TUA 1 (invited)	11:00 – 13:00	Amphitheatre

TUTORIAL ON LOGIC-BASED CONTROL: SWITCHED CONTROL SYSTEMS

Chair: J. P. Hespanha — Univ. Calif. Santa Barbara, USA

I - Supervisory Control Architecture
II - Applications of Switched Control
III - Stability of Switched Systems I
IV - Stability of Switched Systems II

J. P. Hespanha — University of California, USA
D. Liberzon — University of Illinois, USA

Abstract: The overall objective of this tutorial session is to overview a variety of theoretical tools for synthesizing and analyzing logic-based switching control systems. By a logic-based control system we mean a system that combines continuous dynamics (typically modeled by differential or difference equations) with logic-driven elements. These systems are often also called "hybrid."An important category of such systems are those consisting of acontinuous-time process to be controlled, a family of fixed-gain orvariable-gain candidate controllers, and an "event-driven switchinglogic" called a supervisor whose job is to determine in real timewhich controller should be applied to the process. Examples ofsupervisory control systems include re-configurable systems, fault correction systems, and certain types of parameter-adaptive systems. Major reasons for introducing logic and switching are to deal with communication, actuator and sensor constraints, with model uncertainty, with unforeseen events or to avoid performing difficult tasks e.g., precise equipment calibration which might otherwise benecessary were one to consider only conventional controls. The lectures are complemented by notes available on the web at the following URL:http://www.ece.ucsb.edu/~hespanha/med02-logic/index.html

Keywords: Switched Systems, Hybrid Systems, Supervisory Control

TUA 2	11:00 – 13:00	VA - 6

ADAPTIVE CONTROL

Chair: J. Lemos — INESC-ID/IST, PT

Simplified Adaptive Control via Improved Robust Positive Real Conditions

I.Yaesh — Israel Military Industries, IL
U. Shaked — Tel Aviv University, IL

Abstract: Simple adaptive controllers are derived by applying a new method for achieving robust strictly positive real plants via state-feedback. A constant state-feedback gain is derived that guarantees the strictly positive realness of the closed-loop inpresence of polytopic type parameter uncertainties in the modelthat describes the plant. This is achieved by assigning different Lyapunov functions to each of the vertices of the uncertainty polytope. The obtained feedback gain is used to derive a robust simplified adaptive control of systems with polytopic uncertainties.

Keywords: Robust SPR, SAC, Strictly Positive Real Lemma, Simplified Adaptive Control.

Structure Selection in Predictive Adaptive Control: A Maximum Entropy Interpretation

J. M. Lemos — Instituto Superior Técnico, PT

Abstract: This paper is concerned with the selection of the structure of Predictive Adaptive Controllers. using Saridi´s Maximum Entropy formulation of Optimal and Adaptive Control, relationships between performance and certain aspects of controller strucute, observed both in simulations and experiments, are shown to hold. The entropy approach also sheds light on the benefic effect of using more parameters than one would strictly need (referred as "redundant modelling") would the plant order be perfectly known. Both analytic and experimental examples are presented.

Keywords: Adaptive Control, Maximum Entropy, Predictive Control, Learning, Predictive, Stochastic Algorithms

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Adaptive Control in the Presence of Sensor Measure Outliers

J. M. Lemos — Instituto Superior Técnico, PT
R. N. Silva — FCT/UNL, PT
J. S. Marques — Instituto Superior Técnico, PT

Abstract: Adaptive control of plants whose sensor measurements are corrupted by outliers is considered. Outliers are large deviations of the signal being measured, only occurring in a few percent of the observations. For adaptive controllers relying on an implicit Gaussian assumption, both the identification and the underlying control law are yielded by the minimization of quadratic losses. Therefore, although rare, outliers heavily degrade performance due to their large amplitude. This problem is tackled in this paper. Methods for outlier removal which are suitable for adaptive control applications are reviewed and illustrated through an application to position control in the ball and beam plant.

Keywords: Adaptive Control, Robust Estimation, Outliers, Median Filter, Bayes Inference

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Towards a Spline-Based Hybrid Adaptive Nonlinear Observer

J. H. Stoev — Seoul National University, KR
J-Y Choi — Seoul National University, KR

Abstract: We present a novel approach for a adaptive nonlinear adaptive observer using splines. The piecewise properties of splines result in a significant reduction of dynamic order of observer filters. To obtain this result, we use hybrid-like techniques during the observer design.

Keywords: Nonlinear, Observer, Adaptive, Spline, Hybrid

Adaptive Control of Nonlinear Processes Using Polynomial Approach and LQ Control Technique

P. Dostal — Tomas Bata University in Zlin, CZ
V. Bobal — Tomas Bata University in Zlin, CZ
F. Gazdos — Tomas Bata University in Zlin, CZ

Abstract: The paper deals with continous-time adaptive control of nonlinear processes. A nonlinear model of the process is approximated by an external linear model with recursively estimated parameters. Both 1DOF and 2DOF control system configurations are considered. Resulting controllers ensure internal properness and stability of the control system as well as asymptotic tracking of the step reference and step load disturbance attenuation. The design procedure is based on the polynomial method. An application of the LQ control technique yields the control law penalizing the control input changes. The adaptive control is tested on a model of a continuous stirred tank reactor.

Keywords: Nonlinear Process, External Linear Model, Parameter Estimation, Polynomial Method, Adaptive Control.

Singular value and structured singular value bounds in parameter space

N. Bajcinca — Institute for Robotics and Mechatronics,DLR , DE
M. Muhler — Institute for Robotics and Mechatronics,DLR , DE

Abstract: This paper develops a new approach for the output model reference adaptive control of linear continuous-time plants with multiply state delays. The main idea is to include into the control law a feedforward component which compensates for the delayed states,in addition to output feedback. The feedforward is formed byspecial adaptively adjusted prefilters as a function of thedelayed state of the reference model. The output feedbackcomponent is designed as for a plant without delay, but appliedto the time-delay plant. Such a controller structure containing adaptive output feedback and adaptive prefilters from the delayed reference model makes it possible to solve the problem of adaptive exact asymptotic output tracking under parametric uncertainties. The stability is analyzed using theLyapunov-Krasovskii functional method. Simulation results showthe effectiveness of out proposed scheme.

Keywords: Model Reference Adaptive Control; State-Delay Systems

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TUA 3	11:00 - 13:00	VA - 1
FUZZY CONTROL		
Chair: M. Velez		Universidad de Huelva, ES

Incorporating the Crisp Consequent FRM into Dynamic Matrix Control

B. A. Gormandy — Strathclyde University, UK
B. E. Postlethwaite — Strathclyde University, UK

Abstract: Recently, a fuzzy internal model control (FIMC) scheme with the novel crisp consequent fuzzy relational model (ccFRM) was presented by Postlethwaite & Edgar (2000). The design of the FIMC is based on linear IMC. The FIMC was shown to be easy to formulate and possessed all the benefits of linear IMC with the added capability of handling non-linear systems. However, when the FIMC is applied to multi-input multi-output (MIMO) systems with different deadtimes serious dynamic errors are observed in the controller response. Process interactions and deadtimes can be intrinsically handled with model predictive control schemes such as dynamic matrix control (DMC). In this contribution, the procedure for the local linearisation of ccFRM is presented. Transfer functions are then easily extracted and this facilitates the incorporation of the ccFRM into a DMC scheme. The proposed FMPC is compared with the FIMC by using a liquid level system and a binary distillation column.

Keywords: IMC, Model Predictive Control, Fuzzy Model Based Control

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Robust Neuro-Fuzzy Feedback Control for Mobile Manipulator

J. B. Mbede — Bundeswehr Univ. Munich, DE
P. Ele — Université de Yaoundé I, CM
Wu Wei — School of Information Science and Technology, CN

Abstract: Two robust Neuro-Fuzzy feedback controllers for autonomous and intelligent electrically driven mobile manipulator in dynamic and partially known environments containing moving obstacles are presented. The first one is used to generate the commands for the servo-systems of robot arm so that, locally, it may choose its way to its goal autonomously. And the second controller is implemented in mobile platform so that it maintains a permanent flexible path between two nodes in network generated by a probabilistic roadmap approach. In order to consider the compatibility of stabilisation, mobilisation and manipulation, we derive a coordinated fuzzy local planner algorithm so that the mobile manipulator can avoid stably unknown and/or dynamic obstacles. To verify the efficacy of the coordination algorithm, we conduct numerical simulations with representative task trajectories. The results from the simulation are demonstrated and evaluated the effectiveness of the proposed control algorithms.

Keywords: Electrically Driving Mobile Manipulator, Dynamic Obstacle Avoidance, Robust Neuro-Fuzzy Control, And Stabilisation.

Sliding Surface Slope Adjustment in Fuzzy Sliding Mode Controllers

I. Eksin	Istanbul Technical University, TR
M. Guzelkaya	Istanbul Technical University, TR
S. Tokat	Istanbul Technical University, TR

Abstract: Combining fuzzy logic controller and sliding mode controller to exploit the superior sides of these two controllers is an active area in control theory. The dynamic behaviour of the hybrid system named as fuzzy sliding mode controller depends quite heavily on the sliding surface on which the control structure is switched. In this study, the slope of the sliding surface is continuously updated by a new time-varying coefficient. The effectiveness of the proposed method over the classical fuzzy sliding mode control is illustrated by simulations performed on a second order system with uncertain parameters.

Keywords: Fuzzy Logic Control, Hybrid Systems, Sliding Mode, Self-Tuning Control

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Fuzzy Controller for Elimination of the Nonlinear Resonance Phenomenon

O. Kuljaca	University of Texas, USA
L. Kuljaca	University of Zagreb, HR
Z. Vulkic	University of Zagreb, HR
B. Strah	AVL List GmbH, AT

Abstract: The paper deals with the capability of the fuzzy controller to eliminate the frequency resonance jump of the nonlinear system. The simulation method is used for the analysis purposes. The nonlinear system operates in the forced oscillation mode, and the fuzzy regulator of the Mamdani type is used for elimination of the resonance jump. The proposed method of resonance jump elimination proved to be reliable and useful.

Keywords: Nonlinear Resonance, Fuzzy Control, Oscillations

Fuzzy Modelling with Parameters Adjustment Based on Overlap Ratio

M. Vélez	Universidad de Huelva, ES
O. Sánchez	Universidad de Huelva, ES
A. Ollero	Universidad de Sevilla, ES

Abstract: The identification of fuzzy models from input-output data of the process normally lead to representations which are difficult to understand

Keywords: Fuzzy Modeling, Parameters Adjustment, Overlap ratio.

Application of Fuzzy Logic Control to an Automotive Active Suspension System

M. Farahmand	Tehran University, IR
C Lucas	Tehran University, IR

Abstract: In this paper a fuzzy control scheme for active suspension design has been considered. The objective of control is to improve the ride comfort and road holding ability under different road condition. A good suspension system should reduce the body (sprung mass) acceleration to improve the ride comfort. The performance of fuzzy logic controller active suspension is compared with optimal controller in several simulations.

Keywords: Linear Approximation, First And Second-Order Non-Linear Systems, Exponential Stability, State Feedback.

TUA 4	11:00 - 13:00	VA - 2

POWER SYSTEMS

Chair: R. E. Araújo — Universidade do Porto, PT

Induction Motor Robust Adaptive Control

H. H. Ouadi	LAP, ISMRA, FR
F. Giri	LAP, ISMRA, FR

Abstract: An extensive research activity have been devoted, over the last decade to the problem of induction motor control. Most of the proposed controllers are designed under the assumption that the rotor resistance is constant. In practice, such an assumption does not hold due to the skin-effect. Therefore, the proposed controllers may lead in realistic situations to poor control performances, especially during transient periods. In this paper, we propose for the induction motor a new robust adaptatif controller, designed by the the backstepping technique. The rotor resistance time-variation is dealt with using a sigma-modification in the parameter adaptation law. On the other hand, the control model involves a division by the flux variable that may lead to unbounded solutions. Such a risk is avoided by basing the controller design on a Lyapunov function that acoounts for the model singularity. The obtained controller is shown to meet its objectives, namely system regional stabilization, reference speed tracking and reference flux regulation.

Keywords: Induction Motor, Adaptive Control, Robustness

Real Time Simulation of STATCOM with Two Novel Control Algorithms

S. Kincic	Université du Québec, CA
A. Chandra	Université du Québec, CA
B. N. Singh	Tulane University, USA
P. Rastgoufard	Tulane University, USA

Abstract: This paper is aimed to develop two novel control algorithms for reactive power compensation in high voltage transmission lines. A voltage source inverter (VSI) working as Static Synchronous Compensator (STATCOM) is employed to supply/absorb reactive power depending upon line operating conditions. Both the developed control algorithms control output voltage of STATCOM and control techniques do not require any current measurement therefore getting rid of costly current sensors in the system. Both the algorithms are validated by numerical simulation.

Keywords: Voltage Source Inverter, STATCOM, PWM

Modelling and Simulation of Power Electronics Systems Using Bond Graph Formalism

R. E. Araújo	Universidade do Porto, PT
A. V. Leite	Polytechnic Inst. of Bragança, PT
D. S. Freitas	Universidade do Porto, PT

Abstract: This paper deals with the modelling of power electronic systems using the bond graph formalism. The switching components are modelled using an ideal representation so that a constant topology system is obtained. The purpose of the present contribution is to discuss a technique that combines bond graph energy-flow modelling and signal-flow modelling schemes for simulation and prototyping of signal processing algorithms in power electronics systems. In this paper, we will discuss models of the full controlled, semi-controlled and not controlled switches uses in the field of power static converters. By concept, a simulation environment can be examined at different abstraction or hierarchy levels. The approach in this paper is so the formulation of a simulation task at different levels: component level, topology level, functional description and implementation description. The paper concludes with two practical examples of simulation of the power electronics systems.

Keywords: Computer Modelling And Simulation, Power Electronics, Bond Graph

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Optimal Design and Control of Axial-Flux Brushless DC Wheel Motor for Electrical Vehicles

Y-P Yang	National Taiwan University, TW
C-H Cheung	National Taiwan University, TW
S-W Wu	National Taiwan University, TW
J-P Wang	National Taiwan University, TW

Abstract: A multi-objective optimal design of a brushless dc wheel motor is presented. This axial-flux permanent magnet motor is designed to achieve a high torque-to-weight ratio and motor efficiency, and is suitable for the direct-driven wheel applications. The dedicated motor is modelled in magnetic circuits, and designed to meet the specifications of an optimisation scheme, subject to constraints, such as limited space, current density, flux saturation and driving voltage. Finite element analyses are then carried out to obtain the electromagnetic, thermal and modal characteristics of the motor for modification and verification of the preliminary design. The prototypes are fabricated and controlled by the pulse-width-modulation drive with optimal current waveforms. Experimental results show that the direct-driven power system installed on an electric motorcycle has good overall efficiency and long driving range.

Keywords: Electrical Vehicle, Axial-Flux Wheel Motor, Optimal Design, Optimal Current Waveform

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Design of Fuzzy Regulator for Power System Secondary Load Frequency Control

T. Šijak	Brodarski Institut, HR
O. Kuljaca	The University of Texas, USA
L. Kuljaca	University of Zagreb, HR
S. Tešnjak	University of Zagreb, HR

Abstract: The stability analysis of nonlinear system that is harmonically linearised is given[10,3,11]. With the introduction of fuzzy regulator the nonlinear system consists of linear part and two nonlinear parts. The stability analysis is conducted by use of describing function method and Hurwitz stability criterion. Proportional and derivative parameters of Mamdani type fuzzy regulator gains were preliminary tuned (pre-tuned) by Cohen-Coon and Ziegler-Nichols methods [1, 13]. Stability analysis was conducted for the power system secondary load-frequency control model. The proposed stability analysis presents a good starting point for the design of fuzzy regulator for nonlinear systems.

Keywords: Nonlinear System, Fuzzy Control, Power System, Stability Analysis

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Observerless Scheme for Sensorless Control of Induction Motor: Stability Analysis and Design Procedure

M. Montanari	DEIS, University of Bologna, IT
S. Peresada	Kiev Polytechnic Institute, UA
A. Tilli	DEIS, University of Bologna, IT

Abstract: A speed sensorless controller for induction motor based on indirect field orientation concept is considered. Its main feature is that it is observerless. No speed and flux estimation is carried out in the controller, while a load torque estimator is based on the torque current error. The stability analysis of the full order error dynamics is performed using linearization. It is shown that the closed-loop system is locally asymptotically stable. A simple design of the controller parameters is obtained, thanks to the decoupling of the system in two interconnected systems. Experimental results show the performance of the proposed controller in a wide range of operating conditions.

Keywords: Induction Motor, Sensorless Control, Field Orientation, Stability Analysis

TUA 5	**11:00 - 13:20**	**VA - 5**
PRODUCTION SYSTEMS		
Chair: K. Valavanis	Technical University of Crete, GR	

Supervisory Control of Multiple-Part-Type Production Networks

S. Ioannidis	Technical University of Crete, GR
N. Tsourveloudis	Technical University of Crete, GR
K. Valavanis	Technical University of Crete, GR

Abstract: A supervisory controller is derived for scheduling production networks. The supervisory controller is used to tune a set of lower level distributed fuzzy control modules

that minimize WIP and synchronize the production system's operation. Simulation results show that the supervisory controller when compared with the single level distributed controllers reduces WIP and Cycle-Time while keeping backlog in acceptable levels

Keywords: Backlog; Supervisory Control; Production Networks; Work-In-Process;

Stability or Stabilizability? Seidman´s FCFS Example Revisited

J. A. A. Moreira Agilent Technologies, DE
C. F. G. Bispo Instituto Superior Técnico, PT

Abstract: We address the issue of stability for multi-class, non-acyclic, andstochastic queuing networks. This has been an exciting problem, addressedby the research community in over a decade, where the nature of theTraffic Intensity Condition as being sufficient for such networksto be stable has been debated and questioned. We argue that the concept ofstability ought to be replaced by that of stabilizability and thatthis property is intrinsic to the network´s topology. Under this moregeneric setting, and resorting to idling policies, we provide adistributed supervisory controller that is able to stabilize a large setof networks, provided that the traffic intensity condition holds. Seidman´s example is used to demonstrate such property.

Keywords: Queuing Networks, Distributed Scheduling, Stability

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An FPGA-Based Implementation for Median Filter Meeting the Real-Time Requirements of Automated Visual Inspection Systems

M. A. Vega-Rodríguez Univ. de Extremadura, ES
J. M. Sánchez-Pérez Univ. de Extremadura, ES
J. A. Gómez-Pulido Univ. de Extremadura, ES

Abstract: Image processing is a very important field within factory automation, and more concretely, in the automated visual inspection. The main challenge normally is the requirement of real-time results. On the other hand, in many of these applications, the existence of impulsive noise in the acquired images is one of the most habitual problems. Median filter is a robust method to remove the impulsive noise from an image. It is a computationally intensive operation, so it is hard to implement it in real time. This paper introduces a new architecture and optimizations for its implementation with FPGAs. The practical results show the effectiveness of our improvements allowing real-time processing and a minimum use of resources.

Keywords: Factory Automation, Image Processing, Median Filter, Reconfigurable Hardware, Real-Time Processing.

Critical Success Factors for the Implementation of Integrated Automation Solutions with PC Based Control

K. Kumar University of Siegen, DE
H. Roth University of Siegen, DE
L. Karunamoorthy Anna University, IN

Abstract: The new possibilities in connectivity, communication, control, sharing and coordination have shifted the way manufacturing enterprises are to be managed. The survival of industries depends on the integration of new technologies and business management processes. This paper describes the versatile control facilities / techniques / technology based on Personal Computer (PC) available for open system development. The use of fieldbus and ethernet and the integration of system components with Information Technology (IT) is also discussed. The Critical Success Factors (CSFs) for the successful development / implementation of integrated control and automation systems are described as a project management tool for the planning and implementation of Integrated Automation systems.

Keywords: Critical Success Factors, Control Technology, Information Technology, Integrated Automation, Project Management

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Testbed for Analysis of PLC-Controlled Manufacturing Systems

S. Bogdan University of Zagreb, HR
N. Smolic-Rocak University of Zagreb, HR
Z. Kovacic University of Zagreb, HR

Abstract: The aim of the paper is to present a testbed for verification and validation of PLC control algorithms for dispatching operations and resources in manufacturing systems. Based on super blocks, designed in Simulink, and by using Matlab Real Time Workshop (RTW), testbed provides an efficient tool for real-time investigation of various dispatching policies as well as influence of manufacturing system parameters on behavior of the control system.

Keywords: Manufacturing Systems, Programmable Logic Controller, Des Analysis, Implementation

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From Requirements to Function Block Diagrams: New Approach for the Design of Industrial Applications

C. S. Tranoris Univeristy of Patras, GR
K. C. Thramboulidis Univeristy of Patras, GR

Abstract: The always growing need, for innovative products, forces manufacturing plants to improve their ability to quickly respond to market requirements by designing competitive products and modifying existing ones. However most of the traditional methods, products and tools are far away from the new challenging technologies of Software Engineering. Today’s systems are composed of monolithic applications that are almost impossible to integrate and even to expand. Modularity, flexibility, extensibility, reusability

and interoperability are dimensions slightingly addressed by the most traditional proprietary methods and engineering tools. In this paper, we describe our approach for the design of distributed Industrial Process, Measurement and Control Systems (IPMCSs). We adopt the use case driven approach proposed by Ivar Jacobson and the UML notation, to capture requirements. We have defined the process for the transformation of requirements expressed in the form of use cases, to IPMCSs design specifications, expressed in the form of Function Block diagrams. The whole process, which is in the context of the CORFU framework, is fully automated, so an Engineering Support System can support it.

Keywords: Ipmcs, Software Process, Use Cases, Uml, Function Block

TUA 6	**11:00 - 13:00**	**VA - 3**
IMAGE PROCESSING APPLICATIONS		
Chair: H. Araújo		University of Coimbra, PT

Uncertainty Propagation in Estimation of Partial 3D Velocity

N. Gonçalves University of Coimbra, PT
H. Araújo University of Coimbra, PT

Abstract: This paper analyses two methods to compute the 3D velocity of a navigating stereo head in the depth (Z) direction. Both methods, which are function of the optical flow and disparity maps, are presented in two approaches: differential and discrete. Both methods in both formulations are studied within the scope of uncertainty propagation. This provides a mean to point out the critical input variables for each method where special care in measurements should be taken. Different paths (translational, rotational and mixed) as well as different types of surfaces are compared.

Keywords: Uncertainty Propagation ,3D Velocity, Rotation,Translation,Depth Resolution

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2-D Function Reconstruction Application to Superresolution Problem

A. Dzielinski Warsaw Univ. of Technology, PL

Abstract: These paper is aimed at presenting a solution to the superresolution problem from multiple frames using the 2-D function reconstruction algorithm. Also, conditions for such functions to be reconstructed from their nonuniform samples by means of feedforward neural networks are given. Further the multidimensional sampling based approach to reconstruction of a multivariable function is discussed. The attention is payed to several important background issues like function extension and restrictions. A Fourier transform based method for function reconstruction out of given nonuniform samples is briefly presented.The method also solves the superresolution problem.

Keywords: Function Reconstruction, 2-D Systems, Superresolution Problem

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Detection and Classification of 3D Moving Objects

A. R. Lourenço Instituto Superior Técnico, PT
P. J. A. Freitas Instituto Superior Técnico, PT
M. I. Ribeiro Instituto Superior Técnico, PT
J. S. Marques Instituto Superior Técnico, PT

Abstract: The detection and classification of moving objects is a key task in many Control systems. This paper presents a solution for this problem based on a laser range scanner. The method can be summarized as follows. A set of 3D data points on the object surface is obtained using the scanner. A small number of features is then computed to represent the object boundary. In fact three alternative features are considered. Classification algorithms are then designed and evaluated using real data. The experimental tests show that the proposed techniques allow a robust classification of moving objects based on range information.

Keywords: Detection, Feature Extraction, Classification, Moving Objects, Laser

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Vision Based Respiratory Monitoring System

M. Frigola Technical Univ. of Catalonia, ES
J. Amat IRI – UPC / CSIC, ES
J. Pagès Technical Univ. of Catalonia, ES

Abstract: Breathing monitoring systems are demonstrating to have an increasing interest since they can aid to diagnose the patient breathing deficiencies and thus to decide the adequate therapy. This paper describes one such system based on vision, that measures the evolution of the breathing through the analysis of the movement. This remote sensor, besides being completely safe, makes possible a continuous supervision of the patient without causing any disturbance or imposing constraints in the patient actions an behaviour during the monitoring period.

