanced controls to mitigate fatigue loads. Results from an advanced controller are compared to results from an industry standard PID controller, and the improvements in fatigue load mitigation of the advanced controller is documented.

Improved Drive-Train and Blade Fatigue Mitigation in Flexible Wind Turbines Using Disturbance Utilization Control, pp. 1283-1288

Parker, Glenn   Georgia Tech. Res. Inst.
Johnson, Carroll   Univ. of Alabama in Huntsville

Modern wind turbines are experiencing rapid growth in both physical size and rated capacity. As wind turbines grow larger with necessarily lighter construction materials, dampening flexible modes with active control becomes more critical. In this paper we apply the theory of "disturbance utilization control" (DUC) to a 600 kW upwind machine to dampen drive-train torsion and blade flap while regulating generator speed. We show that positive "utility" exists in turbulent wind inflow, and we demonstrate that the optimal DUC controller achieves decreased pitch actuator demand and improved drive-train and blade fatigue life through dampening of torsion oscillation and blade flap.

FrB2   Room 2
Agent and Agent Based Systems (Regular Session)

Chair: Theocharis, John   Aristotle Univ. of Thessaloniki
Co-Chair: Kazadi, Sanza   Jisan Res. Inst.

Different Forms of the Games in Multiagent Reinforcement Learning: Alternating vs. Simultanous Movements, pp. 1289-1294

Akramizadeh, Ali   phd Candidate
Afshar, Ahmad   Amirkabir Univ.
Menhaj, Mohammad Bagher   Control

Multiagent systems are one of the most promising solutions in most of real life applications in which some kinds of social interactions or conventions are involved. Agent oriented applications are broadly explored among which learning in unknown environment is well developed based on Markov Decision Process (MDP). On the other hand, learning in multiagent systems has been recently introduced, basically in conjunction with game theory which is the science of investigating multiple interactive agents. During learning, self-interested agents are attempting to find the equilibrium policy based on the structure of the game, mostly considered as normal form games. In this paper, we focus on bringing into discussion game structures, addressed as normal form games and extensive form games, in learning process. This includes also some modifications and refinements in initially introduced concepts as well as a proposed approach in extensive form games.

Coverage Path Planning for Multiple Robotic Agent-Based Inspection of an Unknown 2D Environment,
pp. 1295-1300

Wang, Xudong   Univ. of Hawaii at Manoa
Syrmos, Vassilis L.   Univ. of Hawaii at Manoa

This paper describes a coverage-based path planning algorithm for multiple robotic agents with the application on the automated inspection of an unknown 2D environment. The proposed path planning algorithm determines a motion path that a robotic agent will follow to sweep and survey all areas of the unknown environment, which is enclosed by the known boundary. The 2D unknown environment is decomposed into a union of simplices using the principle of Delaunay triangulation. The area coverage is equivalent to design a path for a robotic agent to follow and visit all simplices subject to certain mission constraints. A hierarchical mission planner is designed to allocate mission tasks among multiple agents in each level and pass information down to the next level along the hierarchy. The proposed path planning algorithm has been tested and evaluated on the problem of planning path for two types of robotic agents -- flying agents and crawling agents in a two-tier hierarchical mission planner to cover various unknown 2D environments.

Reliable Swarm Design, pp. 1301-1306

Kazadi, Sanza   Jisan Res. Inst.
Wen, Alexander   Jisan Res. Inst.
Volodarsky, Monica   Jisan Res. Inst.

This paper describes how phase space diagrams may be used to predict the final states and system evolution of swarms. Phase space diagrams and system evolutions through phase space are constructed for systems of multiple and single attractors. While the diagrams indicate the number of attractors, the system evolutions confirm them. A method is described for generating stochastic differential equations, which can then be used to construct phase space diagrams. This method is applied to the TSP system update equations, generating a stochastic differential equation whose dynamics provide insight into the TSP system. The use of ensemble system updates transforms systems from directed random walk systems to systems governed by stochastic differential equations. We demonstrate the use on the puck clustering and TSP problems, generating improved reliability and quick evolution of the system.

Polynomial Methods in Noisy Network Localization, pp. 1307-1312

Shames, Iman   The Australian National Univ. and the National
Taghipour Bibalan, Pouyan   The Australian national Univ.
Fidan, Baris   Australian National Univ.
Anderson, Brian D.O.   Australian National Univ.

In this paper we introduce a polynomial method for addressing sensor network localization problems when the measurements are noisy. We compare the result obtained applying this method with the result obtained by other methods in the literature. Later in the paper we propose methods from algebraic geometry to aid us solve the problem in a more elegant way.

FrB3   Room 3
Robot Control (Regular Session)

Chair: Doulgeri, Zoe   Aristotle Univ. of Thessaloniki
Co-Chair: Papageorgiou, Xanthi   National Tech. Univ. of Athens

Prescribed Performance Control for Robot Joint Trajectory Tracking under Parametric and Model Uncertainties, pp. 1313-1318

Doulgeri, Zoe   Aristotle Univ. of Thessaloniki
Karayiannidis, Yiannis   Aristotle Univ. of Thessaloniki
Zoidi, Olga   Aristotle Univ. of Thessaloniki

This work proposes a control law for the robot joint trajectory tracking in free space that achieves a prescribed performance of the joint position error under parametric uncertainties; the control law is extended for the case of bounded disturbances. A performance function incorporating predefined performance indices is used to produce a transformed error that is injected in the controller. Furthermore, asymptotic stability of the velocity error in case of zero disturbances and uniformly ultimate boundedness in an arbitrarily small region for bounded disturbances is achieved. Simulation results confirm the theoretical findings and compare the proposed controller with a conventional one.