Keywords: Medical Applications, Monitoring, Image Processing And Computer Vision

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Expression Influence at Automatic Face Recognition by Using PCAs

P. M. Iriondo UPV-EHU, ES
F. Pérez UPV-EHU, ES
I. Calvo UPV-EHU, ES
M. Graña UPV-EHU, ES

Abstract: Automatic face recognition is a complex matter that is influenced by the circumstances found when the picture was taken. For example, human emotions introduce a certain degree of disturbance that difficult the success at face recognition. This document analyses the behaviour of a recognition system based on the Principal Component Analysis (PCA) technique when facial changes are introduced by human emotions. It will also describe the structure of the face database used by the recognition system, as well as, the experiments used to test it. Finally, the relative influence of every eigenvector in the recognition process is also analysed.

Keywords: Automatic Recognition. Image Recognition. Visual Pattern Recognition. Eigenvectors (Eigenfaces). Robot Vision.

Ultrasonic and Video Data Fusion for Mobile Robot Navigation

A. Bonci Univ. degli studi di Ancona, IT
T. Leo Univ. degli studi di Ancona, IT
S. Longhi Univ. degli studi di Ancona, IT

Abstract: A multisensor fusion approach for improving the map-building capability of a mobile robot is presented in this paper. Ultrasonic and video data are used. A modelling technique for indoor environments based on line features extraction from video data and from range data is proposed. The Hough transform is considered for extracting lines from the occupancy grid and from video images.

Keywords: Sensor Fusion, Mobile Robots, Ultrasonic Transducers, Uncertainty, Robot Vision

TUP 1 (invited) 16:00 – 18:00 Amphitheatre

TUTORIAL ON LOGIC-BASED CONTROL: SWITCHED SUPERVISORY CONTROL

Chair: D. Liberzon Univ. Illinois at Urbana, USA

I- Supervisory Control Architecture
II- Estimator-based Linear Supervisory Control
III- Estimator-based Nonlinear Supervisory Control
IV- Supervisory Control Applications

J. P. Hespanha Univ. Calif. Santa Barbara, USA

Abstract: The overall objective of this tutorial session is to overview a variety of theoretical tools for synthesizing and analyzing logic-based switching control systems. By a logic-based control system we mean a system that combines continuous dynamics (typically modeled by differential or difference equations) with logic-driven elements. These systems are often also called "hybrid."An important category of such systems are those consisting of acontinuous-time process to be controlled, a family of fixed-gain orvariable-gain candidate controllers, and an "event-driven switchinglogic" called a supervisor whose job is to determine in real timewhich controller should be applied to the process. Examples ofsupervisory control systems include re-configurable systems, fault correction systems, and certain types of parameter-adaptive systems. Major reasons for introducing logic and switching are to deal with communication, actuator and sensor constraints, with model uncertainty, with unforeseen events or to avoid performing difficult tasks e.g., precise equipment calibration which might otherwise benecessary were one to consider only conventional controls. The lectures are complemented by notes available on the web at the following URL:http://www.ece.ucsb.edu/~hespanha/med02-logic/index.html

Keywords: Switched Systems, Hybrid Systems, Supervisory Control

TUP 2 (invited) 16:00 – 18:00 VA -1

FMS AND INDUSTRIAL ROBOTS: CONTROL, COMMUNICATIONS, SUPERVISION

Chair: G.M. Dimirovski Dogus Univ., TR

Design and Development of a Factory of the Future in Turkey

Reza Ziarati Dogus University
Martin Ziarati Dogus University
Osman N Ucan Dogus University
David Stockton De Montford University

Abstract: The Factory of the Future programme embraces a number of collaborative research projects primarily concerned with factory automation. The current research encompasses the development of a laser device for machine tool calibration and a wireless network for application in manufacturing factories. A further work concerns research into design of a knowledge-based-system for information automation as the basis for automating an entire manufacturing enterprise.

Keywords: Automation, Knowledge-Based-Systems, Neural Networks, Intelligent Product Cycle

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Soft Computing Agents in Custom Dependent Production

Dimitar Lakov ICCS-BAS
Georgi Kirov ICCS-BAS

Abstract: An application of Soft Computing Agents (SCA) into Custom Dependent Production is considered. It replaces big series with a number of lower sized, customers’ quality oriented. SCAs take advantages of Soft Computing Technology and Intelligent Software Agents. Both models are built on FUZZY MATLAB TOOLBOX and ZEUS of BT platforms respectively. Their compatibility is sought in C objective code generation.

Keywords: Software Intelligent Agent, Soft Computing Agent, Zeus Approach, Custom Dependent Production

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Petri-Net Modeling of Inteligent FMS Communication Protocols and Applications

A. Zakeri Univ. Wolverhampton, UK
Y. Jing Northeastern Univ., CN
G. M. Dimirovski Dogus Univ., TR
N. E. Gough Univ. Wolverhampton, UK

Abstract: In this paper recent results on intelligent communication protocols (ICP) that are tailored for applications within flexible manufacturing systems (FMS) are presented. These have been derived using Petri-net technique for the representation of discrete-event dynamic processes on the grounds of the concept of ICP emulation and by using the technique of object-oriented emulation modelling and programming. Developed models have been derived using three alternatives: math-analytical queue,

adequate Petri-net, and appropriate object-oriented models. Some of the simulations results obtained illustrate these innovated IPC developments for FMS along with an analysis of the respective performance achieved.

Keywords: Flexible manufacturing Systems; information flow; communication protocaols; object oriented modelling; stochastic petri nets.

Automation System Redesign Using Robot Manipulator for Steel-Pipe Production Line

Mile J. Stankovski	SS Cyryl & Methodius Univ., MK
M.K. Vukobratovic	Inst. Mihailo Pupin Beograd, YU
T. D. .Gugulovska	SS Cyryl & Methodius Univ., MK
A.T. Dinibutun	Dogus University, TR

Abstract: Automation system of a real-world steel-pipe production line in factory FZC "11 Oktomvri" Co., Kumanovo, the RM, has been investigated for improving productivity and throughput. The steel-pipe making process is real-world plant is found to have weakness in mechanical manipulation at zinc-plate covering sub-plant, where a robotic arm should replace human worker. An analysis of the task sequence of robot arm relative to the known theoretical developments is presented, and appropriate representation model given. An outline of system engineering features of technical solution employing robotic arm relative to job-shop control of the steel-pipe manufacturing line is presented.

Keywords: Automation; Manipulator Robots; Mechanical Processes; Steel Pipe Production; Zinc-Coating Plant.

TUP 3	16:00 – 18:00	VA - 2
NEURAL NETWORKS		
Chair: S. Costa	Instituto Superior Tecnico, PT	

Neuro-Fuzzy Fault Detection Approach Using a Profibus Network

J. M. F. Calado	Instituto Superior de Engenharia de Lisboa, PT
M. Kowal	University of Zielona Góra, PL
M. J. G. C. Mendes	Instituto Superior de Engenharia de Lisboa, PT
J. Korbicz	University of Zielona Góra, PL
M. G. Sá da Costa	Instituo Superior Técnico, PT

Abstract: Generally three methodologies to develop and test FDI algorithms can de distinguished: software benches, hardware benches and industrial data. The current approach uses a hardware bench constructed with components commonly used in industry that consists on a pilot plant under supervision, a supervision unit, a fault detection unit and a fault simulation unit. All elements are connected to a PROFIBUS network that acts as the communication system exchanging information between automation system and distributed field devices. A fault detection methodology, which is based on neuro-fuzzy models, has been developed and implemented. During the current studies actuator faults, sensor faults and leakages have been considered as incipient and abrupt faults. Several studies have also been performed under multiple simultaneous faulty scenarios.

Keywords: Neuro-Fuzzy, Fault Detection, Fieldbus, Abrupt And Incipient Faults.

Unscented Kalman Filter in Adaptive Neural Model-Based Predictive Control

P. S. Gil	CISUC and DEE-UNL, PT
J. Henriques	CISUC, PT
H. Duarte-Ramos	Univ. Nova Lisboa, PT
A. Dourado	CISUC, PT

Abstract: An adaptive model-based predictive control scheme is proposed for non-linear systems. This methodology exploits the non-linear modelling capabilities of non-linear state-space neural networks and the online weights adjustment by means of an unscented Kalman filter. Results from experiments show evidences on its good tracking performance even when the system's dynamics change.

Keywords: State-Space Neural Networks; On-Line Training; Model-Based Predictive Control; Dual Unscented Kalman Filter

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Nonlinear Systems Modelling Using RBF Neural Networks: A Random Learning Approach to the Resource Allocating Network Algorithm

Z. Ahmida	University of Skikda, DZ
A. Charef	University of Constantine, DZ

Abstract: The paper proposes a batch training technique of RBF neural networks for nonlinear systems identification. The method is based on the philosophy of the resource-allocating network via extended Kalman filter.However,a random learning approach is adopted instead of sequential learning in the original algorithm.In addition, we introduce a relative error threshold criteria. The technique is evaluated in modelling two nonlinear systems.

Keywords: Nonlinear Systems, Identification, Neural Networks, RBF

Dynamic Neuro-Adaptive Control for a Class of Nonlinear Discrete-Time Systems via Sliding Mode

Q. Hui	Tsinghua University, CN
M. Yang	Tsinghua University, CN

Abstract: Dynamic neuro-adaptive sliding-mode control methodologies are proposed for the tracking problem of nonlinear discrete-time input-output systems. The unknown dynamics of the system are approximated via growing radial basis function neural networks. The control laws are based on the sliding mode and simple to implement. The discrete-time adaptive laws for tuning the weight of the dynamic neural network are presented using the adaptive filtering algorithm with residue upper-bound compensation. Simulation studies of this approach demonstrate its validity and effectiveness.

Keywords: Growing Neural Networks, Nonlinear Discrete-Time Systems, Adaptive Control, Sliding Mode Control

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Neural Networks for SISD Real Time Control Systems: Overview and Aspects of Activation Function Reduction

M. Capkovic Slovak Univ. of Technology, CS
S. Kozak Slovak Univ. of Technology, CS

Abstract: This paper deals with a neural network optimized for run-ningon a single (SISD) end-device to obtain real time re-sponsein real time control systems and in this paper specialeffort is made to replace the network activation functionby a less computationally expensive function to preservethe original network qualities (approximation andgeneralization capability).

Keywords: Neural Networks, Real Time, Function Approximation, Network Structure Optimization.

Designing the Power Transformer via the Application of Intelligent Systems

L. H. Geromel University of Campinas, BR
C. R. Souza University of Campinas, BR

Abstract: The large number of variables and the fact that, in addition, their multiple interrelations are not completely known make the power transformer design a quite involved task. The purpose of this work is to present a novel power transformer design methodology using intelligent systems. The expectation is that this work contributes to the simplification of the design procedure. This novel methodology is also an important tool, not only for optimizing the projects, but also for minimizing substantially the necessary time for their execution. The methodology described in this paper allows the application of the artificial neural networks in some specific stages of the design. A database that contains the test results of 300 power transformers is used for the validation of the method. The results of the application of this methodology are presented and discussed in this work.

Keywords: Transformers, Intelligent Systems; Artificial Neural Networks; Power Distribution

TUP 4	**16:00 – 18:00**	**VA - 3**
ADAPTIVE SYSTEMS		
Chair: T. Mendonça	Universidade do Porto, PT	

On-Line Multiple Model Switching Control Implementation: A Case Study

T. Mendonça Universidade do Porto, PT
P. Lago Universidade do Porto, PT
H. Magalhães Universidade do Porto, PT
A. Neves Universidade Aveiro, PT
P. Rocha Universidade Aveiro, PT

Abstract: In this paper, a method for the implementation of on-line multiple switching control is described for the control of neuromuscular blockade of patients undergoing surgery. This scheme is based on multiple models and switching among a finite family of candidate controllers, according to a selection criterion based on the minimization of an identification error. In order to achieve good performance, restrictions based on robust stability are imposed to the initial model controller bank. This paper also presents and evaluates an alternative restriction technique upon the model-controller bank, wich is amenable of practical implementation.

Keywords: tracking, switching, multiple models, control application, on-line control tuning

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Combined Adaptive Flight Control System

A. L. Fradkov Inst. Mech. Engin. of RAS, RU
B. R. Andrievsky Inst. Mech. Engin. of RAS, RU

Abstract: Combined adaptive control scheme is presented and used foradaptive control for attitude of the aircraft with uncertainparameters. The proposed controller ensures finite timeconvergence of augmented error omitting to relay term in controllaw and exponential convergence of the parameter error under thecondition of persistent excitation. This allows to achieve the desired dynamics to the true plant output.The simulation results demonstrate high adaptability propertiesof the proposed controller.

Keywords: Combined Adaptive Control, Aircraft Attitude

Energy Control of a Pendulum by Adaptive Friction Compensation

P. A. Lischinsky Universidad de Los Andes, VE
G. González Universidad de Los Andes, VE

Abstract: This paper presents an adaptive friction compensation scheme for energy control of a actuated inverted pendulum. By controlling the total energy the pendulum oscillates by interchanging potential and kinetic energy in an ideal way. This is achieved by friction compensation, the only energy dissipation source on the system. A static friction model is used and a Lyapunov based adaptation scheme is used to achieve a closed loop friction compensation. Assuming that a nominal friction model is known and that the friction variations can be suitably structured, adaptation is performed on the basis of only one parameter. The paper presentsexperimental results validating the friction model and the adaptive control scheme.

Keywords: Inverted Pendulum, Energy Control, Adaptive Friction Compensation, Mechanical Oscillator

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Control Design of Nonlinear Systems Using the Associated Angular System

Z. Sangelaji University of Sheffield, UK
S. P. Banks University of Sheffield, UK

Abstract: This paper presents design methods of control based upon the associated angular system. An affine nonlinear system is converted to two associated systems; one is a nonlinear equation on an ellipsoid or a hyperbolic and the

other is a radial differential system. A suitable control is designed by considering the one dimensional radial system. This control can be continuous or discontinuous. When the input map of the radial subsystem is zero, the controller may no longer implement to the system. In this paper the idea is improved to remove this obstacle by considering an appropriate positive definite weighting function. The behaviour of resulting subsystems based upon the weighting matrix. If an appropriate weighting function is correctly selected the input map is not zero everywhere. Moreover, if the input map of the radial system is nonzero, the control is continuous and stabilizes the system without requiring any condition.

Keywords: Nonlinear Systems, Stabilization, Lyapunov Method, Nonlinear Control, Adaptive Control.

Adaptive Control of a Two Input - Two Output System Using Delta Models

V. Bobal — Tomas Bata University in Zlin, CZ
P. Navratil — Tomas Bata University in Zlin, CZ
P. Dostal — Tomas Bata University in Zlin, CZ

Abstract: This paper presents the design of an adaptive controller for a two input – two output (TITO) system using delta models. The recursive least squares method is used in identification part of this controller, the synthesis is based on a polynomial approach. This controller has been verified by simulation and real time control of a non-linear laboratory model CE108 - coupled drives apparatus.

Keywords: Adaptive Control, Multivariable Control, Delta Model, Decoupling, Real Time Control

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Classification of Human Driving Behaviour for Urban ACC ``Stop and Go´´ Task

M. Canale — Politecnico di Torino, IT
S. Malan — Politecnico di Torino, IT

Abstract: Intelligent vehicle systems have introduced the necessity for the designer to take care of user preferences inorder to make as comfortable as possible several kinds of driving features. This requirement originates the problemof suitably analyzing the human performances to be implemented in automatic driving tasks. The framework in whichthe present work has been developed is an Adaptive Cruise Control with Stop and Go features for a urban scenery. Inthis context, one of the main requirements is the possibility of tuning the control strategy according to thedriving style. In order to accomplish this task, a study on different drivers has been carried on, by means of astatistical analysis, to give evidence to their behaviour during the driving. The aim of this analysis is to decideif it is possible to determine the driver behaviour, which acquired signals are suitable for this task and whichparameters can be used to describe the driving style. Then an assignment procedure is introduced able to classifythe driving behaviour in the considered Stop and Go task.

Keywords: Driver Behaviour, Statistical Analysis, Automotive Control

TUP 5	16:00 – 18:00	VA - 5

ENERGY SYSTEMS

Chair: J. X. Ostolaza — Univ. of the Basque Country, ES

An Alternative Approach for the control of DC-DC Converters

J. X. Ostolaza — Univ. of the Basque Country, ES
I. Zubia — Univ. of the Basque Country, ES
G. Tapia — Univ. of the Basque Country, ES
A. Tapia — Univ. of the Basque Country, ES
M. Garcia-Sanz — Public Univ. Of Navarre, ES

Abstract: This paper presents an alternative method for the control of DC-DC converters. The proposed method is based on the modelling of the influence of the PWM duty cycle on the behaviour of the converter. The controller is designed using Quantitative Feedback Theory (QFT) techniques. The method is applied to the control of a DC-DC Buck converter, and its performance is tested by simulation.

Keywords: Power Supplies, Voltage Control, Duty Cycles, Robust Control, Control Oriented Models

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Robust Control of an Ideal DCM/CCM Flyback Swithing Converter

J. I. Castillejo — Public University of Navarre, ES
M. Garcia-Sanz — Public University of Navarre, ES

Abstract: The present paper shows an application of QFT robust control techniques for an ideal isolated flyback DC-DC switching converter in both continuous and discontinuous conduction mode. A couple of robust controllers, one for every mode, are designed for a wide load range and combined by means of a scheduler.

Keywords: QFT, Robust Control, Switching Converter

Three-Phase Positive and Negative Sequences Estimator to Generate Current Reference for Selective Active Filters

F. R. Ronchi — DEIS, University of Bologna, IT
A.T. Tilli — DEIS, University of Bologna, IT

Abstract: This article deals with the estimation of three-phase three-wire signal harmonics.It is performed in the d-q synchronous reference frame and implements the internal model concept to isolatepositive and negative sequences of each harmonic.This estimator is suitable to be implemented as reference generator for selective active power filters.Simulation and experimental results are presented.

Keywords: Active Power Filters, Harmonic Distortion, Positive And Negative Sequences

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Torque and Speed Modes Simulation of a DTC-Controlled Induction Motor

N. M. Silva	FEUP, PT
A. P. Martins	FEUP-DEEC-ISR, PT
A. S. Carvalho	FEUP-DEEC-ISR, PT

Abstract: By the huge advantages associated, induction motors drives are still justifying research and development. This paper presents the work developed in Direct Torque Control (DTC) based drives. With a growing importance in several applications, this method was object of a deep study, either in simulation environment and hardware implementation. The reached results confirm some weaknesses and several strengths, pointing out his worth in strength control, particularly in robotics.

Keywords: Converter Control, Induction Motor, Direct Torque Control, Simulation

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SCADA Configuration and Control Modes Implementation of an Experimental Water Supply Canal

M. N. Almeida	Universidade de Evora, PT
J. G. Figueiredo	Universidade de Evora, PT
M. Rijo	Universidade de Evora, PT

Abstract: In the last years, digital controllers became a very interesting alternative to traditional controllers in water supply canal automation, in order to match water supply to water demands. This paper presents several digital control modes tested in an experimental canal. The canal operation and their control modes selection are supervised by a SCADA system developed and configured for this particular canal.

Keywords: Water Supply Canal, Automatic Canal Control, Control Modes, PLC And SCADA Programming, Controllers Field Tests

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Modelling, Control and Field Tests on an Experimental Irrigation Canal

T. Ratinho	Universidade de Evora, PT
J. G. Figueiredo	Universidade de Evora, PT
M. Rijo	Universidade de Evora, PT

Abstract: Irrigation canals are complex hydraulic systemsdifficult to control. Many models and controlstrategies have already been developed using linearcontrol theory. In the present study, a PI controlleris developed and implemented in a brand newprototype canal and its features evaluatedexperimentally. The base model relies on thelinearized Saint-Venant equations which iscompared with a reservoir model to check itsaccuracy. This technique will prove its capabilityand versatility in tuning properly a controller forthis kind of systems.

Keywords: Modelling, Control, Automatic Irrigation Canals

TUP 6	16:00 – 18:00	VA - 6

VISION BASED CONTROL

Chair: J. Santos-Victor — Instituto Superior Tecnico, PT

Nonlinear Visual Control of Remote Cellular Robots

J. Santos-Victor	Instituto Superior Técnico, PT
R. Carelli	Univ. Nacional de San Juan, AR
S. vand der Zwaan	Instituto Superior Técnico, PT

Abstract: This paper presents the design of a stable nonlinear control system for the remote visual position control of a cellular robot. Under realistic assumptions, we prove that the control system succeeds to drive the robot to a neighborhood of the target point, in spite of the unknown camera position and orientation. Two cases are analyzed: the first one considers that only the heading of the robot is controlled and, in the second case, the heading and linear velocity are both simultaneously controlled. The control algorithm is based only on the measurements on the image plane of the vision camera -direct vision control-, thus avoiding the problems related to camera calibration. Theproposed controllers can be easily generalized to the problem of controlling many robots performing a cooperative task.

Keywords: Image Based Control, Visual Servoing, Non-Linear Control

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Adaptive non linear sensor based path following control, including dynamics

L. Lapierre	Instituto Superior Técnico, PT
D. Soetanto	Instituto Superior Técnico, PT
A. Pascoal	Instituto Superior Técnico, PT

Abstract: The aim of this work is to investigate the issue of non-linear dynamic sensor-based control of a robot equipped with a camera, in the path (straight line) following problem. A kinematic control is developed, the dynamic is then back-stepped. The previous adaptive control is then modified to warranty the asymptotic convergence in the presence of an unknown offset in the measure of the heading with the camera.

Keywords: Non-Linear Vsion-Based Dymanic Control

Comparing Visual Servoing Architectures for a Planar Robot

P. Gonçalves	Escola Superior de Tecnologia de Castelo Branco, PT
P. Ferreira	Instituto Superior Técnico, PT
P. Pinto	Instituto Superior Técnico, PT
P. Oliveira	Instituto Superior Técnico, PT
G. Britto	Instituto Superior Técnico, PT
L. Pina	Instituto Superior Técnico, PT
J. C. Pinto	Instituto Superior Técnico, PT

Abstract: This paper presents a study of three different Visual Servoing architectures for a planar robot manipulator, comparing their behaviour in achieving a desired goal. The

studied architectures were 2D Visual Servoing, 2½D Visual Servoing and Visual Servoing by path planning. The target used in the experiments was planar. Four target points were selected as the visual features. Since the robot is planar, has no wrist and the visual features are coplanar, some simplifications could be made in the 2½D Visual Servoing architecture. The other architectures studied were implemented with no simplifications, with the exception of the joint limits potential of the path planning visual servoing. The study presented is based on a 2 d.o.f. planar robot manipulator constructed at Instituto Superior Técnico, and the simulation results were obtained using a Matlab 6.0 Simulink. The final part of the paper consists in the presentation of the simulation results and the possible conclusions. The paper ends with hints of what remains to be done in the near future.

Keywords: 2D Visual Servoing; 2½D Visual Servoing; Path Planning; Machine Vision; Robotic Manipulators

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Obstacle Avoidance in Local Navigation

D. J. Castro — Universidade do Algarve, PT
U. Nunes — Universidade de Coimbra, PT
A. Ruano — Universidade do Algarve, PT

Abstract: A reactive navigation system for an autonomous non-holonomic mobile robot in dynamic environments is presented. A new object detection algorithm and a new reactive collision avoidance method are presented. The sensory perception is based in a laser range finder - LRF system. Simulation results are presented to verify the effectiveness of the proposed local navigational system in unknown environments with multiple moving objects.

Keywords: Obstacle Detection, Tracking, Local Navigation.

Optical Flow-Based Obstacle Detection and Avoidance in Mobile Robot Navigation

M. Sarcinelli-Filho — Universidade Federal do Espirito Santo, BR
H. A. Schneebeli — Universidade Federal do Espirito Santo, BR
E. M. O. Caldeira — Universidade Federal do Espirito Santo, BR
C. M. Soria — Universidad Nacional de San Juan, AR

Abstract: This paper addresses the implementation and experimentation of a sensing system designed to allow a mobile robot to detect and to avoid obstacles in its path. It is a visual sensing system, and is based on the optical flow obtained from two consecutive image frames. An important characteristic of such system focused here is that all the computation involved is performed onboard the robot. An example of using such sensing system in avoiding obstacles is shown in order to check how it performs in a real environment.

Keywords: Optical Flow; Obstacle Avoidance; Autonomous Mobile Robots; Computer Vision

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Calibration Free Visual Feedback 3D Robot Control Based on Fuzzy Agents

M. Bonkovic — FESB, University of Split, HR
D. Stipanicev — FESB, University of Split, HR

Abstract: Robot visual 3D positioning is usually related with the well calibrated system in which the large numbers of calibration parameters cause errors resulting in bad system behaviour. Also, even the small changes in the robot work space needs a recalibration procedure, which is quite time consuming process. Inspired by the fact that biological organisms expose superior adaptive capabilities in motion control in comparison with present day robotic system initiated our efforts to develop the robot control system based on fuzzy agents for visual feedback 3D control of robot arm without any calibration procedure. The paper presents our ideas. The theoretical results are illustrated by simulations.

Keywords: Robot Positioning, Fuzzy Control, Visual Feedback, Agents

TUP 7	**16:00 – 18:20**	**VA - 4**

CONTROLER DESIGN I

Chair: R. Silva — Universidade Nova de Lisboa, PT

Sliding Mode Control of a Class of Mismatched Uncertain Systems

S. M. Yahaya — Univ. Tech. of Malaysia, MY
H. S. O. Johari — Univ. Tech. of Malaysia, MY
A. G. Ruddin — Kolej Univ. Tek. Kebangsaan, MY

Abstract: A proportional-integral sliding mode control is proposed for a system with mismatch uncertainties.The proposed controller gives robust stability for system in the presence of parameters variations,uncertainties and disturbances. A simulation study for a numerical example is given to illustrate the effectiveness of this control design.

Keywords: Robust Control, Sliding Mode Control, Mismatched Uncertainties

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Robust Control for Time-Varying Systems

R. Prokop — Tomas Bata University in Zlin, CZ
P. Hustak — Tomas Bata University in Zlin, CZ
Z. Prokopova — Tomas Bata University in Zlin, CZ

Abstract: A class of continuous-time systems with periodic coefficients is analysed and controlled by robust linear controllers. Time varying parameters are considered as perturbations of a nominal time-invariant linear system. The robust control synthesis is based on general solutions of Diophantine equations in the ring of proper and Hurwitz stable rational functions RPS and the Youla-Kucera parameterization of controllers is utilized. Perturbations and robustness of proposed algorithms are studied through the infinity norms (H_\infy). Resulting control laws for first order systems are of a generalized PI type and a scalar parameter m>0 is introduced for tuning and influencing of control responses. A Matlab + Simulink program system for automatic design and simulation has been developed.

Keywords: Periodic Systems, Robust Control, PI Controllers, Rings.

Discrete Time Sliding Mode Realization of Observer Based Control with CMAC

C. P. Bottura University of Campinas, BR
M. J. Bordon University of Campinas, BR
M. C. M. Teixeira DEE - FEIS - UNESP, BR

Abstract: The control of a discrete time linear system through a sliding mode realization of Luenberger observer based state feedback is addressed. In this type of control it is not uncommon high amplitude state trajectories and inputs to appear and, in this context, a new application of a CMAC neural network is proposed: to reduce the magnitude of control inputs. Simulations show the effectiveness of this approach.

Keywords: Luenberger Observer, CMAC, Sliding Mode, Discrete Time

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One-Dimensional Active Noise Control for Periodic Sources

N. F. da Silva DEE-FCT/UNL, PT
R. Oliveira DEE-FCT/UNL, PT
R. N. Silva DEE-FCT/UNL, PT

Abstract: This paper presents an active noise control application in a laboratory scale ventilation system. The audible noise generated by these systems has periodic behaviour and its frequencies are closely related with the turning speed of the fans. Treating each harmonic separately, a base sinusoidal signal with its frequency proporcional to the angular speed of the machine is used to generate the cancellation signal.The parameters in the system that weights the amplitude and phase to be added to the base signal in order to perform cancellation are derived from an adaptation rule based on the information feedbacked by a microphone. The stability study of the overall system is done by means of a state-space description.Experimental results with a laboratory setup are included.

Keywords: Active Noise, Feedforward Control, State-Space, Gradient Method

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Algebraic disturbance feedback methods in hydrofoil craft control

S. N. Rumyantzev Instituto Superior Tecnico, PT

Abstract: The paper discusses and compares various acceleration feedback approaches in hydrofoil craft control. If a simplified mathematical model is used, then a control system explicitly exhibits an algebraic disturbance feedback loop. The effectiveness of acceleration feedback relates to the choice of the optimal disturbance feedback gain. An integrated analytical framework is suggested. Typical misconceptions borrowed from engineering practices are also examined.

Keywords: High Speed Craft. Acceleration Feedback

Acceleration Feedforward Control of a Magnetic Bearing System Subject to Base Motion

M. S. Kang Kyungwon University, KR

Abstract: This paper concerns on a non-rotating axis-active magnetic bearing (AMB) system subject to base motion. In such a system, it is desirable to retain the axis within the predetermined air-gap. Motivated from this, an optimal acceleration feedforward control is proposed to reduce the base motion response without deteriorating other feedback control performances. Experimental results demonstrate that the proposed feedforward control reduces the air-gap deviation to 29% that by feedback control alone.

Keywords: Magnetic Bearing, Base Motion, Acceleration Feedforward Control

WA 1 (invited)	**9:00 – 11:00**	**Amphitheatre**
DISCRETE-EVENT SYSTEMS: WHERE WE HAVE COME FROM, WHERE WE ARE GOING		
Chair: K. Rudie		Queens Univ., CA

The Current State of Decentralized Discrete-Event Control Systems

K. Rudie Queen´s University

Abstract: This paper summarizes the current state of decentralized discrete-event systems. The focus is on work done by the author together with S. Lafortune and F. Lin on incorporating communication into distributed discrete-event systems and on the computational issues that are currently at the forefront of discrete-event systems research.

Keywords: Discrete Event Systems, Decentralized Control

How Does Perturbation Analysis Fit in Discrete Event System Optimization?

X-R Cao Hong Kong University of Science and Technology

Abstract: In this paper, we describe how perturbation analysis (PA), can be viewed as an integrated part of thediscrete event system optimization theory. Recent research sows that PA is closely related to Markov decision processes (MDPs), and reinforcement learning (RL). Their common goal is to make decisions to improve the system performance based on the information obtained by analyzing the current system behavior. We show that MDP solutions can be derived naturally from performance sensitivity analysis provided by PA. Performance potential plays an important role in both PA and MDPs; it also offers a clear intuitive interpretation for many results. reinforcement learning TD(l), neuro-dynamic programming, etc, are efficient ways

of estimating the performance potentials and related quantities based on sample paths.

Keywords: Gradient-Based Policy Iteration, Perturbation Realization Potentials, Poisson Equations, Q-Learning, Td(l)

Problems and Examples of Decentralized Observation and Control for Discrete Event Systems

A. Puri	University of California, USA
S. Tripakis	VERIMAG, FR
P. Varaiya	University of California, USA

Abstract: We study decentralized observation control problems for discrete event systems.For problems with a single observer or controller, it is well known thatif a solution exists, then a finite-state solution also exists.We show that in the decentralized case there might not exist finite-stateobservers and controllers, even though infinite-state ones exist andthe plant is finite-state.We also give necessary and sufficient conditions for finite-state observersto exist.We then formulate the problem of synthesizing a reliable transmission protocolon top of unreliable channels as a decentralized control problem, andpresent the well known alternating bit protocol (ABP) as a solution.We finally study the existence of solutions forvariations of the reliable transmission problem,where one or both channels can carry only one symbol and are offinite or infinite capacity.We show that a solution exists if one the forward or backward channelis two-symbol and the other one-symbol, whereas no solution exists ifboth are one-symbol.

Keywords: Decentralized Observation, Control, Protocol Synthesis, Alternating Bit Protocol

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Think Continuous, Act Discrete: DES Techniques for Continuous Systems

T. Moor	Australian National Univ., AU
J. Raisch	IFAT, Universität Magdeburg, DE

Abstract: This contribution addresses the synthesis of discrete supervisors for continuous plants, with a particular emphasis on modular and decentralised control architecture. We follow a well known style of reasoning that has been originally developed in the context of DESs and demonstrate its applicability to the design of hybrid systems.

Keywords: Hybrid Systems, Supervisory Control, Discrete Abstractions, Modular Control, Decentralised Control

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WA 2 (invited)	**9:00 – 11:00**	**VA - 1**

CONTROLLED NON-HOLONOMIC ROBOT APPLICATIONS: ENVIRONMENT PERCEPTION

Chair: N.E. Gough — Wolverhampton Univ., UK

Fuzzy Tuned Stochastic Scanpaths for Robot Vision: A Development Review

M. J. Allen	Univ. of Wolverhampton, UK
G. M. Dimirovski	Dogus University, TR
N. E. Gough	Univ. of Wolverhampton, UK
Q. H. Mehdi	Univ. of Wolverhampton, UK

Abstract: The real-time processing of frame sequences obtained from cameras mounted on autonomous mobile robots and vehicles is a computationally intensive task. This paper is a review of the work carried out so far in the development of a procedure using Fuzzy Tuned Stochastic Scanpaths (FTSSs) for efficiently scanning images in a frame sequence. A concise explanation of FTSSs is given here followed by a summary of the experimental work that has been undertaken to date. The results show how the technique can reliably locate objects in scene whilst examining only a fraction of the image surface, e.g. 5%. The paper concludes with a discussion of the project so far and proposes ideas for future work.

Keywords: Autonomous vehicles, fuzzy logic, mobile robot control, robot vision, scanpaths.

A Combined Vision-Robot Arm System for Material Assortment

E. Uyar	Dokuz Eylül University, TR
A.Goren	Dokuz Eylül University, TR
A Ayberk	Dokuz Eylül University, TR

Abstract: This paper represents a live application of computer vision process (imageprocessing) to recognize various objects and the vision-based quidance of arobot arm to assort them.On the first stage of the work the captured image (gray scale) viewed by ablack-white camera, is converted and stored by using a frame grabber cardinto a digital image data in the computer memory for a further segmentationprocess to recognize the object.Well-defined and calculated six invariant moment values of the segmentedobject are used then as feature vectors for a rotation, translation andsize independent identification.A built up revolute jointed robot manipulator with five degrees of freedomand a gripper at the end-effector, is used to carry out the recognizedobjects via a predefined trajectory to designated locations. A joint based type of special control algorithm written in C++, is appliedto the DC-Motors to follow a given trajectory in three-dimensional space.The tracking ability of various paths and synchronous working of the robotarm in connection with image processing for more than 24 selected objectsare tested. Finally a sufficient path following accuracy of 5-10 mm andsatisfying image recognizing of 95% are attained.

Keywords: Image Processing, Robot arm and gripper, Object recognition, inverse kinematics.

A New Visual Navigation Algorithm Using Linear Acceleration Measurements

S. Graovac University of Belgrade, YU

Abstract: In mobile robotics, a number of in-door and out-door motion control applications are based on use of TV camera and appropriate image processing (Visual Navigation Systems - VNS). The accuracy of such systems is limited and can be improved by addition of other devices allowing determination of motion parameters. The use of linear accelerometers, have been analyzed as a particular example of fusion of VNS and Inertial Navigation Systems.

Keywords: Navigation, Mobile Robots, Image Processing, Control Systems, Accelerometers

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Fuzzy Logic Navigation and Control of a Non-Holonomic Smart Vacuum Cleaner

Ali Okatan Dogus University, TR
G. M. Dimirovski Dogus University, TR

Abstract: In this work, a simple fuzzy logic navigation and control design for a non-holonomic robotic vacuum cleaner is presented. The embedded control has been designed by using the Motorola flash micro-controller. A circular cleaning algorithm is used to clean the space, the execution of which is driven according to the underling philosophy binary random sequences and obstacle occurrence. Any kind of obstacle is sensed by infra-red detectors before collision may take place. In turn, navigation and control algorithm is redirects the robot cleaner toward some other area in the vicinity while avoiding a possible collision.

Keywords: Embedded Control, Fuzzy-Logic Control; Mobile Robots, Non-Holonomic Systems, Vacuum Cleaner

WA 3 (invited)	**9:00 – 11:00**	**VA - 4**
SOFT COMPUTING APPLICATIONS		
Chair: R. Ribeiro		Univ. Lusiada, PT

Fuzzy Logic Applications For Advanced Space Mission Control Functions

A. Donati European Space Agency - ESOC

Abstract: Fuzzy Logic (FL) has become a mature technology to be applied in domains such as process control, decision support system, optimisation.In this framework investigations have been carried out at the European Space Operations Centre (ESOC) of the European Space agency (ESA) on the potential use of Fuzzy Logic to implement specific applications in support of mission control functions. The investigations are aimed to support new requirements derived from upcoming complex and challenging missions and to facilitate operations cost reduction.The paper will provide a summary of the implemented cases and the lessons learnt from them, including the areas of applicability of FL based tools for supporting mission control processes and the preconditions required for a successful modelling and implementation.The paper will conclude with potential plans for future advanced mission control applications, making use of synergies between FL and other available technologies.

Keywords: Fuzzy Logic, Satellite Operations, Mission Control, Diagnostic, Planning

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Data Quality Measurement Using a Fuzzy Expert System

F. Moura-Pires Universidade de Evora, PT
R. A. Ribeiro Universidade Lusiada, PT
A. Pereira UNINOVA, PT
F. J. Varas GTD
G. Mantovani ESA, DE
A. Donati GTD

Abstract: This paper describes a data quality fuzzy expert system that was developed by GTD and UNINOVA for the ESA project "Fuzzy Logic for Mission Control Processes". This project was developed for monitoring and diagnosing ENVISAT satellite gyroscopes and attitude level. The system computes two crisp data quality metrics from the input telemetry data, both for the gyroscopes and the attitude level. These measures are then passed to a fuzzy inference engine, which includes a set of fuzzy rules that formalize and capture the relationship between the data quality metrics and the data quality level. After a normalization procedure the final data quality assessment is obtained. The data quality assessment is essential to validate the alarm levels provided to the spacecraft controller.

Keywords: Data Quality; Fuzzy Expert System; Telemetry; Gyroscopes

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An Heterogeneous, Multi-Source Data Fusion (MSDF) System based on a Blackboard/Multi-Agent Architecture applied to the tasks of Landmine Detection and Minefield Delineation

F.J. Varas GTD, ES
F.J. Busto GTD, ES
Manrico Fedi GTD, ES

Abstract: This paper describes a Multi-Source Data Fusion (MSDF) system based on Blackboard/Multi-Agent architecture and fuzzy logic concepts. The MSDF system is being developed by GTD within the framework of the EU-IST projects ARC “Airborne Minefield Area Reduction” (IST-2000-25300) and DEMAND “Demonstration of Multi-sensor Landmine Detection Techniques” (IST-2000-25351). The resulting MSDF system is being applied in an advanced Intelligent Spatial Decision Support System (or Intelligent GIS), in order to assist the human deminer in its job.The MSDF system objective is to perform (at the highest possible degree of functional performance) the Automatic Target Recognition (ATR) of landmines (DEMAND) or minefields (ARC). The proposed system will be able to deal with a flexible, heterogeneous and variable set of sensors, supporting the combination with symbolic sources of information (reports, human experts knowledge, etc.). The addressed multi-sensor platforms are dynamic systems, cooperative, and competitive. Uncertainty is confronted with

a Fuzzy Logic approach.The software architecture chosen to implement the MSDF system is based on the Blackboard architectures and Multi-Agents approach (traditionally known as Knowledge Space). The blackboard represents the system global memory or database, i.e. the system state. The agents feed and/or transform data into the blackboard database. At the end of the paper the results of a case study are presented. This example simulates a set of features gathered for the DEMAND project by using a set of artificial data. A preliminary version of the MSDF software (also called MSDF Build-1) has been used to run this example.Although the simulated sensory data contain moderate uncertainty, the system shows promising results as it is explained at the final conclusions.

Keywords: Decision Support System (Dss), Gis, Multi-Sensor, Data Fusion, De-Mining

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Simulated Annealing and Fuzzy Optimization

L. Varela — University of Minho, PT
R. A. Ribeiro — Lusiada University, PT
F. Pires — University of Évora, PT

Abstract: Simulated Annealing (SA) is an adequate algorithm for solving fuzzy optimization problems, through the selection of the best solution among a finite number of possible solutions. It is a particularly attractive technique to solve fuzzy optimization problems, because it allows finding close to optimal solutions, which, without big computational effort, in a fuzzy environment, is usually good enough. In this context, we present results for a set of fuzzy problems, selected with the purpose of testing the SA algorithm performance, which has been implemented in this work. The problems tested were formulated following a complete fuzzification method proposed by Ribeiro and Moura-Pires (1999). These examples show the flexibility and adaptability of the fuzzy method as well as of the SA algorithm, for the resolution of fuzzy linear optimization problems.In this work, the main objective consists on showing the suitability of the implemented SA, for the resolution of fuzzy linear optimisation problems. The principal evaluation measure of its performance consists on the value obtained for the objective function, in the presence of a certain trade-off situation and considering certain satisfaction level for the conditions that characterize the problem (the threshold level). Other evaluation measure is the time to achieve a solution. Further, the parameters that control the SA algorithm are also discussed to show how easily they can be manipulated.Another objective is to illustrate the flexibility of the optimization method proposed by Ribeiro and Moura-Pires in the formulation of several types of fuzzy linear optimization problems with single or multiple objectives. The fuzzy formulation can vary from a simple model, in which we only admit violations in the conditions parameters, until a global or complete fuzzy model of the problem, in which we allow deviations in the parameters, in the coefficients of the conditions, in the coefficients and in the value of the objective function(s). The main advantage of this method consists on the freedom that the decision maker has to choose any model that he considers adequate for the resolution of a specific problem.

Keywords: Fuzzy Linear Programming, Fuzzy Optimization, Simulated Annealing

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WA 4	9:00 – 11:00	VA - 3

ROBUST CONTROL

Chair: J. M. Lemos — Instituto Superior Técnico, PT

MINIMAX BI-Robust Optimal Parametric H2 Control

P. O. Shirley — INESC-ID/Univ. Aberta, PT
J. M. Lemos — Instituto Superior Técnico, PT

Abstract: The control problem for uncertainties both in the process and in the controller implementation is addressed. The approach is made for parametric models, leading to pure real parameter uncertainty control problems. The objective function used is the H2 norm of the closed loop system. Reduced order controllers are designed with in a static output feedback framework, requiring numeric minimization. An example ofa DC motor speed control with an electronic implemented controller is presented.

Keywords: H2, Optimal Control, Robust Control, Numerical Methods, Parameter Optimization

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Evolutionary m -Synthesis: A Simple Controller for Feedback Loop

M. Dlapa — Tomas Bata University, CZ
R. Prokop — Tomas Bata University, CZ

Abstract: The contribution is focused on design of a simple controller by using the evolutionary mu-synthesis. A new evolutionary algorithm is used for the optimization of the controller. The resulting controller is compared with that designed via the D-K iteration.

Keywords: H-Infinity, m -Synthesis, Differential Migration, Evolutionary Algorithms, Structured Uncertainty

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$H\infty$ Output-Feedback Tracking with Preview of State Multiplicative Systems

E. Gershon — Tel Aviv University, IL
E. Shaked — Tel Aviv University, IL
I. Yaesh — Israel Military Industries, IL

Abstract: The problem of finite-horizon $H\infty$ output-feedback tracking for linear time-varying systems with stochastic state-multiplicative parameter uncertainties is investigated. We consider three tracking patterns depending on thenature of the reference signal i.e : whether it is perfectly knownin advance, measured on line or previewed in a fixed time-intervalahead. The stochastic uncertainties appear in both the dynamic and measurement matrices of the system. For each of the above three cases a solution is found where, given a specific reference signal, the controller plays against nature which chooses the initial condition and the energy-bounded disturbances. The problems are solved, using an expected value of the standard performance index over the stochastic parameters, based on thestate-feedback tracking control solution and a specially devisedbounded real lemma for state-multiplicative systems with tracking signal.

Keywords: Stochastic H∞ Tracking, Stochastic Uncertainty,Preview Tracking

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On Robust Stability Analysis of Polynomials with Polynomic Parameter Dependency

P. Husek Czech Technical University, CZ
R. Pytelkova Czech Technical University, CZ

Abstract: In the paper the problem of robust stability of polynomials with coefficients being general polynomic functions of vector parameter is studied. The parameter is supposed to lie in a multidimensional hyperrectangle. The stability is tested in frequency domain using zero exclusion theorem.

Keywords: Linear Systems, Robust Stability, Parameter Uncertainty, Zero Exclusion Theorem

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Robust controller design via reflection coefficients

U. Nurges Tallinn Technical University, EE

Abstract: The problem of robust controller design bystability region methods via reflection coefficients of the systemcharacteristic polynomial is studied. Two possibilities areconsidered -- the Schur stable polytope building around a givenstable point and the stability radius determination. Then a robustcontroller can be find by quadratic programming approach.

Keywords: Robust Stability, Robust Control, Discrete-Time Systems

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Controller Design Sequence for Multivariable Systems

I. Egaña Public University of Navarre, ES
M. Garcia-Sanz Public University of Navarre, ES

Abstract: Multivariable systems are nowadays one of the most challenging Control Engineering problems. It is possible to find a number of techniques that deal with this topic taking a sequential approach to the feedback controller design. However, not many ideas are stated about the design sequence -which loop to be closed first. This work explores the effect of the bandwidth in the closing sequence as regards loop uncertainty transmission, and points out some guidelines to ease the choice of which loop should be closed first.

Keywords: Multivariable Control, Robust Control

WA 5	**9:00 – 11:00**	**VA - 2**
IDENTIFICATION		
Chair: B. Pasik-Duncan		University of Kansas, USA

Nonlinear System Identification Using a Combined Linear and Ridge-Wavelet Structure

R. K. H. Galvão Inst. Tec. de Aeronautica, BR
V. M. Becerra The University of Reading, UK
J. M. F. Calado ISEL, PT
P. M. Silva ISEL, PT

Abstract: This paper extends a recent result concerning the orthogonalitybetween multidimensional wavelets and linear functions to waveletsof the ridge type. Based on this orthogonality property, a networkstructure comprising a linear and a ridge wavelet term isproposed. The parameters of this structure, termed linear-waveletnetwork, can be adjusted by backpropagation of the output error,with basis on a training set of input-output data. The proposedlinear-wavelet network is applied to the identification of apressure plant from experimental data. In this case study, theintroduction of wavelets does improve both the modelling andvalidation performances of a purely linear model.

Keywords: Wavelet Networks, Neural Networks, Nonlinear System Identification, Training Algorithms, Linear-Wavelet Models

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Hammerstein Model Identification

F. Giri LAP, ISMRA, FR
F. Z. Chaoui LAP, ISMRA, FR
M. Haloua LA2I, EMI, FR
Y. Rochdi LAP, ISMRA, FR
A. Naitali LAP, ISMRA, FR

Abstract: We are considering system identification based on the Hammerstein model i.e. a non-linear static gain in series with linear dynamics. The static gain characteristic is any nonlinear function F. An identification scheme is designed to determine exactly the model of the plant dynamics and a set of N different couples (x , F(x)), where N is arbitrarily chosen by the user. Given the previous couples, one can build up an Nth degree polynomial or polygonal approximation of the static gain characteristic. The main feature of the identification scheme is the design of a persistently exciting input sequence that makes it possible to identify exactly the unknown parameters, using a gradient algorithm and a singular value decomposition.

Keywords: System Identification, Hammerstein Models, Persistent Excitation, Parameter Convergence

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Multivariable EIV Identification

R. Guidorzi University of Bologna, IT
U. Soverini University of Bologna, IT
R. Diversi University of Bologna, IT

Abstract: The identification of errors-in-variables (EIV) models is a challenge that, despite many possible associated advantages, has found only recently some response.This paper considers the problem of identifying multivariable EIV models where the complexity of multivariable identification mixes with the multiple congruence conditions required by the EIV context and proposes a solution endowed with a remarkable degree of robustness.

Keywords: Identification, Errors-In-Variables Models, Multivariable Systems

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Parameter Estimation of Vibratory Systems

A. Herreros University of Valladolid, ES
E. Baeyens University of Valladolid, ES
J. R. Perán University of Valladolid, ES

Abstract: System identification plays a crucial role in modeling vibratorysystems. In many applications, such as fault diagnosis ofmachinery or vibration control, a compact and easy to manipulateparametric mathematical model of the system is necessary. In theseapplications, the model can be obtained from first principles bycombining three discrete ideal elements: inertias, springs anddampers. Therefore the model structure is known a priori.Unfortunately, the estimation of the parameters of a model with agiven structure is not an easy problem. In this paper, a procedurefor the estimation of these parameters is proposed. The estimation ofparameters is converted to a nonconvex multiobjective optimizationproblem. The objectives are the mean square error between themeasured and estimated spectrum of each output. The multiobjectiveoptimization problem is solved by a heuristic algorithm, the MRCDgenetic algorithm.

Keywords: Parametric Identification, Vibration Systems, Multiobjective Optimization, Genetic Algorithms

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Fractional Brownian Motion and Identification for Linear Stochastic Systems

T. E. Duncan University of Kansas, USA
B. E. Pasik-Duncan University of Kansas, USA

Abstract: Introduction to fractional brownian calculus is presented. Veryrecent advances in development of the theory of stochastic lineardifferential and partial differential equationsthat have the Brownian motion replaced by fractional Brownian motion arediscussed. The paper focuses on identification of linear systems withfractional Brownian motion. A parameter identification problem isformulated and solved for a multidimensional parameterof a stochastic system where the parameter appears in thedrift term of a stochastic differential equation that has theBrownian motion replaced by a fractional Brownianmotion with the Hurst parameter in ´(1/2,1)´.These latter fractional Brownian motions seem to beuseful models for many physical phenomena where Brownianmotion is not appropriate. A different stochastic calculus isrequired for these processes because they are notsemimartingales. A family of estimates is given that arisesfrom a formal application of a least squaresalgorithm. The strong consistency of the familyof estimates is verified.