Adaptive Minimum Uncertainty Control for a Flexible Link Manipulator, pp. 1319-1324

Karamolegkos, Nick   Univ. of Patras
Stathopoulos, George   Univ. of Patras
Tzes, Anthony   Univ. of Patras

The development of an adaptive controller for a flexible link manipulator is the subject of this article. The system's measurements are assumed to be corrupted with noise of a priori known bounds. A Set Membership Identifier computes the feasible set (orthotope) within which the parameter vector resides. The orthotope's vertices provide the parameter-vector's bounds, which are used to compute the predicted system-output uncertainty. The controller tunes its gains through an on-line minimization of a cost that penalizes the control effort, the induced uncertainty on the system output, and the tracking error. The scheme is applied in simulation studies on a planar single flexible-link manipulator.

Robust Control of Manipulator Arm Using Combined Shame Via Performance Limitation, pp. 1325-1330

Mohamad Zadeh, Nasser   Tarbiat Modares Univ.
Amirifar, Ramin   Tarbiat Modares Univ.
Mola Gharebagh, Mina   Shiraz Univ. of Tech.

The control of an industrial manipulator Arm with high accuracy in the presence of multi-model is a challenging control problem. In this paper, it is shown that based on identified models a robust linear controller can be designed using the combined pole placement method with sensitivity function shaping in the frequency domain via performance limitation for example modulus margin. This controller provides satisfactory performance for a large range of load variations.

Controlling the Motion of Robot Manipulators on Constrained Surfaces, pp. 1331-1336

Papageorgiou, Xanthi   National Tech. Univ. of Athens
Kyriakopoulos, Kostas J.   National Tech. Univ. of Athens

We present a methodology to steer the end effector of a robotic manipulator, which is constrained in terms of joint rates, on the surface within the workspace, to perform surface tasks. We develop smooth controllers for stabilizing the end effector to a point, and for tracking a trajectory on this surface, while respecting the input constraints, and the same time applying a specific force on it. We show that the resulting closed loop system is uniformly asymptotically stable and we verify our analytical development with computer simulations.

FrB4   Room 4
Hybrid Systems (Regular Session)

Chair: Hui, Qing   Texas Tech. Univ.
Co-Chair: Griggs, Wynita M.   N/A

A Geometrical Treatment for Obtaining Necessary and Sufficient Conditions for Joint Quadratic Lyapunov Function Existence for State-Dependent, Switched Systems: A Two-Dimensional Case, pp. 1337-1342

Griggs, Wynita M.   NUIM
King, Christopher   Northeastern Univ.
Shorten, Robert   Nat. Univ. of Ireland
Mason, Oliver   NUI Maynooth
Wulff, Kai   Otto-von-Guericke-Univ.

The question of existence of joint quadratic Lyapunov functions (QLFs) for state-dependent, switched dynamical systems is given a preliminary geometrical treatment in this paper. The joint QLF problem for a switched system and a collection of regions defined by state vectors that determine when switching occurs consists of finding nonempty intersections of convex sets of QLFs. The existence of a joint QLF guarantees switched system stability. Necessary and sufficient conditions for the existence of a joint QLF are obtained for a two-dimensional problem.

Switched Singular Linear Systems, pp. 1343-1347

Clotet, Josep   Univ. Pol. de Catalunya
Ferrer, Josep   Univ. Pol. de Catalunya
Magret, M. Dolors   Univ. Pol. de Catalunya

We consider switched singular linear systems and determine the set of reachable/controllable states. We derive necessary and sufficient conditions for such a system to be reachable/controllable when an "equisingularity condition" holds.

On Semistability of Nonlinear Switched Systems, pp. 1348-1353

Hui, Qing   Texas Tech. Univ.
Haddad, Wassim M.   Georgia Inst. of Tech.

This paper develops semistability analysis results for nonlinear switched systems. Semistability is the property whereby the solutions of a dynamical system converge to Lyapunov stable equilibrium points determined by the system initial conditions. The main results of the paper involve sufficient conditions for semistability using multiple Lyapunov functions and integral-type inequalities.

A Model Based Control Scheme with Sampled Information, pp. 1354-1360

Conte, Giuseppe	Univ. delle Marche
Perdon, Anna Maria	Univ. Pol. delle Marche
Vitaioli, Giorgio	Univ. Pol. delle Marche

In this paper we consider the problem of driving to zero by means of state feedback the state of a nonlinear plant when only an approximate model of the plant is known and the information about its state is sampled. To this aim, we develop a specific model based control scheme and, under suitable hypotheses, we give a sufficient condition, in terms of length of the sampling interval and of other design parameters, for achieving the control objective.

Dissipativity Theory for Discontinuous Dynamical Systems: Basic Input, State, and Output Properties, and Finite-Time Stability of Feedback Interconnections, pp. 1361-1366

Haddad, Wassim M.	Georgia Inst. of Tech.
Hui, Qing	Texas Tech. Univ.

In this paper we develop dissipativity theory for discontinuous dynamical systems. Specifically, using set-valued supply rate maps and set-valued connective supply rate maps consisting of locally Lebesgue integrable supply rates and connective supply rates, respectively, and set-valued storage maps consisting of piecewise continuous storage functions, dissipativity properties for discontinuous dynamical systems are presented. Furthermore, extended Kalman-Yakubovich-Popov set-valued conditions, in terms of the discontinuous system dynamics, characterizing dissipativity via generalized Clarke gradients and locally Lipschitz continuous storage functions are derived. Finally, these results are used to develop feedback interconnection stability results for discontinuous dynamical systems by appropriately combining the set-valued storage maps for the forward and feedback systems.

FrB5   Room 5
Linear Time Delay Systems (Regular Session)

Chair: Koumboulis, Fotios	Halkis Inst. of Tech.
Co-Chair: Du, Baozhu	Univ. of Hong Kong

Dynamic Measurement Output Feedback Controllers for Exact Model Matching and Disturbance Rejection of General Linear Neutral Time Delay Systems, pp. 1367-1372

Koumboulis, Fotios	Halkis Inst. of Tech.
Kouvakas, Nikolaos	National Tech. Univ. of Athens
Paraskevopoulos, P. N.	National Tech. Univ. of Athens

The control design problem of exact model matching with simultaneous disturbance rejection (EMMDR) for left invertible general neutral multi-delay systems is solved via a dynamic realizable controller using the measurable disturbances and feeding back the measurement outputs of the system. The dynamic part of the controller connecting the measurement outputs and external commands to the inputs is considered to be realizable and proper while the dynamic part of the controller connecting the measurable disturbances to the inputs is considered to be realizable. For the controller to be implementable the transfer matrix mapping the control inputs to the measurable outputs is considered to be realizable. For this controller and open loop plant the necessary and sufficient conditions for the solvability of the EMMDR problem are resolved and the general analytical expression of the controller matrices solving the problem is presented.