Keywords: Parameter Identification, Fractional Brownian Motion, Linearstochastic Systems, Estimation.

Parallel and Distributed MOESP Computational System´s Modelling

C. P. Bottura University of Campinas, BR
A. D. R. Tamariz University of Campinas, BR
G. Barreto University of Campinas, BR
A. F. T. Cáceres University of Campinas, BR

Abstract: In this work a parallel numerical procedure for determining a state space realization for a linear dynamic system representing input-output multivariate data sequences is developed. The presented methodology emphasizes parallel implementation that make RQ factorization and singular value decomposition subroutines utilizations. A sequential execution of the algorithm is made and a parallel implementation on a distributed memory system with an asynchronous parallelization strategy over a workstations network is proposed and executed. Comparisons between the sequential and parallel processing of the identification algorithm are presented.

Keywords: Subspace Method, State Space, System Identification, Computational Data Modelling, High Performance Computing

WA 6	**9:00 – 11:00**	**VA - 5**
STABILITY		
Chair: J. Medanic	University of Illinois at Urbana, USA	

Design of Nonlinear Controls Using Pole-Placement and Singular Perturbation Theory

J. Medanic University of Illinois, USA

Abstract: Point-wise eigenalues and eigenvectors of nonlinear systems are employed as indicators of the local rate of change of the state. Pole-Placement design is used to achieve desired point-wise eigenalues of the closed-loop system in designing nonlinear controls. Singular perturbation theory is applied to place the point-wise eigenvalues to obtain a control that soles the Practical Asymptotic Stability Problem of insuring a desired region of attraction.

Keywords: Nonlinear Systems, Stability, Pole-Placement, Singular Perturbations

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Design of Stabilised Controller and Observer for Uncertain Linear Systems with Time-Varying Delay

S. K. Jain Banaras Hindu University, IN
A. Sharma Banaras Hindu University, IN
S. K. Nagar Banaras Hindu University, IN

Abstract: In this paper design in proposed of the memoryless feedback controller for uncertain dynamic system with time varying delay. It is assumed that uncertainties are bound and finite. A case study is done on different Lyapunov functional forms to obtain the Asymptotic stability of the system. Two linear matrix in equalities are obtained to design the controller. Calculations can be done on the two linear matrix inequalities. For the design it is necessary that there exist positive definite matrices which satisfies these two linear matrix inequalities. Also a novel idea is presented, if a condition is satisfied on the time delay, effect of time delay can be removed on the design of controller. Examples are given to illustrate the results.

Keywords: Lyapunov Function, Uncertain Linear Systems, Time Varying Delays, Feedback Controller.

On Robust Stability of LTI Parameter Dependent Systems

X. Zhang Georgia Tech, USA
A. Lanzon Georgia Tech, USA
P. Tsiotras Georgia Tech, USA

Abstract: In this paper, the complete stability domain for LTIparameter-dependent systems is synthesized by extending existingresults in the literature. This domain is calculated through aguardian map which involves the determinant of the Kronecker sumof a matrix with itself. The stability domain is synthesized forboth single and multi-parameter dependent LTI systems. The singleparameter case is easily computable, whereas the multi-parametercase is more involved. The determinant of the bialternate sum of amatrix with itself is also exploited to reduce the computationalcomplexity of the results.

Keywords: Robust Stability, Guardian Maps, Paremeter-Dependent Lti Systems

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Stability Analysis of Constrained GPC

C. Mañoso UNED, ES
A. P. de Madrid UNED, ES
R. Hernandez UNED, ES
S. Dormido UNED, ES

Abstract: The study of the stability of constrained GPC is a combinatorial task. Some properties are derived that characterise: A) active sets of constraints leading to the same characteristic equation; B) situations where a feedback structure is suspended; and C) impossible physical situations. They dramatically reduce the number of active sets to be analysed.

Keywords: Stability, Predictive Control, Constraints

Stabilization of Continuous Time Systems by First Order Controllers

R. N. Tantaris Tennessee State University, USA
L. H. Keel Tennessee State University, USA
S. P. Bhattacharyya Texas A&M University, USA

Abstract: In this paper we consider the problem of stabilizing a given but arbitrary linear time invariant continuous time system with transfer function P(s), by a first order feedback controller C(s)=(x1+x2)/(s+x3). The complete set of stabilizing controllers is determined in the controller parameter space [x1,x2,x3]; this includes an answer to the existence question of whether ´P(s)´ is "first order stabilizable" or not. The set is shown to be computable explicitly, for fixed x3 by solving linear equations and the three dimensional set is recovered by sweeping over the scalar parameter x3. This result is applicable to a) the simultaneous stabilization problem and b) the robust stabilization problem of a continuum of plants. The latter is illustrated by applying it to the stabilization of an interval family of transfer functions P(s) which reduces to the stabilization of the Kharitonov vertex plants. In each case the solution is facilitated by the fact that linear equations are involved in the solution so that the intersection of sets can be found by adding more equations. Illustrative examples are included. They demonstrate that the shape of the stabilizing set in the controller parameter space is quite different and much more complicated compared to that of PID controllers despite the fact that both are "three term controllers". It is remarkable that despite this complicated topology the set can be unravelled via "linear computations". Extensions and applications to design are discussed.

Keywords: First Order Stabilization, Root Invariant, Stabilizing Parameter Sets

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Controller Design for Unstable Uncertain Bilinear Systems

V. Mahout LAAS-CNRS, FR
S. Tarbouriech LAAS-CNRS, FR
G. Garcia LAAS-CNRS, FR

Abstract: In this paper is presented a result of linear feedback design for bilinearuncertain systems with strictly unstable open-loop systems.The design technique is based on a differential inclusion of thebilinear term for a restricted domain of the state space.Conditions for the local stability of the closed-loop systems can thenbeformulated through some matrix inequalities. The implicit problem beingto maximize the region in which the closed-loop stability can beensured, some convex optimization problems with LMI relaxation schemesare stated. A numerical example borrowed from the literature allows toillustrate the results proposed and to provide some comparisons withsome previous published techniques.

Keywords: Bilinear Systems, Uncertain Systems, Region Of Stability, Design Technique, LMI Relaxation

WA 7	**9:00 – 11:20**	**VA - 6**
SIGNAL PROCESSING		
Chair: V. Barroso	Instituto Superior Tecnico, PT	

On Denoising and Signal Representation

S. Beheshti MIT, USA
M. A. Dahleh MIT, USA

Abstract: We propose a best basis algorithm for extracting information from a noisy data. The best basis search is performed in families of orthonormal bases. Pioneer solutions to this problem suggest finding a threshold for the projection coefficients on each basis. These approaches have focused on the mean-square error of the data or the bases coefficients. In our approach we probabilistically validate bounds on squared ´l_2´ norm of the bases coefficients error in each subspace. We suggest to pick the subspace for which the error upperbound is minimum. The proposed method is comparable with the approach of minimum description length(MDL) denoising. MDL denoising focuses on minimizing the length of the code which describes the data in each subspace given the estimate of the coefficients in that subspace. However, the presented method in this paper suggests to pick the subspace for which the code length of the coefficients given the data is minimum.

Keywords: Best Basis, Denoising, Thresholding, Validation, Minimum Description Length

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Nonlinear Control of Tracking Loops

J. Mannermaa Nokia Mobile Phones, FI
R. Ylinen University of Oulu, FI
M. Kiviahde University of Oulu, FI

Abstract: The tracking loop design of the CDMA-based mobile phones and the positioning and navigation receivers (as GPS ones) has been studied by the RTA unit of Nokia Mobile Phones. The tracking loops are highly nonlinear and when e.g. the satellite location and navigation signals are applied to them, the S/N-ratio is very low. In the co-operation with University of Oulu and Nokia Mobile Phones, new control methods based on the Kalman filters and fuzzy logic have been developed.

Keywords: Cdma (Code Division Multiple Access), Extended Kalman Filter, Fuzzy Control, Lock Loop, Satellite Navigation System.

Blind Channel Estimation with Data from the Intimate ´96 Sea Trial

N. E. Martins University of Algarve, PT
S. M. Jesus University of Algarve, PT

Abstract: Blind multipath channel estimation is studied by time-frequency (TF) analysis. For a linear frequency modulated source, the technique is based on its instantaneous frequency estimation, followed by an approximate formulation of matched-filtering. Tests concern at-sea recorded data during the INTIMATE ´96 experiment.

Keywords: Channel Estimation, Multipath, Time-Frequency, LFM.

Reconstruction of Discrete Data Transmisions: a worst case optimal approach

P. G. Voulgaris University of Illinois, USA
C. H. and Rouzbeh University of Illinois, USA

Abstract: In this paper we present a deterministic worst-case framework for accurate reconstructionof discrete (source) data as an alternative to the traditional probabilisticapproaches in the communications area. This framework can be explored based onrobust control ideas and formulations. Some of the particular problems touched uponare: (i) necessary and sucient conditions for causal (no delay) and noncausal (with delay) reconstruction under deterministic magnitude bounded noise for SISO and MIMO channels, (ii) reconstruction based on linear estimation, (iii) performance optimizationunder channel fading and (iv) combined precoding and estimation optimization underpower constraints. The $\ell 1$ control theory is proposed as a natural key player in thisapproach.

Keywords: Communications, Equalization, $\ell 1$ Optimal

Intrinsic Variance Lower Bound for Inference Problems on Riemannian Manifolds

J. M. Xavier Instituto Superior Tecnico, PT
V. N. Barroso Instituto Superior Tecnico, PT

Abstract: We consider a parametric family of probability densities F = { f_p : O -> R} (O=sample space) where the parameter p takes values in a Riemannian manifold P. We establish a lower-bound for the intrinsic variance of estimators V : O -> M, where M denotes another Riemannian manifold. The derived bound depends on the curvature of the manifold M and differential-geometric generalizations of both the estimator bias and the Fisher information matrix of the model. A numerical example is worked out to illustrate and assess the tightness of the bound.

Keywords: Parametric Statistical Models, Riemannian Manifolds, Intrinsic Mean, Intrinsic Variance Lower-Bound

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Design of an OFDM System for High Rate Communication Over Low Voltage Power Lines

S. Aghajeri University of Tehran, IR
H. R. Shafiee University of Tehran, IR
J. Mohammadpour-Velni University of Tehran, IR

Abstract: In this paper, the design of a base band OFDM system for communication over low voltage (LV) power lines is discussed. Such a system is suitable for the development of networks at homes or small offices. With regarding 802.11b IEEE standard for wireless LAN, the system parameters are set so that transmission of coded data at 12 Mb/s is possible. The proposed system uses a 512-point conjugate symmetric block as input to the IFFT. Simulation results for the proposed system for different channel responses are presented.

Keywords: OFDM,Power Line Communication,Residential Power Line

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WP 1 (invited)	15:30 – 17:30	Amphitheatre
AUTOMOTIVE CONTROL		
Chair: J.A. Cook	Ford Motor Co., USA	

Experimental Results and Implementation Issues of an Iterative Learning Controller for Soft Landing of an Electromechanical Valve Actuator

K. S. Peterson Univ of Michigan, USA
W. Hoffman Univ of Michigan, USA
A. Stefanopoulou Univ of Michigan, USA

Abstract: Numerous studies and papers show that variable valve timing hasthe potential to significantly enhance the automotive engine.Improvements in fuel economy, emissions, and performance can beachieved, as well as cylinder deactivation, and the elimination ofthe throttle and external exhaust gas recirculation. Actuationemploying electromagnets has been proposed as a replacement to thetraditional camshaft to achieve variable valve timing.Unfortunately, the resulting ElectroMechanical Valve actuatorssuffer from large impact velocities between the valve, valveseat, and the actuator itself due to the motion of the valve,leading to excessive noise and wear on the system. Impactvelocities comparable to those achieved by a camshaft arerequired before the system can be used in production vehicles. AnIterative Learning Controller (ILC) is applied to achieve thisperformance. This paper discusses the implementation issuesassociated with the ILC and presents experimental results.

Keywords: Engine Control, Electromechanical Actuators, Observers, Singular perturbations, Iterative Learning Control

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Further Results on Modeling and Identification of an Electronic Throttle Body

A. F. Contreras ITESM-Monterey, MX
I. P. Quiroz ITESM-Monterey, MX
C. Canudas-de-Wit Lab. Automatique, FR

Abstract: Precise control of electronic throttle is critical to drivability,fuel economy and emission performance of present day passenger vehicles. Due to cost, material and packaging constraints,throttle open-loop dynamics may be fairly complex, exhibiting substantial nonlinearities. In this paper we extend previous results obtained on modelling of electronic throttle . We provide a more detail derivation of themechanical model for the DV-E5, present several experimentaltrials that show the substantial hysterics effects exhibited bythe throttle, and finally, we present a modified model that better captures such phenomena.

Keywords: Electronic Throttle, Nonlinearity, Hysteresis,Lugre Model, Parameter Estimation

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Composite Adaptive Engine Load Estimation

A. Stotsky Volvo Car Corp., SE
S. Eriksson Volvo Car Corp., SE

Abstract: In this paper we designed and implemented on-line estimationalgorithms for engine load. The flow into the engine is estimatedvia speed-density calculation, wherein intake manifold temperatureis estimated on-line. First we present ideal gas law withmultiplicative uncertain factor which can be associated withintake manifold mass or temperature to describe the pressure inthe intake manifold. Using the error between measured and modeledpressure we estimate a prediction error which is used togetherwith the tracking error to design adaptive algorithms withimproved identifiability and convergence rate. Tradeoff betweenthe speed of adaptation and the quality of the estimation signalnecessitates the robustness enhancement which is achieved bysigma-modification with sigma factor depending on prediction errorestimate. Then under the transient the estimated parameterconverges to its apriori value, but under ´steady-state´, sigma -modification is not active and adjustment law is driven by bothtracking and prediction errors. The stability of the adaptiveobserver is proved by composite Lyapunov function.

Keywords: Adaptive Engine Load Estimation,Robustness

Power Management Strategy fora Parallel Hybrid Electric Truck

C-C Lin University of Michigan, USA
H. Peng University of Michigan, USA
J. Grizzle University of Michigan, USA

Abstract: Hybrid vehicle techniques are widely studied recently because of their potential to significantly improve the fuel economy and drivability of future ground vehicles. Due to the dual-power-source nature of these vehicles, control strategies based on engineering intuition frequently fail to fully explore the potential of these advanced vehicles. In this paper, we will present a procedure for the design of a near-optimum power management strategy. The design procedure starts by defining a cost function, such as minimizing fuel consumption and selected emission species. The Dynamic Programming (DP) techniques are then utilized to find the optimal control actions. Through analysis of the behavior of the DP control actions, sub-optimal rules are extracted, which, unlike DP control signals, are implementable. The performance of the power management control strategy is verified by using the hybrid vehicle model HE-VESIM developed at the Automotive Research Center of the University of Michigan. A trade-off study between fuel economy and emissions was performed. It was found that significant emission reduction can be achieved at the expense of small increase in fuel consumption.

Keywords: Hybrid Electric Vehicle, Power Management

WP 2 (invited)	15:30 – 17:30	VA - 1
CONTROL OF COMPLEX COMPOSITE NONLINEAR SYSTEMS		
Chair: G.M. Dimirovski		Dogus Univ., TR

Design of Dynamic Compensators for Generalized Composite Systems with Similarity

H. Shi	Southeastern University, CN
G. M. Dimirovski	Dogus University, TR
S. Zhang	Southeastern University, CN
M. J. Stankovski	SS Cyril & Methodius Univ., MK

Abstract: A class of generalized interconnected composite systems, which possess a similar linear sub-structure and a non-linear term, is studied in this paper. Each subsystem contains nonlinear term, and also the interconnections are non-linear and unmatched ones allowing for some uncertainty. A new theoretical result, also generating a novel design method, has been proved. Normal dynamic compensators are designed so that the closed-loop systems with this class of original systems and the compensators are asymptotically stable and have no impulse effect. Since the compensators also possess similar structures, they are considerably easy to implement, and also a destroyed compensator can be easily reproduced.

Keywords: Composite Systems; Generalized Interconnected Systems; Impulse Observable; Normal Dynamic Compensator; R-Controllable

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A Computer Algebra Approach for Problems in Control of Implicit Dynamic Systems

K. Schlacher	J. Kepler Univ., AT
A. Kugi	J. Kepler Univ., AT
K. Zehetleiner	J. Kepler Univ., AT

Abstract:

Keywords: Decision Support System (DSS), GIS, Multi-Sensor, Data Fusion, De-mining

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Quadratic Stability of a Class of Switched Systems

J. Zhao	Northeastern University, CN
G. M. Dimirovski	Dogus University, TR

Abstract: Quadratic stability of a class of switched non-linear systems is studied in this paper. We first transform quadratic stability problem into an equivalent nonlinear programming problem. Then, with the help of Fritz John condition for nonlinear programming problems, we derive a necessary and sufficient condition for the switched systems studied to be quadratically stable. This necessary and sufficient condition is consisted of a set of algebraic equations and inequalities that are amenable to computer algebra evaluation.

Keywords: Complex Hybrid Systems; Fritz John Condition; Nonlinear Programming; Quadratic Stability, Switched Systems

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Output Feedback Control of Composite Nonlinear Uncertain Systems

G. M. Dimirovski	Dogus University, TR
Y. Jing	Northeastern University, CN
S. Zhang	Northeastern University, CN
K. Schlacher	Johannes Kepler University, AT
T.D.K. Gugulovska	Johannes Kepler University, AT

Abstract: The non-linear case of composite interconnected systems with uncertainties is investigated, and an asymptotically stable decentralised control design is proposed. Two new theoretical results have been proved. The design synthesis is performed by means of Lapunov's second method. For this purpose, a set of state observers is constructed first, for which the state estimation errors are shown to tend exponentially to zero. Then sufficient conditions in terms of algebraic inequalities are derived, under which the interconnected system can is stabilised via output feedback control by employing the estimated plant states. Control design solution is obtained by synthesising a common composite Lyapunov function of Lure-Postnikov type.

Keywords: Composite Systems; Decentralised Control; Lyapunov Control Design; Non-Linear Systems; State Estimation; Uncertainty.

WP 3 (invited)	15:30 – 17:30	VA - 4
MULTI-AGENT SYSTEMS		
Chair: G.J. Pappas		Univ. of Pennsylvania, USA

Decentralizing Formations of Multi-Agent Systems

P. Tabuada	University of Pennsylvania, USA
G. J. Pappas	University of Pennsylvania, USA
P. Lima	Instituto Superior Tecnico, PT

Abstract: Formation control and coordination of a group of agents is now an active area of research. While most researchers address the problem of controlling a set of agents to a given formation, no satisfactory results exist regarding the interplay between the formation configuration, its implementation at the level of feedback controllers and the required exchange of information between the agents. We present a methodology that allows to decide when a given formation specification is implementable by local controllers, that is, controllers using only partial state information. The existence of suchdecentralized implementation is clearly useful as it simplifies controldesign and reduces communication needs between the agents.

Keywords: Multi-Agent Systems, Formation Control, Decentralization

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Coverage Control for Mobile Sensing Networks: Variations on a Theme

J. Cortes	University of Twente, NL
S. Martinez	Consejo Superior de Investigaciones Cientificas
T. Karatas	University of Illinois, USA
F. Bullo	University of Illinois, USA

Abstract: This paper presents control and coordination algorithms for networksof autonomous vehicles. We focus on groups of vehicles performingdistributed sensing tasks where each vehicle plays the role of amobile tunable sensor. We design distributed gradient descentalgorithms for a class of utility functions which encodes optimalcoverage and sensing policies. These utility functions are studied ingeographical optimization, vector quantization, and sensor allocationcontexts. The algorithms exploit the computational geometry ofspatial structures such as Voronoi diagrams.

Keywords: Coverage Control, Distributed Algorithms, Centroidal Voronoi Tessellations

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Formation Control Under Limited Sensory Range Constraints

M. B. Egerstedt	Georgia Institute of Technology
M. Abubakr	Georgia Institute of Technology
X. Hu	Royal Institute of Technology

Abstract: Based on the assumption that all robots in a given multi-agent scenario can evaluate a global formation function, we show how a model independent coordination strategy for multi-agent formation control can be obtained. The main theorem states that under a bounded tracking error assumption our method stabilizes the formation error. We furthermore complement this result with an investigation of how limited sensory range capabilities affect the group performance.

Keywords: Multi-Agent Coordination, Sensor Modeling

Optimal Pursuit under Partial Information

J.P. Hespanha	Univ. Calif. at Santa Barbara, USA
M. Prandini	Univ. of Breccia, IT

Abstract: In this paper we address the control of a group of agents in the pursuit of one or several evaders that are moving in a non-accurately mapped terrain. We use the framework of partial information controlled Markov processes to describe this type of games. This allows us to combine map building and pursuit into a single stochastic optimization problem, where the cost function to minimize is the time to capture. We show that an optimal policy exists and suggest a value iteration algorithm to compute it. Since in general this algorithm is computationally very intensive, we also consider a ``greedy´´ solution that scales well with the dimension of the problem. Under this policy, at each time step the pursuers move towards the locations that maximize the probability of finding an evader at the next time. We determine conditions under which this is actually optimal.

Keywords: Pursuit Games; Controlled Markov Processes With Partial Information; Dynamic Programming; Value Iteration; Greedy Policies

WP 4	15:30 – 17:30	VA - 2

INTELIGENT SYSTEMS

Chair: R. Ribeiro — Universidade Lusiada, PT

Weighted Criteria in Multivariable Fuzzy Predictive Control

L. F. Mendonça	Instituto Superior Técnico, PT
J. M. Sousa	Instituto Superior Técnico, PT
U. Kaymak	Erasmus Univ. of Rotterdam, NL
J. M. Sá da Costa	Instituto Superior Técnico, PT

Abstract: Model predictive control (MPC) is a well-known control technique, whichhas been applied to complex and nonlinear processes. In order toincorporate fuzzy goals and constraints in model predictivecontrol, MPC have recently been integrated with fuzzy decisionmaking. Conventionally, the fuzzy optimization problem in such asetting is defined as the simultaneous satisfaction of theconstraints and the goals. This paper proposes an extension ofthis model for satisfying the problem constraints and the goals,where preference for different constraints and goals can bespecified by the decision-maker. The difference in the preferencefor the constraints is represented by a set of associated weightfactors. Simultaneous weighted satisfaction of various criteria ismodeled by using the weighted extensions of (Archimedean) fuzzyt-norms. The weighted satisfaction of the problem constraints andgoals are demonstrated by using a multivariable process. Thesimulation of a gantry crane system is used as case study.

Keywords: Fuzzy Constraints, Weighted Aggregation, Fuzzy Decision Making, Fuzzy Optimization, Weighted T-Norms

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A Hierarchical Modeling Technique of Industrial Plants Using Multimodel Approach

C. D. Stylios	University of Patras, GR
N. Christova	University of Patras, GR
P. P. Groumpos	University of Patras, GR

Abstract: In this study a new hierarchical structure based on a soft computing methodology is presented. The problem of design adequate models for non-linearplants with large uncertainties is under consideration here. The proposed approach is thecombination of different modelling techniques in a hierarchical supervised structure, which has theability to model system behaviour under different circumstances, has been also investigated. A Fuzzy Cognitive Map (FCM) is used to aggregate multiple models and to create a hybrid model, which will select among different models according to the current operational conditions ofthe industrial process. The proposed methodology has been applied to the modelling of a realindustrial plant.

Keywords: Hierarchical Intelligent System, Fuzzy Cognitive Maps, First Principles Model, Fuzzy Logic Model

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Application of Fuzzy-Linguistic Geometry on Robot 3D Path Planning

S. Khanmohammadi	University of Tabriz, IR
A. Aghagolzadeh	University of Tabriz, IR
M. A. B. Zadeh	University of Tabriz, IR
S. Ghaemi	University of Tabriz, IR

Abstract: Linguistic geometry is a new method for decreasing the number of branches in a search tree. It is applicable for solving a variety of search problems such as path planning for a moving robot. However when the object is surrounded by static obstacles, no path may be detected so that the robot has to stay in its original position. In this paper, a fuzzy procedure is introduced to detect the week point of surrounding obstacles for destroying.

Keywords: Linguistic Geometry, 3D Path Planning, Fuzzy

Application of Linguistic Geometry to Real Time 3D Navigation of Multiple Robots

S. Khanmohammadi	University of Tabriz, IR
A. Aghagolzadeh	University of Tabriz, IR
M. A. B. Zadeh	University of Tabriz, IR
S. Ghaemi	University of Tabriz, IR

Abstract: Several papers are published about navigation of multiple robots in parallel. The presented algorithms need a large amount of searches that increases the calculation time and causes serious problems in real time applications of these methods.In this paper the Linguistic geometry is used to reduce the calculation time in real time navigation of multiple robots in industrial plants.

Keywords: Linguistic Geometry, Real Time 3D Path Planning, Multi Robot

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Identification of Continuous Processes Parameters Using Genetic Algorithms

J. M. Herrero	Politechnic Univ. of Valencia, ES
X. Blasco	Politechnic Univ. of Valencia, ES
M. A. Martínez	Politechnic Univ. of Valencia, ES
J. Sanchis	Politechnic Univ. of Valencia, ES

Abstract: This work presents a technique for identifying the parameters of a continuous process using Genetic Algorithms. Theflexibility of this technique allows the parameters identification of high order linear models, and non-linear models.One of the advantages is that any type of input signal can be used. This feature is very useful when an industrialprocess cannot be stopped for specific identification operations, and so regular process operations can be used foridentification. This paper shows the application of this technique to a thermal process and a conveyor system.

Keywords: Genetic Algorithms, Optimization, Process Identification, Non-Linear Models

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On-line Quality Control of Rotating Machinery Using Pattern Recognition

A. Pouliezos	Technical University of Crete, GR
C. Cristalli	AEA srl, IT

Abstract: In this paper it is presented an on-line quality control system for electric motors. It is comprised of accelerometers for vibration measurement and an intelligent monitoring and classification module cen-tred around a PC. The whole system performs very well, can be easily incorporated into existing pro-duction lines and has a wide application range.

Keywords: Quality Control, Pattern Recognition

WP 5	15:30 – 17:30	VA - 3
ROBUST STABILITY		
Chair: C. Silvestre		Inst. Superior Tecnico, PT

Eigenfitting; An Alternative LPV Modelling Technique

A. Nobakhti	UMIST, Control Systems Centre, UK
N. Munro	UMIST, Control Systems Centre, UK

Abstract: Eigenfitting is a technique which, provided the standard criteriaon the scheduling parameter, and the stability of the local LTImodels considered are satisfied, can produce an LPV model withguaranteed global stability

Keywords: Lpv Systems Global Stability

LQG Control of LPV Systems with Parameter-Dependent Lyapunov Function

G. Rödönyi	Hungarian Academy of Sciences, HU
J. Bokor	Computer and Automation Research Institute, HU
B. Lantos	Budapest University of Technology and Economics, HU

Abstract: A LQG control design technique for LPV systems using singleLyapunov function is improved by searching for a parameter-dependent Lyapunov function in order to enhance the LQGperformance of the control. The solution of the LQG LPV problem isbased on parameter-dependent stability. The LQG cost function isminimized simultaneously.

Keywords: LQG, LPV, Parameter-Dependent Lyapunov Function

Sufficient conditions for robust stability and performance

L. Caminiti	Univ. di Roma Tor Vergata, IT
O. M. Grasselli	Univ. di Roma Tor Vergata, IT
S. Paoletti	Universita´ di Siena, IT

Abstract: In this paper robust stability and performance conditions for theclassical unity-feedback control system and for a more generalfeedback configuration are proposed. Uncertainty is represented inthe linear fractional form, where perturbations are assumedto be norm-bounded, stable and unstructured. SuitableH-infinity control problems are derived for satisfyingboth the proposed sufficient conditions. In addition, it is shownthat the first condition puts in a unified framework someconditions existing in the literature and referring to specifickinds of perturbations, such as the additive and themultiplicative ones. Lastly, a property of the family of perturbedsystems whose robust stabilization is guaranteed by the firstcondition is derived.

Keywords: Robust Stability And Performance, Unstructured Perturbations, Small Gain Theorem, Lti Systems.

Robust Model Tracking and 2-D Control Design

F. Leonardi — Pontifícia Universidade Católica de São Paulo, BR
J. Da Cruz — Universidade São Paulo, BR

Abstract: The robust design of model tracking compensators is discussed in this paper from a perspective of loop shaping. It is also shown that 2-D control systems can be designed using the same formulation. The traditional pre-filter design in the 2-D structure may be conservative in the sense that a too large loop gain is required in a wide frequency range. The proposed procedure may reduce this conservativeness.

Keywords: Model Tracking, 2-D Control, Robust Control, Loop Shaping, Time Specifications.

Robust Control for Active Damping of an Hybrid Driveline Vehicle Shuffle

P. Borodani — Fiat Research Center, IT
C. d´Ambrosio — Fiat Research Center, IT

Abstract: This paper presents a new control algorithm for the softening of longitudinal oscillations (shuffle) of a hybrid vehicle to improve comfort and driveability. Quick engine torque variations and ground roughness excite driveline resonance frequency, producing vehicle longitudinal oscillations. To guarantee control robustness to plant variations an Hinf control technique was used. The control was implemented on 16 bit fixed-point microcontroller and was then validated on the road under the worst case conditions. From the experimental test, the performance resulted satisfactory: the control acts to the driver requested torque value avoiding triggering the driveline resonance frequency.

Keywords: Driveline Oscillations, Hybrid Vehicle, Resonance, Shuffle Control, Active Damping

Analysis of Systems with Parametric Uncertainty Described by Fuzzy Functions

P. Husek — Czech Technical University, CZ
R. Pytelkova — Czech Technical University, CZ

Abstract: In the paper an interesting application of fuzzy approach is presented. The problem of stability analysis of uncertain linear systems with coefficients described by fuzzy functions is studied. Each coefficient is considered as a variable interval parametrized by the degree of confidence in validity of the corresponding model.

Keywords: Fuzzy Modelling, Robust Stability Analysis, Parametric Uncertainty

WP 6	**15:30 – 17:30**	**VA - 5**

STOCHASTIC SYSTEMS

Chair: T. Papantoni — University of Colorado, USA

Robust Monitoring of Changes in the Underlying Data Generating Process

A. Burrel — Oklahoma State University, USA
T. Papantoni — University of Colorado at Denver, USA

Abstract: We consider the case where data sequences may be generated by either one of a number of non-parametrically defined processes and where the data generating process may change at any point in time. The objective is to effectively track the latter changes, where each acting process is essentially represented by a whole class of parametrically defined processes. We present, analyze and evaluate robust sequential algorithms which attain the objective for a variety of scenarios. Our robust algorithms consist of appropriate modifications of previously presented parametric sequential algorithms, to mainly resist the occurrence of occasional data outliers in terms of dramatic performance deterioration.

Keywords: Robustness, Sequential, Detection of Changes, Processes with Memory.

Parametric Probabilistic Control: An Information-Geometric Approach

M. Barão — INESC-ID/Univ. Évora, PT
J. M. Lemos — Instituto Superior Técnico, PT

Abstract: A general solution to the design of a nonparametric probabilistic controller minimising the Kullback-Leibler divergence between the joint pdf of states and inputs and an ideal joint pdf is already known from the literature. In this paper a parametric version of the same problem is presented, where the controller is constrained to a parametric family of controllers. The solution yields a backward recursive algorithm for computing the controller parameters. An interpretation of the solution is given under the framework of information geometry. As an example, the algorithm is applied to a linear Gaussian process, yielding the LQ regulator as expected.

Keywords: Probabilistic Control, Kullback-Leibler Divergence, Stochastic Control, Information Geometry

Decentralized Stochastic Minimum Variance Controller

V. Z. Filipovic RCT, YU

Abstract: In this paper, the problem of stochastic control for a class of large-scale systems, is considered. As the local controllers are used a minimum variance controllers. The subsystems are described with multi-input/ multi-output ARMAX models. The interconnections of subsystems are nonlinear functions. It is shown, in the form of theorem, that the overall mean-square tracking error is bounded.

Keywords: Large-Scale Systems, Mimo Stochastic Subsystems, Minimum Variance Controller, Decentralized Control, Global Stability

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On Controllability of Continuous Time Jump Linear System

A. Czornik Silesian Technical University, PL
A. Swierniak Silesian Technical University, PL

Abstract: In this paper we consider a problem of controllability of continuous time linear systems endowed with randomly jumping parameters which can be described by a finite state Markov chain.

Keywords: Jump Linear Systems, Controllability

Predicting the Impact of Disruptions in BMC^3 Workflow

J. J. Shaw ALPHATECH, Inc., USA

Abstract: Measures to safeguard or respond to a cyber attack against a BMC3 system will invariably disrupt the processing flow within that system. We would like to predict the impacts of those disruptions beforehand and select information assurance measures that minimize the disruptions, especially to key BMC3 functions. In this paper we present an analysis method based on perturbation analysis. The method approximates the nominal BMC3 workflow processing using a Markov model, and computes important sensitivity metrics, most notably cost-to-go, and co-state. Initial computational results are encouraging, and indicate that these perturbation methods can predict how disruptions in BMC3 workflow affect mission effectiveness.

Keywords: Perturbation Analysis; Workflow; Costate; Markov.

Optimum Portfolio in a Parameter Jump Difusion Market with Complete and Partial Observations

D. Cajueiro Inst. Tecn. de Aeronautica, BR
T. Yoneyama Inst. Tecn. de Aeronautica, BR

Abstract: This paper addresses the problem of choosing the optimum portfolio in the context of continuous time jump stochastic models. The aim is to maximize the wealth of a small risk-averse investor that operates in this financial market. In the case of complete information, the optimal control problem is formulated and the Hamilton-Jacobi-Bellman equation is solved to yield the solution. On the other hand, to deal with the case of partial observations, the filter equations of the non-observed process are calculated, the original problem is transformed into one with complete information and the behaviour of a certain weighted averaged control law is studied.

Keywords: Financial Systems, Optimal Control, Optimal Filtering And Stochastic Jumps Processes

WP 7	**15:30 – 17:10**	**VA - 6**
DISTRIBUTED / DECENTRALIZED SYSTEMS		
Chair: A. Desbiens		Université Laval, CA

Partial State Decentralized Backstepping Control

A. R. Benaskeur Defence Research Establishment Valcartier, CA
A. Desbiens Université Laval, CA

Abstract: Starting from a unique multivariable backstepping-based controller, extra-terms are introduced in the Lyapunov function to eliminate the cross-terms. Under given conditions, the controller can then be split up into independent scalar regulators, while the closed-loop stability and performances are still guaranteed. In a previous work, the measurements of many of the state variables were required. The novelty lies mainly in the use different extra-terms values, which allow a considerable reduction of the number of the required measured state variables, under similar stability conditions to those obtained with the full state version.

Keywords: Decentralized Control, Lyapunov Function, Multivariable Control, Stability Analysis

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Dynamics of Convoy Control Systems

P. A. Cook UMIST, UK
S. Sudin UMIST, UK

Abstract: We investigate two types of control strategy, with differentinformation requirements, for the operation of a convoy system. Inthe first type, each controller takes account only of the next vehicle ahead, but uses its acceleration as well as relative position and velocity. For the second type, it takes account of more vehicles, but uses only relative positions and velocities. Both types are simulated on the basis of simple models, and representative results are compared.

Keywords: Convoys, Stability, Disturbances, Constraints, Information.

Decentralized and Centralized Control of Redundant Parallel Robot Constructions

J. Böhm UTIA AS CR, CZ
K. Belda UTIA AS CR, CZ
M. Valášek CTU in Prague, CZ

Abstract: The fundamental task of the parallel robot construction, especially redundantly actuated, is to provide effective cooperation among all drives. This paper summarises a set of the available control approaches adjusted to redundant case: decentralized control with reduction of the unproductive part of I/S channels, the simple centralized control and one example of the high level control - Generalized Predictive Control.

Keywords: DAE-ODE Robot Model, PID Control, Generalized Predictive Control, Redundancy, Optimisation.

Backstepping-Based PID Design for TITO Decentralized Control

A. R. Benaskeur Defence Research Establishment Valcartier, CA
A. Desbiens Université Laval, CA

Abstract: This paper addresses stability analysis and design issues in decentralized PID control of Two-Input Two-Output (TITO) plants. Decentralization in obtained via the introduction of an extra term in the tracking error. When this term is set to zero, the resulting controller is multivariable. To obtain a zero static error, an integrator is added to the plant model and is slid back to the controller equation at the end of the design. The combination of the integral action and the approriate selection of the extra term yield a decentralized control law consisting of two independent PIDs.

Keywords: Decentralized Control, PID Control, Integral Action, Stability Analysis

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Decentralized Subspace Methods for Multivariate Systems Identification

C. P. Bottura University of Campinas, BR
A. F. T. Cáceres Univ. Fed. do Maranhão, BR

Abstract: In this work, a decentralized identification methodology based on subspace identification methods for serial interconnected systems is studied. The decentralized aplication of N4SID, MOESP and stochastic subspace identification methods are compared. The decentralized identification results for one interconnected system example is presented.

Keywords: Decentralized Identification, Subspace Methods, Interconnected Systems, Identification

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The Use of Grafcet in the Development of a Passenger-Elevator Communication System

G. Djurovic University of Rijeka, HR
N. Peric University of Zagreb, HR

Abstract: The basic idea is to use Grafcet for the development of a passenger-elevator communication system. The proposed communication system is based on the idea that the information about the travel destinations chosen by the passengers must be given to the elevator control system before the passengers enter the elevator car. The use of Grafcet made it possible to create flexible and reliable computer simulations.

Keywords: Grafcet, Elevator, Communication, Control System

THA 1 (invited) **9:00 – 11:00** **Amphitheatre**

NONLINEAR MODELING AND CONTROL OF CHEMICAL AND BIO-PROCESSES, I

Chair: A. VandeWouwer Mons Polytechnic, BE

Distributed Parameter Modeling of a Fixed-Bed Biofilter with Experimental Validation

A. Vande Wouwer Faculté Polytechnique de Mons
C. Renotte Faculté Polytechnique de Mons
I. Queinnec LAAS
M. Remy Faculté Polytechnique de Mons
P. Bogaerts Faculté Polytechnique de Mons

Abstract: Nitrogen removal is an important step in the treatment of municipal wastewater. Over the past several years, biofilter systems have received considerable attention; see for instance the conference proceedings and journals of the International Water Association (IWA). The main advantages of these wastewater treatment systems are their ease of use, compactness, efficiency, and low energy consumption. New biofilters including dual-column systems have recently been proposed to achieve pretreatment, nitrogen and/or phosphorus removal.Based on experimental data collected from a pilot-scale fixed-bed biofilter, the objective of this work is to develop and validate a dynamic model, which allows the evolution of the several component concentration profiles to be reproduced. This model can be used for simulation purposes (e.g. for system analysis and design) or as a basis for the development of a software sensor (which could be used to estimate unmeasured variables on-line).The modeling task involves the selection of appropriate reaction scheme and kinetics and the derivation of mass balance partial differential equations. The unknown model parameters are estimated by minimizing an ad-hoc error criterion measuring the deviation between the experimental signals and the model prediction. Particular attention is paid to the assumptions on the measurement errors, and the corresponding formulation of an output error criterion.The good model agreement demonstrates the validity of the modeling assumptions. Particularly, very long transient phases observed after changes in the feed flow rate can be explained through the introduction of activation/desactivation mechanisms affecting the biomass, which colonizes the porous bed.

Keywords: Distributed Parameter Systems, Parameter Identification, Biotechnology

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Optimal Coagulation Control Issues at Surface Water Treatment Works: Problems and a New Solution

I. Fletcher	University of Sunderland
A. Adgar	University of Sunderland
C. S. Cox	University of Sunderland
M. Johnson	Mark Johnson Consulting
T. Pearson	Mark Johnson Consulting
A. Wetheril	Mark Johnson Consulting

Abstract: The key to efficient coagulation control is the addition of just sufficient coagulant chemical to the process. Too much coagulant will ensure treatment targets are achieved but at great cost, both in chemical consumed and extra sludge waste produced. Too little coagulant will result in poor treatment performances and problems in subsequent processes such as filtration. This paper investigates current and novel techniques for achieving coagulation control.

Keywords: Water Treatment, Coagulation Control, Process Control, Sensors Design

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Identification and Control Design Issues in Nonlinear Diffusion-Reaction Processes

A. A Alonso	IIM-CSIC
J. R Banga	IIM-CSIC
C. Moles	IIM-CSIC
E. Balsa-Canto	CIMNE, Barcelona (SPAIN)

Abstract: In this contribution, we will discuss some recent results in state reconstruction and robust control of diffusion-convection-reaction systems. The approach settles its roots on the dissipative nature of systems of conservation laws with convex extensions and passivity, as it is understood in systems theory. Dissipation ensures the existence of a low dimensional subspace that captures most of the relevant dynamic features of the distributed process system. This representation will be used to design robust and asymptotically convergent state observers. Passivity conditions, on the other hand, will be derived by making use of convex extensions to construct general classes of storage functions.Thus, this formalism will constitute the basis to set up robust non-linear control design guidelines.The proposed framework will also be employed to address control implementation issues. In particular, the selection of appropriate sensor/actuator placements and stability preservation under input constraints.

Keywords: Distributed Process Systems, Convex Extensions, Sensor/Actuator Placements, Input Constraints

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Optimal Control of Tubular Chemical Reactors: Performance Assessment Under Transient and Diffusive Conditions

I.Y.M. Smets	Katholieke Universiteit Leuven
J. F.M. Van Impe	Katholieke Universiteit Leuven

Abstract: This paper deals with the optimal jacket fluid temperature control of a chemical, exothermic tubular reactor. To enable the derivation of analytical control profiles, the chemical reactor was regarded as a plug flow steady-state reactor during previous research (Smets et al., 2002}.Optimal "bang-singular-bang" type control laws were developed for a combined criterion involving both yield and safety, energy or quality considerations. Furthermore, it was proven that a practically morefeasible "bang-bang" type controller results in nearly optimal performance. In this paper, it is illustrated that these optimaland nearly optimal profiles still perform well under transient and (weakly) diffusive conditions.

Keywords: Tubular Reactors, Distributed Parameter Systems, Optimal Control, Transient, Diffusion

THA 2 (invited)	**9:00 – 11:00**	**VA - 4**

DYNAMIC GAMES: THEORY AND APPLICATIONS

Chair: J.B. Cruz, Jr. — Ohio State Univ., USA

Ordinal Game Theory and Applications: A New Framework for Games without Payoff Functions

J. B. Cruz, Jr.	The Ohio State University
M. A. Simaan	University of Pittsburgh

Abstract: Decision-making problems that involve two or more decision-makers with competing objectives are often optimized using the theory of games. This theory requires that each point in the decision space be mapped, through a payoff function, into a real number representing the value of the collective set of decisions to each decision-maker. This theory, which is cardinal in nature, requires that each decision-maker determine its decision by maximizing its payoff function taking into account the choice of decisions by all other decision-makers. While this theory has been very useful in addressing some aspects of quantitative decision-making in many applications, it has not been able to adequately address qualitative problems in fields such as social and political sciences, as well as a large segment of complex problems in engineering, business and management. The main reason for this is the inherent difficulty in defining an adequate payoff function for each decision maker.In this paper, we present a theory where, instead of a payoff function, the decision-makers are able to rank order their decisions against decision choices by the other decision-makers. Such a rank ordering could be the result of personal, subjective, preferences derived from qualitative analysis, as is the case in many social sciences problems. In such problems a heuristic, knowledge-based, rank ordering of decision choices in a finite decision space can be viewed as a first step in the process of modeling complex problems for which a mathematical description is usually extremely difficult, if not impossible, to obtain. We will refer to traditional payoff-based games as ‘‘Cardinal Games“ and to these new types of rank ordering-based games as ‘‘Ordinal Games“. In this paper, we review the theory of ordinal games and discuss associated solution concepts such as the Nash equilibrium. We will also show that these solutions are general in nature and can be characterized, in terms of existence and uniqueness, with conditions that are more intuitive and much less restrictive than those of the traditional cardinal games. We will illustrate these concepts with several examples of deterministic matrix games including an example of team composition in a complex military operation.

Keywords: Game Theory; Decision-Making, Payoff Functions, Nash Solutions, Rank Ordering

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Multi-Person Games for Infrastructure Exploitation

J. Medanic University of Illinois, USA

Abstract: Recent efforts at stimulating competition and market forces in some of the most fundamental sectors of infrastructure in the US have led to important restructuring, motivating the need of further development of multi-person game strategies as instruments in determining suitable modes of operation. Strategy concepts for games with infrastructure are considered and a classes of neutral games between the infrastructure and individual decision-makers are identified.

Keywords: Multi-Person Games, Infrastructure Control, Nash And Stackelberg Strategies

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Differential Game with Dynamic Switching Strategies

F.L. Pereira Univ. of Porto, PT
J.B. Sousa Univ. of Porto, PT

Abstract: This article addresses a two-person zero-sum finite horizons witching differential game with graph and dynamic control constraints. The general class of coordinated control of a group of dynamic systems under perturbations and with un modeled dynamics is presented as a motivation since the way switching between configurations occurs may affect the performance of the system. Optimality conditions are given under additional simplifying assumptions.

Keywords: Switching Differential Games, Hybrid Systems, Impulsive Control

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Simple-Motion Pursuit-Evasion Differential Games

M. Pachter Air Force Institute of Technology

Abstract: Simple-motion pursuit-evasion in the half plane is considered. The pursuer is endowed with a capture circle of radius $\ell > 0$, however his speed is less than, or equal to, the evader´s. Nevertheless, since the playing space has a a boundary and $\ell > 0$, there exist initial states such that capture can be guaranteed. The capture zone is determined and the pursuit and evasion strategies are characterized.

Keywords: Differential Games, Pursuit-Evasion

THA 3 (invited) 9:00 – 11:00 VA - 1

IMPULSIVE CONTROL: THEORY AND APPLICATIONS

Chair: F.L. Pereira Univ. of Porto, PT

Lyapunov Stability for Impulsive Dynamical Systems

F.L. Pereira Univ. of Porto, PT
G.N. da Silva Univ. Estadual Paulista, BR

Abstract: In this article, we derive stability conditions of the Lyapounovtype for impulsive dynamic control systems. Besides a componentabsolutely continuous with respect to the Lebesgue measure, asingular one is incorporated into the dynamics by enlarging thecontrol space in order to encompass also regular Borel measures.

Keywords: Impulsive Control, Lyapounov Stability, Measure Differential Inclusions

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State Estimation Problem for Impulsive Control Systems

T. F. Filippova Russian Academy of Sci., RU

Abstract: The paper deals with the state estimation problem for impulsive control system described by differential inclusions with measures. The problem is studied under uncertainty conditions with set--membership description of uncertain variables which are taken to be unknown but bounded with given bounds. In such problem setting instead of an isolated trajectory of the dynamical control system we have a tube of such trajectories and a phase state vector should be replaced by a set of its possible values. The techniques of estimation the trajectory tubes and their crossections (the reachable sets) that may be considered as set-valued state estimates to differential inclusions with impulses are studied.

Keywords: Impulsive Control, Uncertainty, State Estimation.

An Algorithm for Impulsive Control Problem

V. A. Baturin Russian Academy of Sci., RU
E. V. Goncharova Russian Academy of Sci., RU

Abstract: In this article, an iterative algorithm to compute control strategiesfor dynamic optimization problems which admit solutions withtrajectories of bounded variation is presented. The method developedinvolves an implicit nonlinear Goh´s trasformation to a reduced problemwhich is a conventional one. To solve the reduced problem, a numericalmethod is applied based on local approximations to reachable set.

Keywords: Impulsive Control, Numerical Algorithm, Reduced Problem Transformation, Reachable Set

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Analysis of a Jump Curve Arising in a Problem of Exploitation of Renewable Resource Stocks

J. Baumeister J.W. Goethe Univ., DE
A. Leitao Federal Univ. Santa Catarina, BR

Abstract: *not available*

Keywords: *not available*

THA 4	9:00 – 11:00	VA - 3
HYBRID SYSTEMS		
Chair: P.Antsaklis	University of Notre Dame, USA	

Model-Based Networked Control Systems- Necessary and Sufficient Conditions for Stability

L. A. Montestruque University of Notre Dame, USA
P. J. Antsaklis University of Notre Dame, USA

Abstract: The control of a continuous linear plant where the state sensor is connected to a controller/actuator via a network is addressed. The work focuses on reducing the network usage using knowledge of the plant dynamics. Necessary and sufficient conditions for stability are derived in terms of the update time h and the parameters of the plant and of its model.

Keywords: Control Over Networks, Stabilizability, Minimum Feedback Information, Hybrid Systems

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Practical Stabilization of the Extended Nonholonomic Double Integrator

A. P. Aguiar Instituto Superior Técnico, PT
A. M. Pascoal Instituto Superior Técnico, PT

Abstract: This paper derives hybrid control laws for the extended nonholonomic double integrator (ENDI). A new logic-based hybrid controller is proposed that yields global stability and convergence of the trajectories of the closed loop system to an arbitrarily small neighborhood of the origin. The problem of practical stabilization of the ENDI system under input saturation constraints and in the presence of small input additive disturbances is also posed and solved. Stability and convergence proofs are presented. Simulations illustrate the performance of the controllers derived.