A Matrix Transformation Approach to H-Infinity Control Via Static Output Feedback for Input Delay Systems, pp. 1373-1378

Du, Baozhu	Univ. of Hong Kong
Lam, James	Univ. of Hong Kong
Shu, Zhan	Univ. of Hong Kong

This paper addresses the static output feedback (SOF) H-infinity control for continuous-time linear systems with an unknown input delay from a novel perspective. New equivalent characterizations on the stability and H-infinity performance of the closed-loop system are established in terms of nonlinear matrix inequalities with free parametrization matrices. These delay-dependent characterizations possess a special monotonic structure, which leads to linearized iterative computation. The effectiveness and merits of the proposed approach are shown through numerical examples.

12:40-13:00   FrB5.3
Robust Controllers for Delayed Systems, pp. 1379-1384

  Dlapa, Marek   Tomas Bata Univ. in Zlin
  Matusu, Radek   Tomas Bata Univ. in Zlin

A way for treating general delayed systems with uncertain delays in both numerator and denominator is shown. The proposed procedure is demonstrated by an example. A simple controller is derived via algebraic theory and the structured singular value, which treats uncertain time delay in both the numerator and the denominator of an anisochronic system. The overall performance is verified by simulations and compared with standard tool for robust control design.

13:00-13:20   FrB5.4
Robust Stabilization of a Class of Uncertain Systems with Time Delay*

  Saadaoui, Karim   Engineering School of Tunis (ENIT), Tunisia

13:20-13:40   FrB5.5
On Estimating the Exponential Decay Rate for Linear Systems with Interval Time-Varying Delay, pp. 1385-1389

  Huang, He   City Univ. of Hong Kong
  Feng, Gang   City Univ. of Hong Kong

This paper presents a delay-dependent approach to studying the exponential stability of linear systems with interval time-varying delay. It is assumed that the upper and lower bounds of the time delay are known. Delay-dependent stability conditions are derived based on an integral inequality, and the exponential decay rate can be obtained by means of the feasibility of a linear matrix inequality. By fully considering the information of the delayed states and introducing slack variables, the conservatism in some existing results is further reduced. Two numerical examples are finally provided to demonstrate the effectiveness of the proposed approach.

FrB6   Room 6
Approximate Dynamic Programming (Invited Session)

  Chair: Ferrari, Silvia   Duke Univ.
  Co-Chair: Jagannathan, Sarangapani   Missouri Univ. of Science and Tech.
  Organizer: Ferrari, Silvia   Duke Univ.
  Organizer: Lewis, Frank L.   Univ. of Texas at Arlington
  Organizer: Jagannathan, Sarangapani   Missouri Univ. of Science and Tech.

12:00-12:20   FrB6.1
Optimal Control of Affine Nonlinear Discrete-Time Systems (I), pp. 1390-1395

  Dierks, Travis   Missouri Univ. of Science and Tech.
  Jagannathan, Sarangapani   Missouri Univ. of Science and Tech.

In this paper, direct neural dynamic programming techniques are utilized to solve the Hamilton Jacobi-Bellman equation in real time for the optimal control of general affine nonlinear discrete-time systems. In the presence of partially unknown dynamics, the optimal regulation control problem is addressed while the optimal tracking control problem is addressed in the presence of known dynamics. Each design entails two portions: an action neural network (NN) that is designed to produce a nearly optimal control signal, and a critic NN which evaluates the performance of the system. Novel weight update laws for the critic and action NN's are derived, and all parameters are tuned online. Lyapunov techniques are used to show that all signals are uniformly ultimately bounded (UUB) and that the output of the action NN approaches the optimal control input with small bounded error. Simulation results are also presented to demonstrate the effectiveness of the approach.

12:20-12:40   FrB6.2
Application of Optimal Impulsive Control Method to Advertising (I), pp. 1396-1401

  Balakrishnan, S.N.   Missori Univ. of Science and Tech.
  Ding, Jie   Missouri Univ. of S & T

Advertising departments in companies face hard choices when have to decide how much and when to spend on advertising over the year in order to maximize the customer goodwill and minimize the advertising expenditure. To address these issues, this paper proposes an optimal impulsive control method, in which the control is discrete and only applied when the goodwill is below some pre-specified level. Optimality conditions for impulse driven systems are derived first. Simulation results based on optimal impulsive control method and an existing technique are presented. Analysis of the results show that integrated goodwill is greater with the optimal impulsive control method. Furthermore, this paper describes how to find a feasible suboptimal solution when an optimal solution doesn't exist.

Adaptive Optimal Controllers Based on Generalized Policy Iteration in a Continuous-Time Framework (I), pp. 1402-1409

Vrabie, Draguna — The Univ. of Texas at Arlington
Vamvoudakis, Kyriakos — The Univ. of Texas at Arlington
Lewis, Frank L. — Univ. of Texas at Arlington

In this paper we present two adaptive algorithms which offer solution to the continuous-time optimal control problem for nonlinear, affine in the inputs, time-invariant systems. Both algorithms were developed based on the Generalized Policy Iteration technique and involve adaptation of two neural network structures namely Actor, providing the control signal, and Critic, performing evaluation of the control performance. Despite the similarities, the two adaptive algorithms differ in the manner in which the adaptation takes place, required knowledge on the system dynamics, and formulation of the persistence of excitation requirement. The main difference is that one algorithm uses sequential adaptation of the actor and critic structures, i.e. while one is trained the other one is kept constant, while for the second algorithm the two neural networks are trained synchronously in a continuous-time fashion. The two algorithms are described in detail and proof of convergence is provided. Simulation results of applying the two algorithms for finding the optimal state feedback controller of a nonlinear system are also presented.

A Penalty Function Method for Exploratory Adaptive-Critic Neural Network Control (I), pp. 1410-1414

Di Muro, Gianluca — Duke Univ.
Ferrari, Silvia — Duke Univ.

A constrained penalty function method for exploratory adaptive-critic neural network (NN) control is presented. While constrained approximate dynamic programming has been effective to guarantee closed-loop system performance and stability objectives, in the presence of a change in the plant dynamics it may not have the necessary plasticity to explore and fully adapt to the new behaviors of the plant, if these violate the constraints. A generalized constrained approach is introduced to overcome these limitations. Through this methodology it is shown that NNs are not only capable to acquire new plasticity when necessary, but also can adjust their parametric structure reducing their hidden nodes and becoming more computationally efficient.

Approximate Dynamic Programming for Continuous State and Control Problems (I), pp. 1415-1420

Si, Jennie — Arizona State Univ.
Yang, Lei — Arizona State Univ.
Lu, Chao — Tsinghua Univ.
Sun, Jian — Tsinghua Univ.
Mei, ShengWei — Tsinghua Univ.

Dynamic programming (DP) is an approach to computing the optimal control policy over time under nonlinearity and uncertainty by employing the principle of optimality introduced by Richard Bellman. Instead of enumerating all possible control sequences, dynamic programming only searches admissible state and/or action values that satisfy the principle of optimality. Therefore, the computation complexity can be much improved over the direct enumeration method. However, the computational efforts and the data storage requirement increase exponentially with the dimensionality of the system, which are reflected in the three curses: the state space, the observation space, and the action space. Thus, the traditional DP approach was limited to solving small size problems. This paper aims at exploring a class of approximate/adaptive dynamic programming algorithms including those applicable to continuous state and continuous control problems. The paper will review these algorithms, especially direct heuristic dynamic programming (direct (HDP), which has been demonstrated useful in some large and complex continuous state and control problems. The paper also introduces two application studies of the direct HDP - one is when it is used in a nonlinear tracking problem, and the other is on a power grid coordination control problem based on China southern network

Chair: Voutetakis, Spyridon   Centre for Res. and Tech. Hellas (CERTH)
Co-Chair: Rocha, Ronilson   Federal Univ. of Ouro Preto

16:20-16:40   FrC1.1

Modeling and Analysis of an Integrated Power System Based on Methanol Autothermal Reforming, pp. 1421-1426

Ipsakis, Dimitris   Chemical Process Engineering Res. Inst.
Voutetakis, Spyridon   Centre for Res. and Tech. Hellas (CERTH)
Seferlis, Panos   Aristotle Univ. of Thessaloniki
Papadopoulou, Simira   Alexander Tech. Educational Inst. of Thessaloniki
Stoukides, Michael   Department of Chemical Engineering

The integrated power system under consideration, consists of the fuel processor (reformer and preferential oxidation reactors), the fuel cell and the heat management system. In the reformer reactor, methanol, air and water are co-fed to produce hydrogen under autothermal conditions. The produced hydrogen due to the high content of CO (>5000ppm), is treated in the preferential oxidation reactor (PROX) for the CO minimization at acceptable levels (<50ppm). After the oxidation clean-up step, the anode of the polymer electrolyte membrane (PEM) fuel cell is fed with the reformate gas (~60-65% H_2, ~15-25% CO_2, ~15-20% N_2, ~1-3%CH_3OH and traces of CO). The present paper is focused on the mathematical analysis of the main subsystems of the integrated power unit. The two reactors are modeled via a system of partial differential equations (PDE's) and the species flowrates and reactor temperature are analyzed along the length of each reactor. Moreover, the PEM fuel cell voltage-current characteristic is modeled via a non-linear equation that depends on the mass & energy balances (ordinary differential equations) of the concerned species. Finally, the heat management system is analyzed in order to provide insights for future control studies that will depend on the developed mathematical model (model-based control).

16:40-17:00   FrC1.2

A Sensorless Control for Wind Turbine, pp. 1427-1432

Rocha, Ronilson   Federal Univ. of Ouro Preto

This paper presents a sensorless control for a stall regulated variable speed wind turbine, where the speed reference is obtained from the estimated aerodynamic torque. The LQG/LTR methodology is applied to the design of an optimal discrete-time feedback controller for a Wind Energy Conversion System, aiming to maximize the efficiency on energy conversion and to minimize the detrimental dynamic loads due to wind fluctuation and ripple torque. The trade-off between the efficiency maximization of the energy conversion and the dynamic load effects minimization is considered in the quadratic cost function of the LQG/LTR design. The resulting control structure is simulated considering a step variation on wind speed. The performance of the proposed control scheme is discussed showing that it really leads the WECS operation near to the maximum efficiency point and reduces the detrimental dynamic loads. It is also presented some alternatives for sensorless control for the electrical generator.

17:00-17:20   FrC1.3

*A Fuzzy Inference Self-Organizing-Map Based Model for Short Term Load Forecasting of Iran**

Farhadi, Mahdi   Birjand Univ. of Tech.

In this paper , by presenting a new combination modelof artificial neural networks and fuzzy expert system, the initial daily load forecasting of Iran is done more accurately using the knowledge of an expert and the fuzzy expertsystem for special days (including the new year vacation , official holidays , days before and after official holidays).The effect of temperature is also included in the initial forecasted model of the Kohonen Self-Organizing Map (SOM) neural network for all days of the year , normal, and special.The Mean Absolute Percentage Error (MAPE) values of the years 1380, 1381 and 1382 (in the Iranian solar calendar) are consist of normal and special days are 1.89%,1.90% and 1.68% respectively.By studying the performance of the designed software based on the present model it is possible to understand the valuable acts of this model. Some of them are: high accuracy in forecasting normal days, high improvement in the forecasting of special days using the fuzzy expert system, high speed of training and forecasting stages, and suitable sensitivity toward temperature, the possibility of accounting other environmental factors such as humidity, cloud overlay, and wind speed.