Keywords: Nonholonomic Systems, Hybrid Control, Practical Stabilization, Extended Nonholonomic Double Integrator

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Observers for Hybrid Systems with Continuous State Resets

A. Balluchi PARADES, IT
L. Benvenuti Univ. di Roma, La Sapienza, IT
A. L. Sangiovanni-Vincentelli Univ. di Roma, La Sapienza, IT

Abstract: A methodology for the design of dynamical observers for hybrid plants has been recently proposed in [5]. The hybrid observer consists of two parts: a location observer that identifies the current location of the hybrid plant and acontinuous observer that estimates the continuous state of the hybrid plant. When an appropriate set of properties on the hybrid plant is satisfied, the hybrid observer identifies the current location of the plant after a finite number of steps and converges exponentially to the continuous state. In this note the previous result is extended to hybrid model with continuous state resets.

Keywords: Hybrid Systems Observers, Hybrid Systems, Discrete events systems

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Coarsest Quantizer Density for Quadratic Stabilization of Two-Input Linear Systems

E. Nicola Iowa State University, USA

Abstract: In this paper, we compute a lower bound on the coarsest quantizer density for a given quadratic Control Lyapunov Functionof a two-input unstable system. The lower bound depends on the product of the magnitude of the unstable eigenvalues of the system and the selected CLF.The search over CLF´s is transformed into a problem involving one parameter on a compact set, and it is performed by gridding.We use this approach to verify that the coarsest quantizer quadratically stabilizinga two-input linear discrete-time system has a quantization density greater than or equal to the coarsest density needed to quadratically stabilize a single input system with the same set of unstable eigen values.

Keywords: Quantization, Hybrid Systems, Control With Limited Information

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Robust Control of Hybrid Systems with Analog Uncertainty

V. Z. Filipovic RCT, YU

Abstract: In this paper design of robust hybrid controller for nonlinear systems is considered. The feedback is nonlinear function. Switching sequence is determined by minimization of suitable defined priority function. Model uncertainty belongs to the compact set. Finally, the stability of closed loop systems is proved. It is shown that state variables are bounded. Such kind of stability is not a Lyapunov stability and closely related to the notion of stability used in adaptive control.

Keywords: Nonlinear Systems, Model Uncertainty, Hybrid Controller, Stability

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A General Methodology for Stability Analysis of Differential Petri Nets

G. N. Davrazos University of Patras, GR
N. T. Koussoulas University of Patras, GR

Abstract: In this paper we present a transformation method of the fundamental equation of Differential Petri Nets

(DPNs) into a compatible linear system form and a general method for stability analysis of hybrid systems modelled by DPNs.

Keywords: Hybrid Systems, Differential Petri Nets, Lyapunov Stability

THA 5	9:00 – 10:40	VA - 2
SYSTEMS MODELLING		
Chair: J. Bokor	Computer and Automation Research Institute, HU	

On the Identification of Nonlinear Models of Unmanned Underwater Vehicles

A. Tiano — University of Pavia, IT
M. Carreras — University of Girona, ES
P. Ridao — University of Girona, ES
A. Zirilli — University of Pavia, IT

Abstract: This paper presents an identification method for both off-line and on-line identification of non linear models of Unmanned Underwater Vehicles (UUVs). The proposed method can be applied to a quite general class of non linear multivariable models and is characterised by an excellent numerical performance, as illustrated through a simulated example. The validity of the proposed method is also demonstrated by an application to the identification of the dynamic behaviour of the GARBI underwater robotic vehicle.

Keywords: Identification, Parameter Estimation, Numerical Methods, Unmanned Underwater Vehicles

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Experimental Comparison of Different Friction Models for Accurate Low-Velocity Tracking

V. Lampaert — Katholieke Universiteit Leuven, BE
J. Swevers — Katholieke Universiteit Leuven, BE
F. Al-Bender — Katholieke Universiteit Leuven, BE

Abstract: Low velocity friction causes positioning and contouring errors such as the quadrant glitch in machine tool table systems. Numerous comprehensive friction models are described in literature. A comparison of these models with respect to feedforward friction compensation is not yet available: only comparisons with the Coulomb friction model are available. This paper compares four friction models, one static model and three comprehensive dynamic models, with respect to their friction compensation ability.

Keywords: Friction Modelling, Identification, Compensation, Control

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Extension of the Lugre Dynamic Tire Friction Model to 2D Motion

E. Velenis — Georgia Tech, USA
P. Tsiotras — Georgia Tech, USA
C. Canudas-de-Wit — Laboratoire d´ Automatique de Grenoble, FR

Abstract: An extension of the LuGre dynamic friction model from longitudinalmotion to longitudinal/lateral motion is developed. Applying thismodel to the motion of a tire we derive a model for tire-roadcontact forces and moments. A comparison of the steady-statebehaviour of the dynamic model with existing static tire frictionmodels is also presented. This comparison allows one to determinethe values of the parameters for the new model. Introducing a setof mean states we reduce the order of the system and derive amodel in lumped form which is useful for control purposes.

Keywords: 2D Dynamic Tire Friction Models

Nonlinear Active Suspension Modelling Using Linear Parameter Varying Approach

I. Szászi — Budapest University of Technology and Economics, HU
P. Gáspár — Computer and Automation Research Institute, HU
J. Bokor — Computer and Automation Research Institute, HU

Abstract: This paper is concerned with the nonlinear modelling of vehiclesuspension systems, which includes electro-hydraulic actuators andthe nonlinear characteristics of dampings and springs. Insimulation examples the performance signals of the nonlinear modelare compared with the linear model. A Linear Parameter Varying(LPV) technique is applied in the construction of the nonlinearmodel, in which the highly nonlinear effects in the state spacedescription can be taken into consideration.

Keywords: Nonlinear Modelling, Vehicle Dynamics, Linear Parameter Varying modelling, Robustness

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Model Reduction by Sub-Structuring

A. Beghi — Universita` di Padova, IT
A. Portone — Max Planck Institute for Plasma Physics, DE

Abstract: In the study of control problems of electromechanical systems, model reduction schemes based on eigenstructureanalysis are often used. In particular, preserving the physical meaning of the state variables and the model parameters in the reduced order models allows to obtain interesting interpretations in terms of physical quantities of the simplified model, its parameters, and the approximations involved. In the paper, a novel procedure which enjoys such properties is presented. In this technique, the physical system is split insubstructures, then in the simplified model a single state (or few states) is used to describe the dynamic ofeach substructure and its effect on the output. To show the effective ness of the technique, some results onits application to derive low-order models of tokamak devices are reported.

Keywords: Model Reduction, Modal Approach, Tokamak Control

A Frequency Domain Method For Controller Design In Delta Domain

P. Sarkar NERIST, NIRJULI, IN
J. Pal IIT, IN

Abstract: A frequency domain approximate model matching technique is proposed for controller design in delta domain. The frequency response of the reference model and plant are computed at discrete frequency points in the low frequency zone. The controller parameters are calculated by matching the frequency responses of the reference model and plant. The method is algebraic and require solving linear algebraic equations and can be used to design PI, PID and other higher order controllers. The proposed method further, provides a unified framework for the design of controller in the continuous-time framework from the given discrete-time description of the system. Example is included to highlight the usefulness of the method

Keywords: Delta Operator Delta Transfer Function, Exact Model Matching, Approximate Model Matching, Approximate Frequency Fitting

THA 6 **9:00 – 11:00** **VA - 5**

LINEAR CONTROL

Chair: D. Sales Army Polytechnic School, EC

A New Approach to the H-Infinite with Static Output Feedback Synthesis Problem

D. Sales Army Polytechnic School, EC
G. Correa LNCC, BR

Abstract: This paper considers the H∞ with static output feedback synthesis problem, formulated as a feasibility problem involving a bilinear matrix inequality (BMI, for short). In our approach in this paper, this problem is solved by means of a sequence of easier auxiliary quadratic optimization problems, and the optimal controller is determined through a line search on the non-negative real axis. It is worth noting as well that a great number of interesting control problems can be formulated as that of minimizing the maximum eigenvalue of a BMI, which is known to be non-convex and non-differentiable. In addition, the algorithm to be presented here can be applied, in principle, to all of these problems.

Keywords: Optimal Control, Static Output Feedback, And Bilinear Matrix Inequality

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Computation of the Frequency-Response Gain of Sampled-Data Systems via Projection in the Lifted Domain

L. Mirkin Technion - IIT, IL
Z. Palmor Technion IIT, IL

Abstract: This paper addresses the computation of the frequency response gain of sampled-data systems. The proposed method is based upon a novel necessary and sufficient condition for the frequency-response gain to be less than a given gamma and thus can be used as a basis for a bisection algorithm. Unlike all currently existing results, the proposed procedure requires the operator gamma^2I-D_{11}D_{11} neither to be positive nor even to be invertible, thus eliminating unnecessary restrictions of the existing approaches (here D_{11} stands for the feedthrough term of the lifted system).

Keywords: Sampled-Data Systems, Frequency Response, Lifting Technique

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A Generalized Standard Problem and Its Resolution Using LMIs

R. Drai Ecole des Mines de Paris, FR

Abstract: The objective of this paper is to formulate and solve a generalized standard problem where frequency-dependent dissipativity constraints are imposed on the closed-loop system. We show how this problem can be handled within the linear matrix inequality (LMI) framework. The approach is illustrated by the synthesis of a controller insuring simultaneously the kind of phase and gain shapingas typically considered in positive real control and H_infinity control.

Keywords: Robust Control, Dissipativity Constraints, LMIs.

An Algorithm for Feasibility Problems of Frequency-Dependent LMIs

G. O. Corrêa LNCC/MCT, BR
D. M. Sales Escuela Politecnica del Ejército, EC

Abstract: noindent{largebf Abstract}vskip .1inIn this note, an algorithm is introduced for feasibility problems associated with frequency-dependent,linear matrix inequalities. An auxiliary ´H_2´ cost-functional is introduced and a sequence of ´H_2´ problems with a single linear constraint is considered in which the ´H_2´ cost-functionalis kept unchanged while the linear constraints are iteratively modified. Conditions are established under which the sequence of solutions to the auxiliary problems yields a solution to the original feasibility problem. The method is illustrated by a numerical example corresponding to a ´H_infty´ robust performance testfor a multivariable system.

Keywords: Linear Matriz Inequalities, H_2-Optimization, Robust Performance

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Finite Dimensional Q-Parametrization for Continuous Time Control Design

S. Hbaïeb Supélec, Service Automatique, FR
S. Font Supélec, Service Automatique, FR
P. Bendotti Electricité De France, FR
C-M Falinower Electricité De France, FR

Abstract: The main challenge in the convex optimization approach for control design is to deal with an infinite dimensional Youla-Kucera parameter. This parameter should be approximated by a finite dimensional subspace, thus making the problem tractable. A straightforward basis for continuous time purposes is introduced in this paper. It

presents the advantage of taking into account some a prior knowledge of the system. Thus, among its theoretical properties, this basis shows good numerical qualities. Application to the benchmark problem of the water level control in a steam generator of a Pressurized Water Reactor is shown.

Keywords: Linear Control, Convex Optimization, Finite Dimensional Basis, Continuous Time, Steam Generators.

SISO Control Systems with Poorly Controllable and Observable Parts

M. E. Penati — University of Bologna, IT
M. Zanzi — University of Bologna, IT
G. Bertoni — University of Bologna, IT

Abstract: This paper presents some procedures related to the synthesis in the time domain of SISO linear and stationary systems with poorly controllable and observable parts. These procedures are of a non-empirical type even in the case of high-order systems and are often used, as can be seen in the examples provided, to control the flight attitude of an aircraft.

Keywords: Poor Controllability, Poor Observability, Pole Assignment, PD Standard Regulator, Derivative Compensating Network.

THA 7	**9:00 – 11:00**	**VA - 6**
ROBOTICS I		
Chair: I. Ribeiro	Instituto Superior Tecnico, PT	

Evolutionary Algorithm Based On-Line Path Planner for UAV Navigation

A. N. Kostaras — Technical University of Crete, GR
I. K. Nikolos — Technical University of Crete, GR
N. C. Tsourveloudis — Technical University of Crete, GR
K. P. Valavanis — Technical University of Crete, GR

Abstract: An Evolutionary Algorithm-based on-line path planner for Unmanned Aerial Vehicles (UAVs) is presented to calculate a curved path line with desired characteristics in a completely unknown 3-D environment. The proposed on-line path planner is based on an off-line one, used for navigation in known environments. The path line is represented using B-Spline curves, with the coordinates of their control points being the genes of the artificial chromosome of the Evolutionary Algorithm (EA). Given a completely unknown rough 3-D artificial environment and assuming an enforced maximum flight height to consider flight envelope restrictions, the problem of UAV navigation is being solved. The on-line planner, given the on-board radar readings, gradually produces a smooth 3-D trajectory for a UAV aimed at reaching a predetermined target in an unknown environment. The produced trajectory consists of smaller B-Spline curves, smoothly connected with each other. The planner has been tested under different scenarios and has been proven effective in guiding a UAV to its final destination.

Keywords: B-Splines, 3-D Path Planning, Evolutionary Algorithms, Navigation, UAV

An Efficient Robot Path Planning System for Large Environments Using Pre-Calculated Paths

D. Cagigas — University of Seville, ES
J. Abascal — Univ. of the Basque Country, ES

Abstract: In this paper it is shown how traditional robot pathplanning systems based on topological maps (graphs) can be adapted and extended in order to gain efficiency when search spaces are too large. Specific problems not usually treated in mobile robot path planning such path planning between floors of a building or/and different buildings are also viewed.The working environment is mapped into a hierarchy of abstraction levels using a special H-Graph (Hierarchical Graph). Nodes in an abstraction level can represent another sub-maps in a deeper level. Path planning is made using a path skeleton which is built from the deepest abstraction levels of the hierarchy to the upper levels and completed in the last step of the algorithm. In order not to lose accuracy in the skeleton generation and speed up path´s construction, a table of significant paths is attached to every sub-map. Some experimental results based on a real AGV (Automated Guided Vehicle) system applied to electric powered wheelchairs are showed and compared to traditional heuristic search algorithms used in robot path planning.

Keywords: Path Planning, Hierarchical Search, Automated Guided Vehicles

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A New Method for Tracking Memorized Paths: Appication to Unicycle Robots

F. Diaz del Rio — Universidad de Sevilla, ES
G. Jimenez — Universidad de Sevilla, ES
J. L. Sevillano — Universidad de Sevilla, ES
C. A. Amaya — Universidad de Sevilla, ES
A. C. Balcells — Universidad de Sevilla, ES

Abstract: To follow a memorized trajectory,there are several possibilities: "trajectory tracking" (temporal deterministic requirements), "path following" (point to track is the "nearest" to robot´s position). We present (for non-determinism): "error adaptive tracking" (tracking pace adapts to errors). We apply it to a unicycle robot. It has advantages of path foll., but avoids its obstacles.

Keywords: Nonholonomic Constraints, Unicycle Mobile Robots, Path Following, Trajectory Tracking, Differential Geometry

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Fuzzy Compensating for Uncertainties on Force Control: an integrated approach

S. J. C. Marques — Instituto Superior de Engenharia de Lisboa, PT
J. M. G. Sá da Costa — Instituto Superior Técnico, PT

Abstract: In this paper a control structure which integrates a fuzzyadaptive schema with a fuzzy sliding mode approach in a positionbased explicit force control strategy, to compensate for modellinguncertainties of the manipulator and environment, load variationand external disturbances as well, is proposed. This controlstructure allows for uncertainties

compensation in an integratedway, in two places of the control loop: in the referencetrajectory and into the inner position controller. In this innercontrol loop a fuzzy sliding mode control, will compensate foruncertainties in the manipulator model, leaved out by the positioncontroller. In the outer loop a fuzzy adaptive controller adjuststhe manipulator tip position to compensate for uncertainties inthe environment, like stiffness and geometric location, with thepurpose of reducing the error in force. To show the performance ontracking force/position trajectories and to validate the proposedcontrol structure, simulations results are presented with thefirst three degree of freedom Puma560 manipulator.

Keywords: Robotics, Force Control, Fuzzy Adaptive Control, Fuzzy Sliding Mode Control

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Generation of virtual trajectories in robot force control using neural networks

L. J. Nunes — Instituto Superior Técnico, PT
L. F. Baptista — Instituto Superior Técnico, PT
J. M. Sousa — Instituto Superior Técnico, PT
J. M. G. Sá da Costa — Instituto Superior Técnico, PT

Abstract: Fuzzy predictive controllers have been applied to severalapplications with good control performance. However, thismethodology often leads to nonconvex optimization problems, whichare difficult to solve for fast processes, i.e. processes withhigh sampling frequencies. This paper proposes a new methodologyin which a Neural Network (NN) trajectory generator is trainedoff-line from data generated by a fuzzy predictive controller andthen adapted on-line using an extension of the classicalbackpropagation method, which is made possible by an InternalModel Control (IMC) architecture. The IMC structure is usedon-line, not only to cope with model-plant mismatches anddisturbances, but also to define an error criterion from thosemismatches, which can be used to update the direct and inverse NNdynamic models used in the control architecture. The proposedmethodology is applied by simulation to a realistic robotsimulator, where force and position are both controlled. Theproposed scheme reveals an accurate force/position controlperformance.

Keywords: Algorithms And Architectures For Real-Time Control, Fuzzy Systems, Neural Networks, Predictive Control, Robot Force Control

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Adaptive Steering Control for Autonomous Mobile Robots

O. B. Manolov — Institute of Control & Systems Research, BG

Abstract: An approach of adaptive controller design for a mobile robot movement control along the trajectory, based on the Second Lyapunov method and combined with a LaSalle invariance principle is presented. For the mobile robot dynamics description as a reference model a two-dimensional non-linear nonstationary equations is used. The final expressions of the first derivative of Lyapunov function shows that the proposed approach, with rough off-line estimations of the mobile robot dynamics parameters, can be successfully used. Furthermore, at last but not least, the attempt of a direct adaptive controller design by using of this approach might be implemented with a new Lyapunov function. The presented results from some numerical experiments and simulations confirm the proposed approach.

Keywords: Mobile Robot Dynamics, Adaptive Parameters Adjustment, Lyapunov Function, Direct Controller Design

THP 1 (invited)	**15:30 – 17:30**	**Amphitheatre**

NONLINEAR MODELING AND CONTROL OF CHEMICAL AND BIO-PROCESSES, II

Chair:A.Vande Wouwer — Mons Polytechnic, BE

Hybrid First-Principles Neural Network Approach to Modeling of Animal Cell Cultures

A. Vande Wouwer — Faculté Polytechnique de Mons
C. Renotte — Faculté Polytechnique de Mons
M. Remy — Faculté Polytechnique de Mons
P. Bogaerts — Faculté Polytechnique de Mons

Abstract: The sparsity and low quality of measurement data in biochemical applications often make the development of black-box neural network models particularly delicate. Hence, it is appealing to resort to a hybrid physical-neural network approach, which combines a first-principles model and a partial neural network model. In this study, the hybrid approach is applied to a real case study, e.g. batch CHO animal cell cultures. Two alternative model structures are developed, in which NNs are used to describe either the reaction kinetics or the complete reaction rates (including the reaction pseudo-stoichiometry). Parameters and initial conditions are estimated from experimental data using a maximum likelihood approach, which takes all the measurement errors into account. A special procedure for initializing the minimization of the objective function is devised. The good model agreement is demonstrated with cross-validation tests.

Keywords: Radial Base Function Networks, Parameter Identification, Biotechnology

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Optimal Design of Interconnected Bioreactors: Some New Results

J. Harmand — INRA, FR
A. Rapaport — INRA, FR

Abstract: This paper deals with the optimal design of two Continuous StirredBioreactors in series in which a single reaction occurs. The term "optimal"should be understood here as the minimum of the total volume of the tworeactors required torealize a given conversion rate given a quantity of matter to be treated bytime unit Q*Sin. The existing results have only considered either the designof N reactors (with different volumes) in series with only one feed intothe first reactor or a distributed feeding system with N tank of equalvolumes. In addition, very few of the existing papers consider arecirculation loop to eventually improve the results (and even so, from whatwe know, none of them theoretically). The present study investigates - for atwo tank system and in comparison to the existing results proposed inthe litterature - the gain of performance that can be

obtained in bothdistributing the input flow rate between the different reactors and inimplementing a recirculation loop. Both Monod and Haldane kinetics areinvestigated.

Keywords: Continuous Stirred Bioreactors, Multi-Feeding, Recirculation Loop, Optimal Design, Haldane Law

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Efficient and Robust Numerical Strategies for the Optimal Control of Non-Linear Bio-Processes

J. R. Banga IIM-CSIC, Vigo (SPAIN)
E. Balsa-Canto CIMNE, Barcelona (SPAIN)
C. G. Moles IIM-CSIC, Vigo (SPAIN)
A. A. Alonso IIM-CSIC, Vigo (SPAIN)

Abstract: The dynamic optimization (open loop optimal control) of non-linearbio-processes is considered in this contribution. These processes aredescribed by sets of differential and algebraic equations (DAEs),usually subject to constraints in the state and control variables. Areview of the available solution techniques for this class of problemsis presented, highlighting the numerical difficulties arising from thenon-linear, constrained and often discontinuous nature of these systems.In order to surmount these difficulties, we present several alternativestochastic and hybrid techniques based on the control vector parameterization (CVP) approach.The CVP approach is a direct method which transforms the originalproblem into a non-linear programming (NLP) problem, which must besolved by a suitable (efficient and robust) solver. In particular,the hybrid technique uses a first global optimization phase followedby a fast second phase based on a local deterministic method, so itcan handle the nonconvexity of many of these NLPs. The efficiency and robustness of these techniques is illustrated bysolving several challenging case studies regarding the optimal controlof fed-batch bioreactors and other bio-processes. In order to fairlyevaluate their advantages, a careful and critical comparison with several other direct approaches is provided. The results indicate thatthe two-phase hybrid approach presents the best compromise between robustness and efficiency.

Keywords: Optimal Control, Dynamic Optimization, Nonlinear Bioprocesses, Global Optimization

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Optimization Methods for Improving Fed-Batch Cultivation of E. Coli Producing Recombinant Proteins

I. Rocha Universidade do Minho, PT
E. C. Ferreira Universidade do Minho, PT

Abstract: Two optimisation techniques for the fed-batch cultivation of high cell density Escherichia coli producing recombinant proteins were compared.An unstructured model for the growth, based on the General State Space Dynamical Model [1] was used to represent the four major metabolic pathways: oxidative growth on glucose, fermentative growth on glucose, oxidative growth on acetate, and maintenance. The dilution rate (dependent on the substrate feed rate) was chosen as the input variable. Recombinant protein production is known to be proportional, in our system, to the biomass concentration. Thus, biomass productivity was chosen as the criterion to be maximized.The two methods compared were a first order gradient method based on Pontryagin's minimum principle and a stochastic method based on the biological principle of natural evolution, using a genetic algorithm. The former method revealed less efficient concerning to the computed maximum, and dependence on good initial values.

Keywords: Optimisation, Fed-Batch Fermentation, E. Coli, Gradient Methods, Genetic Algorithms.

THP 2 (invited)	**15:30 – 17:30**	**VA - 4**

CONTROL, OPTIMIZATION AND COMPUTATION

Chair: F. Silva Leite Univ. of Coimbra, PT

Smooth Interpolating Curves on Manifolds with Applications to Path Planning

K. Hueper University of Wuerzburg, DE
F. S. Leite University of Coimbra, PT

Abstract: A procedure is presented to produce smooth interpolating curves on manifolds. The method is a combination of the pull back/push forward technique with unrolling data from the manifold into some vector space, solving therethe interpolation problem, and then wrapping the resulting interpolation curve back to the manifold.

Keywords: Euclidean Group, Interpolation, Manifolds, Rolling, Wrapping

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Control Theoretic Smoothing Splines as an Approximationto a Continuous Linear Filter

C. Martin Texas Tech Univ., USA
W.P. Dayawansa Texas Tech Univ., USA

Abstract: In this article, an iterative algorithm to compute control strategiesfor dynamic optimization problems which admit solutions withtrajectories of bounded variation is presented. The method developedinvolves an implicit nonlinear Goh´s trasformation to a reduced problem which is a conventional one. To solve the reduce problem, a numerical method is applied based on a local approximation to reachable set.