17:20-17:40   FrC1.4

*Static Security Assessment of Iran's North-West Power System Tie-Lines Using Multi-Rate Statistical Methods and SOM Neural Network**

Mashhadi Kashtiban, Atabak   azad Univ. of khameneh
Barzrgar, Javad   amirkabir

17:40-18:00   FrC1.5

Investigation of Compared Neural Network Models for 24 Hours Ahead Load Forecasting of Iran Power Network*

   Farhadi, Mahdi   Birjand Univ. of Tech.

18:00-18:20   FrC1.6

New MPPT Controller Design for PV Arrays Using Neural Networks (Zanjan City Case Study)*

   Habibi, Mehran   Power and Water Univ. of Tech.
   Yazdizadeh, Alireza   Shahid Abbaspour Univ. of Tech.

FrC2   Room 2

Industrial Automation/ Education and Training (Regular Session)

   Chair: Bistak, Pavol   Faculty of Electrical Engineering and Information
                                            Technology, Slovak Univ. of Tech. in Bratislava
   Co-Chair: Zakova, Katarina   Slovak Univ. of Tech.

16:20-16:40   FrC2.1

A Contribution to Remote Control of Inverted Pendulum, pp. 1433-1438

   Kolencik, Milos   Faculty of Electrical Engineering and Information Tech.
   Zakova, Katarina   Slovak Univ. of Tech.

The paper presents two approaches that can be used for remote control of a given technological equipment. We devoted our attention to the control of the inverted pendulum plant that represents a typical nonlinear system used as a benchmark in control education at many universities. The first approach is based on building the client-server application that connects .NET technology and Macromedia Flash format. In the second case the Java client-server application was created. The application combines the created graphical user interface with the Matlab engine running on the server.

16:40-17:00   FrC2.2

Teaching Remote Control and Monitoring Using Industrial Ethernet System*

   Abdul Salam, Ahmed   Roads & Transport Authority

17:00-17:20   FrC2.3

Establishment of Industrial Control Laboratory for Undergraduate and Postgraduate Curricula*

   Abdul Salam, Ahmed   Roads & Transport Authority

17:20-17:40   FrC2.4

Matlab and Java Based Virtual and Remote Laboratories for Control Engineering, pp. 1439-1444

   Bistak, Pavol   Faculty of Electrical Engineering and Information Technology, Slov

Virtual and remote laboratories play an important role in the education process of engineers. Their expansion is closely connected to the growth of Internet. The paper deals with the structure of virtual and remote laboratories. It explains the main components of the client server application and describes the data exchange between this application and Matlab/Simulink software based on COM technology.

17:40-18:00   FrC2.5

Open Motion Control, a Model Based Development Platform for Rapid Prototyping., pp. 1445-1450

   Botto, Gianluca   Pol. di Torino
   Carabelli, Stefano   Pol. di Torino
   Suarez, Lester Daniel   Pol. di Torino
   Visconti, Marco   Pol. di Torino
   Truccone, Paolo   Actua S.r.l Spin off Pol. di torino

In this paper, an integrated and open-architecture motion control (OMC) development environment is presented. The application is founded on a model-based technological approach which represents an effective way to focus on maximum theoretical performance in the mechatronic prototyping. In order to achieve openness flexibility, an open-architecture supported by a DSP/FPGA-based digital platform is provided.

18:00-18:20   FrC2.6

Applying Autonomous Control Methods in Different Logistic Processes – a Comparison by Using an Autonomous Control Application Matrix, pp. 1451-1455

   Windt, Katja   Jacobs Univ.
   Becker, Till   Jacobs Univ.

Autonomously controlled processes represent a decentralized approach to deal with today's increasing complexity in production logistics. Different autonomous control methods offer the possibility to redesign

logistics processes in the way that control is shifted from centralized planning to autonomous logistic objects. The performance of these methods embedded in logistic processes needs to be measured in order to select the appropriate method for each process. This measurement can be done using an evaluation system but due to the vast diversity of logistic processes, it is extremely difficult to give general recommendations regarding the performance of autonomous control methods in different settings. Especially companies have to be able to find the most suitable methods for their individual logistic processes. This paper introduces an Autonomous Control Application Matrix which allows identifying the autonomous control method that fits best to a specific logistic process. The matrix contains actual performance values, performance percentage, and rank of each method in combination with a specific process.

FrC3   Room 3
Biomedical Engineering II (Regular Session)

Chair: Aspragathos, Nikos   Univ. of Patras
Co-Chair: Theocharis, John   Aristotle Univ. of Thessaloniki

16:20-16:40   FrC3.1

Feature Extraction Based on a Fuzzy Complementary Criterion for Gait Recognition Using GRF Signals, pp. 1456-1461

Moustakidis, Serafeim   Aristotle Univ. of Thessaloniki
Theocharis, John   Aristotle Univ. of Thessaloniki
Giakas, Giannis   Univ. of Thessaly

A novel wavelet-based feature extraction approach is introduced in this paper for subject recognition utilizing ground reaction force (GRF) measurements. A wavelet-packet (WP) decomposition scheme is firstly proposed to recognize the discriminating frequency subbands and subsequently an efficient feature selection (FS) method is applied on the selected WP bands providing a compact set of powerful and complementary features. Our approach relies on a non-global fuzzy set-based criterion to assess the significance of every subband or feature. This local evaluation measure with respect to patterns is implemented by a fuzzy partition vector (FPV) constructed by invoking a fuzzy class allocation scheme that assigns membership grades to every class. The FS is driven by a fuzzy complementary criterion (FuzCoC) that acts upon the feature FPVs, handling simultaneously both the discrimination power and the redundancy between the features. To demonstrate the performance capabilities of our approach an extensive experimental setup is designed with tasks of increasing difficulty.

16:40-17:00   FrC3.2

An Expert System for Supporting the Conceptual Design of Controllers for Lower Limbs Rehabilitation Systems, pp. 1462-1467

Moulianitis, Vassilis   Univ. of Patras
Syrimpeis, Vasileios   Univ.
Aspragathos, Nikos   Univ. of Patras
Panagiotopoulos, Elias   General Univ. Hospital of Patras

In this paper, an Expert System (ES) for supporting the conceptual design of a closed loop control scheme for the rehabilitation of lower limb disabilities is presented. The design of the controllers is based on the exploitation of experts knowledge concerning the gait cycle and uses pathological muscles electromyographical (EMG) data for feedback signals. EMGs from normal muscles are also used to detect the gait phases and an expert system for supporting the selection of the suitable set of muscles is developed. The acquired knowledge concerning the gait phases and the muscles EMGs is presented. Finally, a case study of designing a controller for the correction of the drop foot syndrome is presented.

17:00-17:20   FrC3.3

Sequential Feature Selection Methods for Parkinsonian Human Sleep Analysis, pp. 1468-1473

Fairley, Jacqueline   Georgia Inst. of Tech.
Georgoulas, George   Dept. of Informatics and Communications Tech.
Vachtsevanos, George J.   Georgia Inst. of Tech.

This paper focuses on the selection of quantitative features from the polysomnogram (psg) to enhance automated/computerized approaches in analyzing the human sleep cycle for pathology identification. Validation of the utilization of the psg as a metric for pathology identification is cited by Bliwise et al. . The pathological case investigated in this study was pre-Parkinsonian disease. This case is of interest because, to the author's knowledge, studies to investigate quantitative features to describe the human sleep cycles of pre- Parkinsonian disease patients have not been previously conducted. In this study a total of 67 quantitative features were investigated in the characterization of the human sleep cycles for adult pre-Parkinsonian patients and normal

control subject psgs. Adult normal human sleep may contain time durations of at least 6.5 hours . According to international sleep scoring standards, a minimum of four biological channels are required in a psg recording . Computation of all 67 features over such a large data set for multiple patients/subjects poses computational efficiency issues especially when attempts are made to incorporate these automated methods in a clinical environment. To alleviate the computational burden of processing all 67 features, in this study, intelligent feature selection techniques were incorporated to establish optimal feature sub-sets that best characterized the human sleep cycles. Feature sub-sets for characterization of psg data for adult pre-Parkinsonian patients and normal control subjects were obtained using the sequential forward and backward feature selection algorithms and k-Nearest Neighbor (k-NN) classification. An investigation of these feature selection techniques toward the characterization of adult pre-Parkinsonia

17:20-17:40   FrC3.4

Exploiting Prior Knowledge and Preferential Attachment to Infer Biological Interaction Networks, pp. 1474-1479

Amato, Francesco   Univ. degli Studi Magna Graecia di Catanzaro
Cosentino, Carlo   Univ. degli Studi Magna Grćcia di Catanzaro
Montefusco, Francesco   Univ. degli Studi Magna Graecia di Catanzaro

The problem of reverse-engineering the topology of interaction networks from time-course experimental data has received a considerable attention in the literature, due to the potential applications in the most diverse fields, comprising engineering, biology, economics and social sciences. An important insight was brought by the introduction of the concept of scale-free topology, whose implications have been widely discussed in literature over the last decade. The aim of this work is to investigate whether it is possible to improve the performances of an inference technique, based on dynamical linear systems and LMI-based optimization, by exploiting the same mechanisms that underpin scale-free networks generation, i.e. growth and preferential attachment (PA). The work is prominently concerned with applications in the biological domain, though the algorithm can be in principle adapted also to other frameworks. A statistical evaluation is performed, by using numerically simulated networks, showing that the growth and PA mechanisms actually improve the inference power of the considered technique. Finally the method is applied to a biological case-study, validating the results against experimental data available in literature.

17:40-18:00   FrC3.5

On the Use of State-Observers in Compartmental Systems Control, pp. 1480-1485

Sousa, Cláudia   School of Education Jean Piaget - Piaget Inst.
Mendonça, Teresa   Univ. do Porto
Rocha, Paula   Univ. of Porto

In this paper we analyse the performance of state-observers in the control of compartmental systems under the presence of uncertainties in the system initial state. We combine a state feedback law with positivity constraints and a state observer and prove that, as expected, the mass control objective is still attained. Moreover we show that, for a class of three-compartmental systems of interest, the resulting mass control law also allows reaching a desired steady state. Our results are illustrated by several simulations for the control of the administration of a neuromuscular relaxant to patients undergoing surgery, which show the relevance of incorporating an observer for convergence acceleration even in case the original system is asymptotically stable.

18:00-18:20   FrC3.6

Control of Heart Conduction System Arrhythmia by Means of Sliding Mode Scheme, pp. 1486-1491

Naderi, Ramin   ACECR
Azemi, Asad   Penn State Univ. Cty. campus
Yazdanpanah, M. J.   Tehran Univ.

In this paper, we present a sliding mode controller for FitzHugh-Nagumo (FHN) model affected by uncertainties, disturbances and immeasurable states. The sliding mode controller has been utilized with the aim of external signal tracking for the single cell FHN model. Both methods of Proportional Derivative Sliding Mode Control (PDSMC) and Proportional Integrator Derivative Sliding Mode Control (PIDSMC) are applied to the FHN model. For these control strategies, salient features of the controllers and their potentials are described. Simulation results for both methods are presented and compared. It is shown that different features of the control performance of the PIDSMC such as robustness, precision and chattering elimination are quite comparable to those of PDSMC. Since FHN model seems to correctly capture the electrical behavior of the heart Conduction system, therefore, this method might have important applications, especially, the proposed approach may be employed in control of cardiac arrhythmia.