Keywords: Impulsive Control, Numerical Algorithm, Reduced Problem Transformation, Reachable Set

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Conserved Quantities along the Pontryagin Extremals of Quasi-Invariant Optimal Control Problems

D. F. M. Torres Universidade de Aveiro, PT

Abstract: The universal principle described by Noether´s theorem asserts that invariance of the integral functionals with respect to a family of transformations result in existence of a certain conservation law or equivalently the first integral of the corresponding Euler-Lagrange differential equations. This first integral is computed in terms of the Langangian and the family of transformations. This result is of great

importance in physics, engineering, systems and control and their applications. In optimal control important relation between invariance of the problem under a family of transformations, and the existence of preserved quantities along the Pontryagin extremals was established in the publications by van der Schaft (1981), Sussmann (1995), Jurdjevic (1997), and the author (2001). In this paper several extensions of Noether theorem are provided in the direction, which enlarges the scope of its application. We formulate a more general version of Noether´s theorem for optimal control problems, which incorporates the possibility to consider a family of transformations depending on several parameters and, what is more important, to deal with quasi-invariant and not necessarily invariant optimal control problems. We trust that this latter extension provides new possibilities, and we illustrate it with several examples not covered by the previous known optimal control versions of Noether´s theorem.

Keywords: Optimal Control, Pontryagin Maximum Principle, First Noether Theorem, Conservation Laws, Invariance Up To First-Order Terms In The Parameters

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An Application of Control-Theoretic Methods to Digital Arithmetic Algorithms

E. A. Rocha — University of Aveiro, PT
A. Sarychev — University of Aveiro, PT
A. Pereira — University of Aveiro, PT
R. Rodrigues — University of Aveiro, PT

Abstract: Digital Arithmetic has been an active field of research over thepast two decades. Our work concerns normalization methods over redundant number systems and the search for a global proof of convergence. We model redundant normalization algorithms as discrete-time time-variant dynamical control systems anduse results on time-variant feedback stabilization for controlsystems in order to prove the convergence of algorithms for elementary functions.

Keywords: Digital Arithmetic, Discrete-Time Control Systems, Stabilization

THP 3 (invited)	**15:30 – 17:30**	**VA - 1**
IMPULSIVE CONTROL THEORY		
Chair: F.L. Pereira		Univ. of Porto, PT

Hamilton-Jacobi Conditions for a Class of Impulsive Control Problems

A.C. Matos — Univ. of Porto, PT
F.L. Pereira — Univ. of Porto, PT

Abstract: This work presents optimality conditions of Hamilton-Jacobitype for a classe of vector-valued impulsive control optimalproblems.The dynamics are defined by a measure driven differential inclusionand the vector fields associated with the singular term do not satisfythe so called Frobenius condition.

Keywords: Impulsive Control, Hamilton-Jacobi Conditions

Sufficient Optimality Conditions for Classical and Impulsive Optimal Control Problems

V. A. Dykhta — Irkutsk State Economic Academy, RU
N. V. Antipina — Irkutsk State University, RU

Abstract: We discuss sufficient optimality conditions expressed in terms of a family $\{j\,a(t,x) | a \in A\}$ of auxiliary functions which satisfy to Lyapunov-Krotov differential inequality. Special attention is paid to a relaxed optimal control problem with impulsive behavior of control and discontinuous trajectories.

Keywords: Sufficient Conditions, Extremal, Lyapunov-Krotov Inequality, Discontinuous Trajectories

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A Maximum Principle for a Free Time Impulsive Control Problem

A. Arutynov — Peoples Friendship Univ., RU
F.L. Pereira — Univ. of Porto, PT

Abstract: In this article, we introduce and discuss the issues involved inthe problem of finding the optimal control strategy for a freetime impulsive dynamic system subject to endpoint constraints. AMaximum Principle is presented and an outline of its proof is sketched.

Keywords: Maximum Principle, Impulsive Control, Free Time

Impulse Stochastic Control Problem

F. F. Dufour — MAB, Universite Bordeaux I, FR
B. B. Miller — Institute for Information Transmission Problems, RU

Abstract: An optimal singular stochastic control problem is considered inthis work. Applying a time transformation, it is shown that thisproblem is equivalent to an optimal stopping problem. Using thisresult, it is shown under some technical hypotheses the existenceof an optimal singular control.

Keywords: Singular Control, Optimal Control Stochastic Control, Change Of Time

THP 4	**15:30 – 17:30**	**VA - 2**
CONTROLER DESIGN II		
Chair: E. A. Tannuri		Escola Politécnica, University of São Paulo, BR

PID Regulator Tuning for Factorable Nonlinear Plants

C. Banyasz — Hungarian Academy of Sci., HU
L. Keviczky — Hungarian Academy of Sci., HU

Abstract: In the paper simple PID tuning methods are extended for Hammerstein and Wiener type block-oriented cascade factorable nonlinear models. It is shown that this

extension is quite straightforward for both IS and IU Hammerstein models, however the extension can be performed only for IS Wiener models.

Keywords: PID Regulator, Nonlinear Process, Wiener/Hammerstein Model

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Optimal Ripple-Free Deadbeat Disturbance Rejection Controllers for Systems with Time Delays

H. A. Elaydi — Islamic University of Gaza
R. A. Paz — New Mexico State Univ., USA

Abstract: A ripple-free deadbeat Disturbance Rejection controller for a system with time delays is proposed here. Our approach to this problem uses an affine parametrization of the Diophantine equation. Based on this parametrization, LMI conditions are used to provide optimal or constrained controllers for design quantities such as overshoot, undershoot, control amplitude, ``slew rate´´ as well as for norm bounds such as ℓ_1, ℓ_2 and $\ell\infty$.

Keywords: Ripple-Free, Deadbeat, LMI, Time-Delays, Disturbance-Rejection

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Optimal L2 Ripple-Free Deadbeat Controllers for Systems with Time Delays

H. A. Elaydi — Islamic University of Gaza
R. A. Paz — New Mexico State University, USA

Abstract: A ripple-free deadbeat controller for a system with time-delays is provided. Previous approaches to this problem rely on the Diophantine equation. However, until recently, solutions to the Diophantine equation would exhibit extremely bad transient responses, because the inherent freedom in the equations was difficult to manage. This approach uses an affine parametrization of solutions of the Diophantine equation. Based on this parametrization, optimal ℓ_2 controllers are obtained.

Keywords: Ripple-Free, Deadbeat, LMI, Time-Delays, ℓ_2

Deflection Reduction Control for a Continuous Parameter System with a Traveling Mass

H. Joo — Yeungnam University, KR
Y. G. Sung — Chosun University, KR

Abstract: In this paper,the deflection reduction control are proposed for a simply supported beam under a traveling mass. Using Euler-Bernoulli beam theory, the equation of motion are derived by including the acceleration effects of a mass traveling along a vibration path.The assumed mode method is employed to discritize the equation of motion with the static deflection of the beam.For the deflection reduction of the beam under a traveling mass ,an optimal controller with full state feedback is designed based on the linearlized equations of motion to evaluate the control performance.As control input devices, two piezoceramic actuators are glued at bottom of the beam at different locations which is determined by the minimization of an optimal cost functional.Numerical simulations are contucted with respect to different constant velocities and different traveling masses.The control configuration shows exellent performance under unknown disturbances to the system.

Keywords: LQG,Piezocermanic Actuator,Traveling Mass, Optimal Control

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Adaptive Control of River Pollution Problem

F. Zheng — National University of Singapore, SG
Q-G Wang — National University of Singapore, SG
T-H Lee — National University of Singapore, SG

Abstract: The model of river pollution process is an uncertain linear systems with multiple delays occurring in the state variables. In this paper, the problem of adaptive control for general uncertain linear systems with multiple delays is first studied and then applied to the control of river pollution process. The essential requirement for the uncertainties is that they satisfy matching conditions and are norm-bounded, but the bounds of the uncertainties are not necessarily known. An adaptive controller is developed based on linear matrix inequality technique and it is shown that the controller can guarante e the state variables of the closed loop system to converge, globally, uniformly and exponentially, to a ball in the state space with any pre-specified convergence rate. Furthermore, the radius of the ball can also be designed to be as small as desired by tuning the controller parameters.

Keywords: Time Delay Systems, Uncertain Systems, Adaptive Control, Linear Matrix Inequalities, River Pollution Control

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Comparing Two Different Control Algorithms Applied to Dynamic Positioning of a Pipeline Launching Barge

E. A. Tannuri — University of São Paulo, BR
C. P. Pesce — University of São Paulo, BR

Abstract: This work was motivated by the necessity of estimating the required power for a Dynamic Positioning System (DPS) to be installed in an already existing pipeline-laying barge, which operates in both intermediate and deep waters (up to 1000 meters). Small-scale experiments were used to obtain current and wind forces acting during operation. Additional environmental effects were estimated using validated models. A numerical simulator was then developed, also including propeller dynamics, thruster allocation logics and the controller. A robust non-linear sliding mode control (SM) was applied, and was compared to the so-common optimal linear LQ control. This paper describes, in details, the application of both controllers and the methodology used for comparison, focusing on: dynamic performance and energy consumption, number of adjusting parameters, implementation simplicity and robustness to modelling errors. The analyses showed that both controllers satisfy operational performance requirements, although the

SM controller is more appropriate, due to good robustness properties and fewer number of parameters to be adjusted. The LQ controller is simpler, but extremely dependent on weight matrix adjustment, what is very time-consuming and must be redone whenever the barge heading changes.

Keywords: Sliding Mode Control, Optimal Control, Dynamic Positioning, Launching Barge

THP 5	**15:30 – 17:30**	**VA - 3**
FILTERING		
Chair: P. O. Shirley	INESC-ID/Univ. Aberta, PT	

Acoustic Based Station Keeping of the IES ROV

J. M. Silva — Instituto Superior de Engenharia do Porto, PT
A. O. Martins — Instituto Superior de Engenharia do Porto, PT

Abstract: This paper describes the acoustic based navigation system used by the IES ROV. The paper presents the integration of a LBL system and an acoustic ranging sensor. We report the results obtained at ROV station keeping using this sensors. The impact of the integration of the Sontek Argonaut DVL in the position estimation is also evaluated.

Keywords: Control Applications, Underwater Vehicle Control, Acoustic Based Control, Kalman Filtering

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Small Satellites Attitude Determination Using a Predictive Algorithm for Attitude Stabilization and Spin Control

S. M. Marques — ISR/Instituto Superior Técnico, PT
P. N. Tabuada — ISR/Instituto Superior Técnico, PT
P. U. Lima — ISR/Instituto Superior Técnico, PT

Abstract: This paper presents results of closed loop attitude estimation for smallsatellites, based on Extended Kalman filter and Singular Value Decomposition methods. The controller is based on an algorithm for attitude stabilization and spin control of small satellites using only electromagnetic actuation. Both estimators use the measurement of two sensors: magnetometer and Sun sensor. The point-by-point attitude determination methods, which include the SVD, are based on the measurements of at least two attitude sensors in a single point in time. So a problem arises when only one measurement is available. In this case, a solution to estimate the attitude until the SVD is fully operational again is presented . The control algorithm takesadvantage of the time-varying nature of the problem (the geomagnetic field changes throughout the orbit) by using the most appropriate control effort (according to an energy-based criterion) given the geomanetic fied and the satellite angular velocity at each actuation instant. Results of simulations with the predictive controller in the loop for both the extended Kalman filter and the SVD attitude estimators are presented.

Keywords: Small Satellites, Attitude Determination And Control, Extended kalman Filter, Non-Linear Time-Varying Control

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Derivative State Estimation of Singular Stochastic Systems

P. Zampa — University of West Bohemia, CZ
R. Arnost — University of West Bohemia, CZ

Abstract: This paper deals with a solution to the estimation task of continuous-time systemstate variables measurement of which is influenced by noise in a singularfashion. Naturally, the estimation problem is well known as the Kalmanfiltering in case of a regular task but such a solution fails in the case ofa singular task. The presented solution is based on recently submitted new approach to systemtheory which requires accurate system description corresponding to ourobservations of the real world.

Keywords: Kalman Filter, Optimal Estimation, System Theory, Stochastic Causal System, Singular Uncertainty

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Mixed H^2/Hinfinite Criterion for Optimal Adaptive Filtering

J. Mohammadpour-Velni — University of Tehran, IR
M. J. Yazdanpanah — University of Tehran, IR

Abstract: In this paper, we will examine the combination possibility of H_2 (least-mean-squares) performance with H_inf-optimal performance in adaptive filtering. It will be seen that the resulting adaptive algorithms allow for a trade-off between average and worst-case performances and are most applicable in situations in which because of modelling errors, the exact statistics of the underlying signals are not known. In this paper, a nonlinear adaptive filter that recursively minimizes the LMS error over all filters that guarantees a pre-specified worst-case H_inf bound. Ultimately, a simple example will be presented to compare the algorithms behaviour with H_inf adaptive filter and the other mixed algorithms.

Keywords: H_2/H_Inf Estimation, Adaptive Filtering, Robust Theory

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Random and Systematic Errors Evaluation in Radiation Therapy

G. Y. Gluhchev — Institute of Information Technologies, BG

Abstract: A comprehensive approach to the detection of systematic and random errors in radiation therapy is described. Before looking for a systematic error an attempt to detect a random error is made.The systematic error is evaluated on the base of a measured displacement using a statistical approach, and a maximum likelihood correction is suggested.

Keywords: Systematic Error, Random Error, Radiation Therapy

THP 6	15:30 – 17:30	VA - 6
ROBOTICS II		
Chair: M. Caccia		CNR-IAN, IT

Experimental Results with a Simplified Model Based Wave Filter with Inertial Sensor Feedback for Surface Vessels

K-P Lindegaard	Norwegian University of Science and Technology, NO
B. Vik	Norwegian University of Science and Technology, NO
T. I. Fossen	Norwegian University of Science and Technology, NO

Abstract: A new model based observer for surface vessels which incorporates inertial measurements is proposed and analyzed. The purpose of this extension is to pave the way for taking advantage of measured accelerations and angular velocities in a positioning operation of marine crafts. The proposed filter is easy to tune and handles unsynchronized measurements better than a previous design. Experiments with a model ship exposed to irregular waves while performing a dynamic positioning operation illustrates performance.

Keywords: Marine Vehicle Control, Inertial Navigation, Observers, Asymptotic Stability

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A Framework for the Automation of a Remotely Operated Vehicle

S. Fraga	Universidade do Porto, PT
J. Sousa	Universidade do Porto, PT
F. Pereira	Universidade do Porto, PT

Abstract: A framework for the automation of a Remotely Operate Vehicle (ROV) is presented. This framework entails a three-layered control architecture, a principled approach to design and implementation within the architecture, and hybrid systems design techniques. The control architecture is structured according to the principle of composition of vehicle motions from a minimal set of elemental manoeuvres that are designed and verified independently. The principled approach is based on distributed hybrid systems techniques, and spans integrated design, simulation and implementation as the same model is used throughout. Hybrid systems control techniques are used to synthesize the elemental manoeuvres and to design protocols that coordinate the execution of elemental manoeuvres within a complex manoeuvre. The architecture is fault-tolerant by design since it uses verified manoeuvres. This work is part of the Inspection of Underwater Structures (IES) project whose main objective is the implementation of a ROV-based system for the inspection of underwater structures.

Keywords: Remotely Operated Vehicle, Trajectory Generation, Vehicle Automation, Manoeuvres, Underwater Inspection

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Learning Motor Representations for Robot Navigation

R. Vassallo	Instituto Superior Técnico, PT
J. Santos-Victor	Instituto Superior Técnico, PT
H. Schneebeli	Universidade Federal do Espirito Santo, BR

Abstract: We propose a methodology for learning and using a motor representation in topological navigation through a imitation/following behaviour for a mobile robot.In the learning phase, the robot imitates the tutor and associates its own motion perception to motor words. The created motor representation(vocabulary) is based on the robot´s internal motion capabilities. Thisvocabulary represents a powerful tool for building topological maps. While following a person, the robot can build maps by capturing images to define nodes and associating motor words to the links. In addition, during map navigation, sequences of motor words represent the actions needed for reaching a desired goal. The great advantage of this approach is to explore the robot´s specific motion repertoire through an imitation behaviour.The relation between motor vocabulary and imitation is stressed by recent findings in neurophysiology, where some visuomotor neurons (mirror neurons) may represent an internal motor representation related to the animal´s capacity of imitation.

Keywords: Imitation, Motor Representation, Topological Navigation, Computer Vision

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A Reconfigurable Control Architecture for Mobile Robots

G. Bruzzone	CNR-IAN, IT
M. Caccia	CNR-IAN, IT
P. Coletta	CNR-IAN, IT
G. Veruggio	CNR-IAN, IT

Abstract: In this paper we propose a method to design a reconfigurable control architecture for mobile robots. The Petri net formalism is used for the synthesis of an architecture that guarantees the correct behaviour of the system; the reconfiguration problem is stated as the one to mark a set of places of the net, and it is solved using heuristic search methods. Simulation results are provided to show the effectiveness of the proposed design scheme.

Keywords: Petri-Nets, Control System Design, Autonomous Mobile Robots

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A Probabilistic Approach for the Localization of Mobile Robots in Topological Maps

A. Vale	ISR/Instituto Superior Técnico, PT
M. I. Ribeiro	ISR/Instituto Superior Técnico, PT

Abstract: The navigation of mobile robots in outdoors environments is becomingincreasingly important fostered by a large number of challengingapplications. Localization, map building and world representation are key issuesfor the navigation in unstructured environments.This paper presents a probabilistic approach for the localizationof mobile robots aiming at outdoors applications. A Markov model anda topological map for world representation are the frameworks

that supportthe proposed algorithm. Simulation results illustrate the performance ofthe localization procedure.

Keywords: Mobile Robots, Localization, Markov Models, Topological Maps

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Interval Modelling of a SCARA Robot for Robust Control

M. García-Sanz Public University of Navarre, ES
I. Egaña Public University of Navarre, ES
J. Villanueva Public University of Navarre, ES

Abstract: This paper deals with the modelling of a SCARA robot, comprising the first and the second axis. The goal is to state an uncertain parametric model for robust control design. Therefore, the differential equations obtained by means of Lagrange´s method are analysed in order to outline suitable estimation experiments. Inertial parameters are compared to those derived from a CAD draft. Finally, a diagonal MIMO robust controller is designed to show the use of the proposed model.

Keywords: SCARA Robot Arm, Interval Modelling, Multivariable Systems, Quantitative Feedback Theory (QFT), Robust Control

THP 7	**15:30 – 17:30**	**VA - 5**
NON-LINEAR SYSTEMS		
Chair: J. Gonçalves	Calif. Inst. Techn., USA	

Quadratic Surface Lyapunov Functions in the Analysis of Feedback Systems with Double Integrators and Saturations

J. M. Gonçalves Calif. Inst. Techn., USA

Abstract: Many systems like servo systems, satellites, hard-disks, and CDplayers, can be modeled as linear systems with a single integratorand a saturation. Many times, such systems are controlled with a PIcontroller resulting in a feedback interconnection with a doubleintegrator and a saturation. In this paper, we propose a looptransformation that results in bounded operators so that classicalanalysis tools like mu-analysis or IQCs can be applied. In orderto show boundedness of all operators, we use quadratic surfaceLyapunov functions to efficiently check if a double integrator infeedback with a saturation nonlinearity has L2-gain less than´gamma >0´. We show that for many of such systems, the L2-gainis non-conservative in the sense that this is approximately equal tothe lower bound obtained by replacing the saturation with a constantgain of 1.

Keywords: Quadratic Surface Lyapunov Function, Double Integrator, Saturation, Impact Map, Robustness Analysis

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Way-Point Tracking of Underactuated AUVs in the Presence of Ocean Currents

A. P. Aguiar Instituto Superior Técnico, PT
A. M. Pascoal Instituto Superior Técnico, PT

Abstract: This paper addresses the problem of dynamic positioning and way-point tracking of an underactuated autonomous underwater vehicles (AUVs) in the presence of constant unknown ocean currents and parametric model uncertainty. A nonlinear adaptive controller is proposed that steers the AUV to track a sequence of points consisting of desired positions (x,y) in a inertial reference frame, followed by vehicle positioning at the final point. The controller is first derived at the kinematic level assuming that the ocean current disturbance is known. An exponential observer is then designed and convergence of the resulting closed loop system trajectories is analyzed. Finally, integrator backstepping andLyapunov based techniques are used to extend the kinematic controller to the dynamic case and to deal with model parameter uncertainty. Simulation results are presented and discussed.

Keywords: Underactuated Systems, Autonomous Underwater Vehicles, Way-Point Tracking, Nonlinear Adaptive Control

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The Hopf Bifurcation and Controlled Oscillations in Electromechanical Systems

F. Gomez-Estern Ingenieria de Sistemas y Automatica E.S Ingenieros, ES
J. Aracil Ingenieria de Sistemas y Automatica E.S Ingenieros, ES
F. Gordillo Ingenieria de Sistemas y Automatica E.S Ingenieros, ES

Abstract: This paper deals with the problem of obtaining stable and robustoscillations in electromechanical systems. The system istransformed via an appropriate feedback law into a generalized Hamiltonianclosed--loop system that exhibits a Hopfbifurcation. At this bifurcation emerges a limit cyclecorresponding to a stable and robust sinusoidal oscillation whereamplitude and frequency are adjustable parameters. The mostpowerful property of the method is that it provides a Lyapunovfunction for the stability of the oscillation: the closed--loopgeneralized energy function. The same holds for the criticalpoint on the non--oscillating side of the Hopf bifurcation.The method is illustrated by simulation and real experimentationon a magnetic levitation system.

Keywords: Nonlinear Control, Periodic Orbits, Hopf Bifurcation, Hamiltonian Methods, Passivity-Based Control

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Switching Control of Time-Varying Discrete Plants

L. M. Rato Universidade de Évora/INESC, PT
J. M. Lemos Instituto Superior Técnico, PT

Abstract: This paper describes a supervised discrete-times witching control algorithm.The supervisor chooses the controller among afinite set of candidate controllers.The process is assumed to be modelled by alinear time-varying discrete system.The process is described by a systemthat commutes among a finite set of discrete linear time-invariantmodels.This paper provesthe stability of the closed loop system if the time intervalbetween consecutive commuting instants is large enough.

Keywords: Switching Control, Time-Varying, Multiple-Model, Markov

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Approximate input-output feedback linearization for the Swinging Crane System Using a State Observer

J. Borges Instituto Superior Técnico, PT
M. Ayala Botto Instituto Superior Técnico, PT
J. Sá da Costa Instituto Superior Técnico, PT

Abstract: This paper presents an approach to handle the linearizationcontrol problem of nonlinear systems, specifically when theirrelative degree is not well defined. The mentioned approach isbased on an appropriate choice of the linearization law and on theintegration of a linear state observer in the controllinearization loop. The application of exact state feedbacklinearization methods to systems which fail to have a well definedrelative degree is normally impossible. Furthermore, as the methodis based on state feedback, its application is also impossiblewhen plant/model mismatches exists. As a consequence, theusefulness of these methodologies demands for new strategies suchthat an implementation to real-life problems renders possible. Theapproach followed in this paper represents a step into thesolution of this problem, which is corroborated by experimentalresults obtained from a laboratorial setup.

Keywords: Input-Output Feedback Linearization, State Observer, approximate Linearization, Experimental Setup

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Separation Principle for Nonlinear Systems in Critical Case

A. Fialova University of West Bohemia in Pilsen, CZ

Abstract: Stabilization and observer design are one of fundamental areasinvestigated in the system theory. Many articles have been dedicatedto these. For linear systems we have not problem with separation ofdesign of control and design of observer, but in case when we workwith nonlinear systems we have a many problems. This papers dealswith separation principle for special class of nonlinear system andby using theory of Central manifold.

Keywords: Non-Linear System, Local Stabilization, Local Observers.

FA 1 (invited)	**9:00 – 11:00**	**Amphitheatre**
NAVIGATION, GUIDANCE AND CONTROL OF AUTONOMOUS VEHICLES, I		
Chair: A. Pascoal		Inst. Superior Tecnico, PT

Efficient Computation of Dynamic Probabilistic Maps

J. P. Hespanha University of California, USA
H. H. Kizilocak University of Southern California, USA

Abstract: We develop efficient algorithms to compute probabilistic maps for a large number of mobile objects. By a probabilistic map we mean the probability density of the objects´ positions, conditioned to noisy sensor measurements. The main result of the paper is that, under suitable assumptions, the joint probability distribution of n objects that lie in a region partitioned into N cells can be approximately determined from an aggregate measurement function that can be represented with memory complexity o(N), regardless of the number of objects n. This is far more compact than an extensive representation of the joint distribution, whose memory complexity is o(N^n). In general, the approximation error introduced by this compact representation can be made arbitrarily small. Three main assumptions make this valid: the objects are indistinguishable from the sensor view-point, there is a minimum distance between any two of them, and their motion is essentially independent when they are far from each other.

Keywords: Probabilistic Maps, State Estimation, Kalman Filter, Markov Chains

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Stabilization of an Underactuated Autonomous Underwater Vehicle via Logic-based Hybrid Control

A. Aguiar Inst. Superior Tecnico, PT
A. Pascoal Inst. Superior Tecnico, PT

Abstract: This paper considers the problem of global stabilization of an underactuated autonomous underwater vehicle (AUV) in the horizontal planeto a point, with a desired orientation.Controllability and stabilizability properties of the vehicle model are discussed and a logic-based hybrid controller is proposed that yields global convergence of the AUV to an arbitrarily small neighborhood of the origin. Convergence and stability of the closed loop system are analyzed.To illustrate the performance ofthe control law developed, simulation results are presented using the model of the Sirene AUV.