Chair: Dr.-Ing. Sourkounis, Constantinos	Ruhr-Univ. Bochum
Co-Chair: Alexandridis, Antonis	Univ. of Patras

16:20-16:40   FrC4.1

Switching Losses and Harmonic Currents Evaluation of PWM Techniques for VSI-Fed Dual Stator Induction Motor Drive, pp. 1492-1497

Khoudir, Marouani	Pol. Military School (EMP)
Khaldi, Mohamed	Pol. Military School (EMP)
Khoucha, Farid	Pol. Military School (EMP)
Kheloui, Abdelaziz	Pol. Military School (EMP)

In this paper, an analytical evaluation of the harmonic currents and the switching losses in dual stator induction motor (DSIM) drive fed by two three-phase VSIs controlled by PWM techniques is presented. Based on the sine-triangle and space vector PWM techniques concept, eight variants of PWM strategies are presented and compared. So, continuous (CPWM) and discontinuous (DPWM) PWM techniques are obtained according to the selected switching sequences. The analysis is applied to determine the optimal modulation technique that minimizes the switching losses and the rms value of the harmonic currents. It is shown that the CPWM at low modulation and DPWM techniques at the high modulation range have superior performance. Whereas, reduced switching losses are obtained with the DPWM techniques. Therefore, an optimal PWM scheme is obtained with transition between these PWM strategies to allow a performance drive optimization over the whole voltage range

16:40-17:00   FrC4.2

Current and Voltage Control of Paralleled Multi-Module Inverter Systems, pp. 1498-1503

Talebi, Nasser	Shahrood Univ. of Tech.
Sadrnia, M.A.	Shahrood Univ. of Tech.
Rafiei, S.M.R.	Shahrood Univ. of Tech.

Power inverters are used to acquire an ac output voltage from a dc power supply. The parallel connection of inverters results in several advantages, like improvement of the system reliability and increasing of the power capacity. The control problem for parallel-connected inverters is proper voltage regulation and equal current distribution. In this paper, a characteristic loci based compensator (Approximate commutative compensator) is used to obtain design objectives. In order to compare results, H_; and LQG/LTR controllers, are also implemented on parallel inverters. Simulation results of the single-module, two-module and three-module inverter systems with different kinds of loads and parametric uncertainties, have demonstrated the feasibility of the proposed control scheme in proper voltage regulation and equal current distribution.

17:00-17:20   FrC4.3

Dynamic Torque Control in Electromechanical Drive Train with PID-State Control, pp. 1504-1510

Dr.-Ing. Sourkounis, Constantinos	Ruhr-Univ. Bochum

For numerous technical processes, high load peaks result from the stochastic workflow. Those load peaks propagate in the power train of the electromechanical drive system to the feeding power grid and at the same time stimulate torsion oscillations. For smoothing the load peaks as well as damping the torque oscillations a novel torque control was designed. The concept consists of a PID-state control and was com-pared to standard control methods such as standard PID control.

17:20-17:40   FrC4.4

A Passivity-Based PI Control Design for DC-Drives, pp. 1511-1516

Marmidis, Grigorios	Univ. of Patras
Alexandridis, Antonis	Univ. of Patras

In this paper, a new controller design method is developed for the control of separately excited dc motors, fed by a three phase PWM ac-dc converter. A complete model is developed using the d-q reference frame for the ac part and the conventional dc formulation for the motor. Based on passivity analysis, by using as storage function the total energy of the system, it is proven that the system is always passive independently from the way the converter is regulated. Therefore, suitable PI controllers are proposed that achieve angular speed regulation and unit power factor operation. Finally, extensive simulations verify the effectiveness of the proposed control scheme.

Sensorless Sliding Mode Observer Based on Rotor Position Error for Salient-Pole PMSM, pp. 1517-1522

Ilioudis, Vasilios   Aristotle Univ. of Thessaloniki
Margaris, Nikolaos   Aristotle Univ. of Thessaloniki

This paper introduces a new simple sensorless algorithm of estimating the Permanent Magnet Synchronous Motor (PMSM) speed and position. The proposed estimation method is implemented using a stator flux/current and a modified back Electromotive Force (EMF) observer connected in cascade. The flux/current observer based on sliding mode techniques ensures stator currents convergence while the modified back EMF observer provides accurate rotor position estimation at a wide range of motor speeds. An adaptive stator resistance observer is embedded in the flux/current Sliding Mode Observer (SMO) and improves the overall observation system convergence. Simulation results show good properties of the proposed estimation approach.

FrC5   Room 5
Observers (Regular Session)

Chair: Zak, Stanislaw   Purdue Univ.
Co-Chair: Darouach, Mohamed   Univ. Henri Poincare-Nancy

16:20-16:40   FrC5.1
Motorcycle Roll Motion Stabilization and Observer Design, pp. 1523-1528

Mammar, Said   IBISC-CNRS-FRE3190
Slimi, Hamid   EVRY
Glaser, Sébastien   LCPC

This paper is devoted for the development of a stabilized roll motion model of a motorcycle coupled to a PI observer for state an unknown input estimation (fault). The feedback controller is designed for robust stabilization by yaw angle feedback to the steering torque, it is based on the loop shaping H_{∞} method for static feedback controller design. The controller and the observer are designed on a linear rider-motorcycle model and then tested on a model with nonlinear tire-road interaction forces. Simulation and preliminary experimental results show the effectiveness of the approach.

16:40-17:00   FrC5.2
Asymptotic Quotient Observers for 2-D Fornasini Marchesini Models, pp. 1529-1534

Ntogramatzidis, Lorenzo   Curtin Univ. of Tech.
Cantoni, Michael   Univ. of Melbourne

The concepts of conditioned-invariant, detectability and input-containing subspaces are developed within the context of observer design for 2-D Fornasini-Marchesini models in a general form. Specifically, a link is establised between these subspaces and the existence of so-called quotient observers, which estimate the local state modulo a conditioned invariant subspace. We also consider the synthesis of observers that are asymptotic in the sense that the estimation error (modulo a conditioned invariant subspace) tends to zero away from the boundary values.

17:00-17:20   FrC5.3
Functional Observers for Linear Descriptor Systems, pp. 1535-1539

Darouach, Mohamed   Univ. Henri Poincare-Nancy

This paper is concerned with the design of functional observers for linear time-invariant descriptor systems. The order of these observers is equal to the dimension r of the functional to be estimated. Sufficient conditions for the existence and stability of these observers are given. The obtained results extend those given for the standard systems. Continuous and discrete time systems are considered.

17:20-17:40   FrC5.4
Wavelet Usage for Features Exctraction for Crack Localization, pp. 1540-1545

Georgoulas, George   Dept. of Informatics and Communications Tech.
Kappatos, Vassilios   Univ. of Patras
Stylios, Chrysostomos   TEI of Epirus
Dermatas, Evangelos   Univ. of Patras

In this research work we investigate the analysis of Acoustic Emission (AE) signals using wavelet decomposition to locate a single event (crack), taking place into three typical areas in a ship hull. The problem is a typical classification problem based on the use of novel features extracted from the AE time series. As in most classification problems the extraction of an appropriate set of features plays a major role in the overall performance of the system and it is by no means a trivial task. Once a suitable set of features is extracted even

"simple" classification models can perform adequately whereas a non-informative set of features even combined with sophisticated classifiers can lead to disappointing results. Exploiting the multi-resolution capabilities of wavelet decomposition a set of features is extracted which combined with a simple classifier manages to give superior classification rates for noisy environments compared to our previous work where conventional features have been involved.

17:40-18:00   FrC5.5

Reduced-Order Observer Based Decentralized Controller Design: The LMI Approach, pp. 1546-1551

Lian, Jianming   Purdue Univ.
Kalsi, Karanjit   Purdue Univ.
Zak, Stanislaw   Purdue Univ.

The robust stabilization problem is considered for a class of nonlinear interconnected systems consisting of linear subsystems coupled by nonlinear interconnections. The interconnections are unknown and quadratically bounded. A novel decentralized dynamic output feedback based linear controller is proposed, which is characterized by the observer-controller separation property. The feedback gain matrices of local controllers are obtained by solving an optimization problem subject to linear matrix inequalities. The local projection operator based reduced-order unknown input observer is employed to asymptotically estimate the states of each subsystem. The closed-loop system driven by the proposed decentralized controller is guaranteed to be connectively stable with maximized interconnection bounds.

18:00-18:20   FrC5.6

Robust Observer for a Class of Uncertain Linear Systems, pp. 1552-1556

Sfaihi, Boutheina   INTITUT NATIONAL DES SCIENCES APPLIQUEES ET DE Tech.
Kallel, Hichem   INTITUT NATIONAL DES SCIENCES APPLIQUEES ET DE Tech.

In this paper a novel framework for robust observer for linear systems with parametric uncertain state matrix is introduced. A new class of high gain observer which incorporates a second gain update output estimation error is developed. With lesser restrictive conditions, it is shown that the conceived high gain observer for a chosen nominal system is insensitive to non-bounded parameters variation and provides good performances. Analytical developments are detailed and adopted choices are justified. Convergence properties for the robust observer are proved through Lyapunov method. Approach validity is illustrated via a detailed numerical example with extensive simulation results.

FrC6   Room 6

New Trends in Missile Guidance and Control (Invited Session)

Chair: Balakrishnan, S.N.   Missori Univ. of Science and Tech.
Co-Chair: Shinar, Josef   Tech. Israel Inst. of Tech.
Organizer: Balakrishnan, S.N.   Missori Univ. of Science and Tech.
Organizer: Tsourdos, Antonios   Cranfield Univ.
Organizer: Shinar, Josef   Tech. Israel Inst. of Tech.

16:20-16:40   FrC6.1

Earliest Intercept Geometry Guidance to Improve Mid-Course Guidance in Area Air-Defence (I), pp. 1557-1562

Shin, Hyo-Sang   KAIST
Antonios Tsourdos, Antonios Tsourdos   Cranfield Univ.
White, Brian A.   Cranfield Univ.
Tahk, Min-Jea   KAIST

This paper describes a mid-course guidance strategy based on the Earliest Intercept Geometry (EIG) Guidance. An analytical solution and performance validation will be addressed for generalized mid-course guidance problem in area air-defence to improve rechability and performance. The EIG is generated for a wide range of possible manoeuvres of the challenging missile based on the guidance algorithm using differential geometry concepts. The main idea is that a mid-course guidance law can defend the area as long as it assures that the depending area and objects are always within the defended area defined by EIG. The velocity of Intercept Point in EIG is analytically derived to control the Intercept Geometry and the defended area. The proposed method can be applied in deciding a missile launch window and launch point for the launch phase.

Meeting the Challenges of Modern Interceptor Guidance by Non-Conventional Approaches (I),
pp. 1563-1568

Shinar, Josef   Tech. Israel Inst. of Tech.
Turetsky, Vladimir   Tech. Israel Inst. of Tech.

The challenge of intercepting threats with non conventional warheads, the major drive for the development of ballistic missile defense systems since the first Gulf War of 1991, became even more serious when the reentry vehicles were assumed to be capable of maneuvering. Successful interception of such targets, requiring very small miss distances, cannot be guaranteed by the classical guidance and estimation methods that have been used against manned aircraft. Future interceptor guidance strategy has to be based on pursuit-evasion game concepts and the estimator design has to be integrated with the guidance law. Following such non conventional approaches has the potential to achieve the requirement of hit-to-kill accuracy against randomly maneuvering threats.

Control for Autonomous VTOL Aircraft with Restricted Inputs, pp. 1569-1574

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This study presents simple controllers for achieving global stability in a Vertical Take-off and Landing (VTOL) aircraft with bounded thrust input. While previous studies apply nonlinear combinations of nested saturation functions for stabilizing the equilibrium point of the system, the proposed controllers are based on smooth uniformly bounded functions that can easily be implemented. A procedure for synthesizing a control function that steers the aircraft to an acceptable configuration while reducing the applied control effort is also presented. Using the flatness property the approach is based on a simple solution to a (sub) optimal control problem with a quadratic index of performance.