Keywords: Nonholonomic and underactuated systems; autonomous underwater vehicles, hybrid control; stabilization.

Optical Triangulation-Correlation Sensors for Underwater Vehicles´ Motion Estimation

M. Caccia CNR-IAN

Abstract: The problem of providing a reliable estimate of the slow motion of unmanned underwater vehicles is faced by proposing, for near bottom applications, an optical triangulation-correlation sensor. Theoretical and experimental motivations of the proposed approach are discussed and preliminary results obtained from data gathered by a sensor prototype mounted on a ROV in operating conditions are reported.

Keywords: Motion Estimation, Underwater Vision

Vehicle Maneuvering and Multiarm Motion Coordination Within Grasping Operations

G. Casalino	DIST-Univ. of Genova, IT
G. Indiveri	DII - University of Lecce, IT
A. Turetta	DIST-Univ. of Genova, IT
M. Aicardi	DIST-Univ. of Genova, IT

Abstract: The paper deals with the problem of suitably coordinating the manoeuvring of a non-holonomic vehicle and the motion of a supported manipulation system (composed by one or two arms) when the overall system is commanded to execute a given grasping or manipulation task. The objective being clearly that of suitably exploiting the extra dof´s offered by the vehicle for better accomplishing the assigned task in cooperative way. Results are obtained by merging together some recent ones, relevant to the field of non-holonomic vehicle guidance and manoeuvring, with those concerning the coordination of fixed base multiarm manipulation systems.

Keywords: Multirobot, Robot Grasping, Vehicle Manoeuvring, Robot Cooperation

FA 2 (invited) 9:00 – 11:00 VA - 4

MODELLING AND CONTROL OF BIOTECHNOLOGICAL PROCESSES

Chair: S. Caraman Univ. of Galati, RO

Neuro-fuzzy Control of Microorganism Mean Age in Biotechnological Processes

S. V. Caraman	Dunarea de Jos University
L. Frangu	Dunarea de Jos University
E. Ceanga	Dunarea de Jos University
M. Barbu	Dunarea de Jos University

Abstract: The paper deals with the neuro-fuzzy control of the biosynthesis process of the alphaamylase and bacterial protease with microorganism Bacillus subtilis, which is a discontinuous one. The authors propose a control method based on the mean age information. The control strategy combines fuzzy and neural techniques for the determining of the process model and for the estimation of the necessary state variables. The models, the neural observer and the control strategy are validated by computer simulation, comparing the results to the experimental data offered by the Food Research Institute from Bucharest.

Keywords: Fuzzy, Neural Observer, Mean Age, Batch Biosynthesis Process

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State Estimation in Biotechnology: A Multi Models Interval Observer

H. Valdés-González	Laboratoire d´Automatique de Grenoble, FR
J-M Flaus	Laboratoire d´Automatique de Grenoble, FR
G. Acuña	Univ. de Santiago de Chile, CL
D. Boukraa	Laboratoire d´Automatique de Grenoble, FR

Abstract: This paper presents a multimodel interval observer based on a globally convergent Interval Moving Horizon State Estimation (IMHSE) method. The proposed technique is applied in a bounded error context over a biotechnological dynamical system described by a discrete-time non-linear model. The goal of this method is to detect dynamical variations of the involved model parameters in time. These variations are taken into account using several different models that will be commuted and used by our interval observer to reconstruct the states of the system. Our approach consists of using a model for the nominal dynamic state and other models to describe operating anomaly situations (perturbed parameters). Our algorithm informs us on-line which model best describes the behaviour of the system. An application of this methodology is illustrated with a real example of Solid Substrate Cultivation.

Keywords: MHSE, Interval Observer, Multimodel, Biotechnology

Bioprocesses Optimal Control Based on Hybrid Techniques: A Case Study

I. Dumitrache	Polytechnic Univ., RO
M. Caramihai	Polytechnic Univ., RO

Abstract: *not available*

Keywords: *not available*

Adaptive Control of Bioprocesses

C. Lupu	Polyt. Univ. Bucharest, RO
M. Haszler	Polyt. Univ. Bucharest, RO
D. Popescu	Polyt. Univ. Bucharest, RO

Abstract: This research study has been directed to a new and delicate field, of the biotechnology. Bioprocesses are characterised by time variable evolutions and non-linearities. The biosensors' wanting determines the complicated access to the bioparameters. The genetics changes or the metabolic variations of the micro-organisms make difficult the bioprocess reiteration. Because of the specific features of the bioprocesses, the control task is not so easy to realise. Taking into account the particularities of the bioprocesses, this paper recommends an adequate methodology for the bioprocess control. It proposes a solution for the automatic control of the technological parameters by means of a model based control design with its extended adaptive version. The advantage is immediately: the identification is made using experimental techniques, even in closed loop for linear models, the control design is based on the identified model and easily extended to its adaptive version in order to compensate the parameters variations.

Keywords: Adaptive, Control, Bioprocess, Identification

FA 3 (invited)	9:00 – 11:00	VA - 1
MODELING, ESTIMATION AND CONTROL INFINITE DIMENSIONAL SYSTEMS, I		
Chair: M.A. Demetriou	Worcester Polytechnic Inst., USA	

Auxiliary Signal Design for Multi-Model Identification in Systems with Multiple Delays

S. Campbell NC State University
K. Drake NC St University
R. Nikoukhah INRIA, FR

Abstract: In an active approach for model detection and its use in failure detection, an auxiliary control is applied in order to assist in model identification. Recentlyan active approach for robust multi-model identification and failure detection in the presence of bounded energy noise over possibly short time intervals has been introduced. This paper begins the examination of the extension of the original designprocedure to problems with several delays.The original infinite dimensional delay problem will be approximated by a finite dimensional non-delayed system.A number of approximation schemes for systems with delays have been developed in the literature, however, their use in this setting is new. Inthis paper we shall present computational tests comparing two different approximation approaches. One is based on a discretization and the other on a spline approximation approach.

Keywords: Identification, Delay, Auxiliary Signal

On-Line Fault Detection and Accommodation for a Class of Positive Real Infinite Dimensional Systems

M. Demetriou Worcester Polytechnic Institute

Abstract: The proposed work considers a class of positive real infinite dimensional systems which at some unanticipated instance experience actuator failures. In order to detect actuator failures for this class of systems, an infinite dimensional adaptive detection observer is proposed to monitor the system. By employing only input and output signals, a residual signal is generated which prior to any actuatorfailures is zero and upon the onset of any actuator failure attainsa nonzero value, thus indicating the presence of a failure. To diagnose/isolate the actuator failure, adaptive estimates of the actuator effectiveness (indicator) factors are proposed so that theypredict healthy actuators prior to failure and isolate the specific actuator failure by attaining a non-unity value. Accommodation of the actuator failures which takes the form of control reconfiguration is proposed for a specific type of actuator failures and simulation results of a 1-D heat conduction equation are presented.

Keywords: Fault Detection, Infinite Dimensional Systems, Positive Real Systems, Actuator Faults

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The Set of Divergent Infinite Products in a Banach Space is Sigma-Porous

S. Reich Israel Institute of Technology, IL
A. J. Zaslavski Israel Institute of Technology, IL

Abstract: Let K be a bounded closed convex subset of a Banach space. We study several convergence properties of infinite products of nonexpansive self-mappings of K. In our recent work we have considered several spaces of sequences of such self-mappings. Endowing them with appropriate topologies, we have shown that the infinite products corresponding to generic sequences converge. In this paper we present new results which show that the subsets consisting of all sequences of mappings with divergent infinite products are not onlyof the first Baire category, but also sigma-porous.

Keywords: Complete Metric Space, Fixed Point, Generic Property, Infinite Product, Porous Set

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On an Abstract Nonlinear Programming Problem

S. Aizicovici Ohio Univ., USA

Abstract: *not available*

Keywords: *not available*

FA 4 (invited)	9:00 - 11:00	VA - 2
FAULT DETECTION AND ISOLATION FOR MULTIVARIABLE SYSTEMS		
Chair: G.J. Balas	Univ. of Minnesota, USA	

A Geometric View on Inversion Based FDI for Linear Systems

A. Edelmayer CARI HAS
C. E. Vera Univ. Venezuela, VE
F. Szigeti Univ. Venezuela, VE

Abstract: Input reconstruction by means of dynamic system inversion is a relatively new idea to construct residual generators for robust detection and isolation of faults (FDI) in linear and nonlinear systems. The construction and calculation of the inverse from the FDI perspective, however, give rise to questions which cannot be successfully addressed relying on the results achieved in the past years. The paper presents a view on the properties of the inverse for linear multivariable systems from the point of view of the fault detection and isolation problem by using invariant subspaces and the results of classical geometrical system theory.

Keywords: Fault Detection And Isolation, Geometric System Theory, Inverse System, Input Observability, Input Reconstruction, Invariant subspaces, Inverse system, Linear systems.

System Inversion and Fault Detection: The Failure Affine Nonlinear Case

F. Szigeti Univ. Los Andes, VE
A. Bolivar Univ. Los Andes, VE

Abstract: In this paper, nonlinear system inversion is revisted in order to apply it to fault detection and isolation problem.The considered concept of invertibility is less conservative than the ones known in the literature, and the invertibility condition, in spite that a state space algorithm is proposed, does not depend on the given state space realization. Fault detectability concepts based on that inversion algorithm hence neither will depend on the state space realization. The main difficulty is in the residual generation combined by inversion.

Keywords: Fault Detection And Isolation, Nonlinear System, System Inversion, State Elimination

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Invariant Subspaces for LPV Systems and their Applications

J. Bokor Computer and Automation Research Institute, HU
Z. Szabo CARI HAS
G. Stikkel CARI HAS

Abstract: The aim of this paper is to extend the notion of (A,B)-invariant and (C,A)-invariant subspaces, known in the geometric control theory of the linear time invariant (LTI) systems, to the linear parameter-varying (LPV) systems by introducing the concept of parameter-varying (A,B)-invariant and parameter-varying (C,A)-invariant subspaces. The parameter dependence in the state matrix of these LPV systems is assumedto be in affine form.Algorithms are given to compute these subspaces and it is shown how these subspaces are related to certain invariant distributions if certain conditions are fulfilled for the parameters.As an application a condition is given for the solvability of disturbance decoupling problem for LPV systems. A numerical example is also provided.

Keywords: LPV Systems, Invariant Subspaces, Controllability, Observability

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Application of FDI to a Nonlinear Boeing-747 Aircraft

I. Szaszi Budapest University of Technology and Economics, HU
S. Ganguli Univ. of Minnesota, USA
A. Marcos Univ. of Minnesota, USA
G. Balas Univ. of Minnesota, USA
J. Bokor Computer and Automation Research Institute, HU

Abstract: This paper presents a fault detection and isolation (FDI) filter design for a linearized longitudinal dynamics of a Boeing 747 series 100/200. The FDI filterdesign is based on fundamental problem of residual generation (FPRG). In our case the fault detection filter is sensitive to elevator and stabilizer faults.Three types of actuator failures are considered in this paper: lock failure, loss in effectiveness and a float failure. The FDI filter design is based on open looplinearized model and applied in the closed loop to a high fidelity nonlinear model of the aircraft.

Keywords: Fault Detection, Invariant Subspaces, Nonlinear System

FA 5	9:00 - 11:00	VA - 5
NETWORKS		
Chair: C. F. G. Bispo	Instituto Superior Tecnico, PT	

A Hyperbolic Geometry Approach to Multipath Routing

E. A. Jonckheere University of Southern California, USA
P. Lohsoonthorn University of Southern California, USA

Abstract: A hyperbolic geometry method is devised for routing packets of the same message along multiple paths. The primary motivation is to defeat the attack scenario in which a link is compromised by ``eavesdropping.´´ Rerouting is restricted to be along near optimal paths to mitigate out-of-order packet arrival, against which TCP is not quite robust. On a hyperbolic graph, near optimal paths are called quasi-geodesics and have the property that they remain within an identifiable neighborhood of the optimal path, so that the search for near optimum paths can be narrowed down. More specifically, yet another property of hyperbolic graphs allows the near optimum paths to be computed as locally optimum paths, with a minimum modification of distance vectoring.

Keywords: Computer Network Security, Hyperbolic Graphs

Bifurcations of TCP and UDP traffic under RED

P. Ranjan University of Maryland, USA
R. J. La University of Maryland, USA
E. H. Abed University of Maryland, USA

Abstract: Recently researchers have proposed active queue management (AQM) mechanisms as a means of better managing congestion at the bottlenecks inside the network. Random Early Detection (RED) mechanism has been proposed to control the average queue size at the congested routers. Ithas been shown that the interaction between an RED gateway and TCP connections can lead to period-doubling bifurcation and chaos. In this paper we extend this model and study the interaction of the RED gateway with TCP and UDP connections, using a discrete-time model.We show that the presence of UDP traffic fundamentally changes the dynamics of the system. Second, with the help of bifurcation diagrams, we demonstrate the existence of nonlinear phenomena, such as oscillations and chaos, as the parameters of the RED mechanism are varied.

Keywords: Bifurcation, RED, TCP, UDP, AQM

Adaptive Predictive control of IP Traffic

B. A. Costa Instituto Superior Técnico, PT
M. S. Nunes Instituto Superior Técnico, PT
J. M. Lemos Instituto Superior Técnico, PT

Abstract: In this paper, automatic control principles are usedto control Internet IP traffic. A service model is proposed forapplications that can adapt their flows to available networkresources. The proposed service model is based on two servicesthat a network must provide, one with high Quality of Service (QS)possible based on resource reservation, and the other using theBest-Effort service. The flow of an application is composed of QSand BE packets. QS packets are used to obtain a minimum level ofQoS, while BE packets are used to improve the resourceutilization, to increase the throughput and to balance the cost ofthe transmission. A control algorithm is used to control the BEpackets in a end-to-end basis. This approach is analyzed in theDiffServ framework for Internet with quality-of-service (QOS).

Keywords: Adaptive, Predictive, Internet Traffic, Diffserv

A Sufficient Statistic Approach in Nonlinear Channel Gain Estimation of Flat Fading Wireless Channels from Noisy Measurements

C. D. Charalambous University of Otawa, CA
A. A. Nejad University of Otawa, CA
D. Makrakis University of Otawa, CA

Abstract: This paper employs a sufficient statistic to estimate the channel gains for flat fading wireless channels, when the measurements are corrupted by additive white Gaussian noise. These include optimal estimates for Rayleigh, Ricean, Log-Normal and Nakagami channel gains. The methodology consists of two steps. In the first step, a recursive equation which propagates the conditional distribution of the channel gain given the sample path of the observed data is formed. In the second step, this recursive equation is solved explicitly in terms of a finite number of statistics which are propagated recursively. The conditional distribution is a sufficient statistic, and therefore, its computation has direct implication in channel estimation, power control and receiver design. Simulation results illustrate the superiority of the optimal nonlinear estimators for high transmission rates and low signal-to-noise ratios. Such scenarios are expected to be seen in future broadband 4th generation wireless systems.

Keywords: Estimation, Filtering, Wirelss Fading Channels

Control of Discrete Communication Networks: Asymptotic Efficiency and Buffer Optimization

J. Hammer University of Florida, USA

Abstract: Asymptotic efficiency is an optimization criterion for maximizing the flow through large capacity networks. This note describes a control methodology that maximizes asymptotic efficiency in the presence of unmodeled traffic uncertainties. Often, feedback controllers can achieve asymptotic efficiency of 1 despite significant traffic uncertainties.

Keywords: Communication Networks, Robust Nonlinear Control, Efficiency, Feedback Control.

Non-Concurrent Error Detection and Correction in Fault-Tolerant Linear Finite-State Machines

C. N. Hadjicostis University of Illinois at Urbana-Champaign, USA

Abstract: Previous work constructed fault-tolerant linear finite-state machines (LFSMs) by embedding a given LFSM into a larger, redundant LFSM that preserves the evolution and properties of the original one while enabling an external mechanism to perform {em concurrent} error detection and correction. In this paper, we construct fault-tolerant LFSMs that allow the external mechanism to perform {em non-concurrent} error detection and correction (i.e., to perform checking periodically, for instance, once every N time steps). This approach relaxes the requirements on the reliability of the error detecting/correcting mechanism because the mechanism operates at a slower speed than the rest of the system. We discuss constructions for single error detection and also present a scheme which is based on BCH codes and allows efficient non-concurrent detection and correction of multiple errors.

Keywords: Fault Tolerance, Linear Coding, Linear Finite-State Machines, System Embeddings, Non-Concurrent Error Detection And Correction

FA 6	**9:00 - 11:00**	**VA - 3**
ROBOTICS III		
Chair: P. Lima	Instituto Superior Tecnico, PT	

Internet-Based Satellite Teleoperation of the Romeo ROV in Antarctica

Ga. Bruzzone CNR-IAN, IT
R. Bono CNR-IAN, IT
Gi. Bruzzone CNR-IAN, IT
M. Caccia CNR-IAN, IT
M. Cini CNR-SRT, IT
P. Coletta CNR-IAN, IT
M. Maggiore CNR-SRT, IT
E. Spirandelli CNR-IAN, IT
G. Veruggio CNR-IAN, IT

Abstract: In this paper the Internet-based satellite teleoperation system of the Romeo ROV (Remotely Operated Vehicle), will be described. Romeo is the latest ROV prototype developed by Robotlab, the Robotics Department of the Istituto Automazione Navale of Consiglio Nazionale delle Ricerche (CNR-IAN) for scientific applications and robotics research. Some teleoperation tests were carried out on the period December 2001 - January 2002 in the course of the XVII Italian Expedition to Antarctica. During the experiments, manifold users connected to the world wide web had the possibility to remotely operate Romeo immerse in the Antarctic sea nearby the Terra Nova Bay Italian Base.

These experiments are to authors; knowledge the first example of satellite teleoperation of a ROV directly usable by users surfing on the web.

Keywords: Underwater Robotics, Teleoperation, Internet

Design of the ISePorto Robocup Middle-Size League Robotic Soccer Team: Control, Localisation and Coordination

A. O. Martins	Instituto Superior de Engenharia do Porto, PT
J. Almeida	Instituto Superior de Engenharia do Porto, PT
E. Silva	Instituto Superior de Engenharia do Porto, PT
J. P. Baptista	Instituto Superior de Engenharia do Porto, PT

Abstract: This paper describes the design and implementation status of the ISePorto robotic football team for participation in Robocup Middle Size League (F2000). The objectives guiding the project were the applications and research in hybrid control and coordination systems. The system has also an educational support role. A special attention is made to the custom design to allow the execution of complex manoeuvres and team coordinated behaviours. The robot has different pass, shot, and manoeuvre capabilities providing high level tactical and strategic planing and coordination. The current team status is also covered.

Keywords: Control Applications, Robocup, Robotic Soccer, Mobile Robotics, Vehicle Control

A Remote Experiment on Motor Control of Mobile Robots

A. Khamis	Carlos III Univ. of Madrid, ES
M. P. Vernet	University of Applied Sciences FH Ravensburg-Weingarten, DE
K. Schilling	University of Applied Sciences FH Ravensburg-Weingarten, DE

Abstract: Laboratory experiments are essential in engineering education, current telematics techniques allow now to offer such experiments with real hardware also via Internet. Here a survey on the design and implementation of such remote experiments are addressed. Particular emphasis is on user interface enhancement through the use of virtual reality, as well as on network performance tests.

Keywords: Mobile Robots, Telematics, Virtual Laboratories, Virtual Reality

Control System of a Demining Robot

L. Marques	University of Coimbra, PT
M. Y. Rachkov	Inst. of Systems and Robotics, PT
A. T. de Almeida	Inst. Systems and Robotics, PT

Abstract: This paper describes methods and experiments used to control and adjust the trajectory of a pneumatic walking robot for landmine detection. The structure of the robot is optimised to scan natural terrains with a landmine detection system. The robot control architecture is presented. A description of the rotation methods implemented to adjust the course to the planned trajectory is provided jointly with experimental results. Implementation of on-board control system and mine detection block are presented.

Keywords: Humanitarian Demining, Legged Robots

Mobile Robot Control Architecture via Control Output Fusion: Stability Issues

E. O. Freire	Universidade Tiradentes, BR
T. F. Bastos-Filho	Universidade Federal do Espirito Santo, BR
M. Sarcinelli-Filho	Universidade Federal do Espirito Santo, BR
R. Carelli	Univ. Nacional de San Juan, AR

Abstract: A new architecture proposed by the authors in previous papers for controlling the navigation of a mobile robot, called fusion of the output of different controllers, is considered again. The novelty here included is the analysis of the stability of such control architecture. Both a formal Lyapunov-type analysis and a conjecture based on energy considerations are presented. In addition, a supervisor is included in the original control architecture in order to allow detecting changes in the robot navigation phases and ensuring the accomplishment of the stability conjecture. The control system thus modified is implemented in a commercial robot and practical experiments are run. Their results are presented in order to illustrate the system performance.

Keywords: Mobile Robots; Robot Control; Data Fusion; Information Filter; Lyapunov Functions

A Master-Model Based Stable Time Delayed Force Feedback Systems

H. M. Arioui	LSC, Evry University, FR
A. Kheddar	LSC, Evry University, FR
S. Mammar	LSC, Evry University, FR

Abstract: In this paper a controller derived from Smith predictor for non-varying time delayed force reflecting interaction devices is presented. A feedback law which compensates the time delay by its elimination from the characteristic equation of the closed loop system is developed. The originality of the method consists in using only the master device model to achieve a ``prediction´´ on the remote force reflecting environment (real or virtual). This method is robust within certain calculated safe intervals. Effects of model estimation errors on stability are considered, simulation results about performances are also given. The method is easy to implement within a frame of force refelecting real or virtual teleoperators.

Keywords: Teleoperation, Virtual Reality Haptics, Time Delay, Force Feedback

FA 7	9:00 - 11:00	VA - 6
CONTROL METHODS		
Chair: F. Fahroo	Naval Postgraduate School, USA	

Identification and Predictive Control of Wiener Nonlinear Systems

L Gonçalves	Universidade de Trás-os-montes e Alto Douro, PT
T. Mendonça	Universidade do Porto, PT
J. M. Lemos	Instituto Superior Técnico, PT

Abstract: Wiener models consisting of a linear dynamic element followed n series by a static nonlinear element are considered to be ideal for representing a wide range of nonlinear processes behaviour. In this paper we propose a system dentification approach to Wiener models with unmeasurable internal signal.Using the proposed algorithm, the nternal signal s recovered and the Wiener model s ncorporated nto a SISO GPC based control scheme. Thus, removing the nonlinearity from the control problem the resulting system preserves many of the favorable properties of linear predictive control.The applicability of the proposed algorithms s illustrated using simulations.

Keywords: System Identification, Predictive Control, Wiener Systems

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An I/O Mixed Constrained Stabilizing MPC Apllied to Nonlinear Processes

J. M. Igreja	DEQ - ISEL - IPL, PT
J. E. Cruces	DEQ - ISEL - IPL, PT

Abstract: A constrained stabilizing receding horizon predictive controller is developed in GPC framework. The open loop QP minimization problem with mixed constraints over the prediction horizon is formulated. The optimization subroutine uses Lemke;s method to attempt to minimize the objective quadratic function subject to a set of linear restrictions for the non-negative decision variables. Closed loop stability conditions are discussed for the unconstrained and constrained cases. Feasibility management is also addressed. Two illustrative simulation applications of nonlinear chemical reactors models are presented.

Keywords: Constrained predictive control, Adaptive Control, Nonlinear Processes, Quadratic Programming, Stabilizing Feedback, Infeasibility Manegement.

Use of Filtered Smith Predictor in DMC

C. Ramos	Politechnic Univ. of Valencia, ES
M. Martínez	Politechnic Univ. of Valencia, ES
X. Blasco	Politechnic Univ. of Valencia, ES
J. M. Herrero	Politechnic Univ. of Valencia, ES

Abstract: The use of DMC in industry is very extended.Traditionally, its formulation has been based on the Dynamic Matrix model, obtained from the step response of thesystem. This work shows an alternative formulation that is based on a transfer function model, and divides the DMC intotwo parts: controller and predictor. This allows the easy substitution of one for another. Thus, SPDMC is obtained bysubstituting the predictor for the Smith predictor (SP) - this being equivalent to DMC. The SPDMC properties have beenmade more robust by adding filters.

Keywords: Lowpass Filters, Predictive Control, Prediction Methods, Delay Compensation, Robustness.

Exploiting Higher-Order Derivatives in Computational Optimal Control

I. M. Ross	Naval Postgraduate School, USA
J. Rea	Massachusetts Inst. of Tech., USA
F. Fahroo	Naval Postgraduate School, USA

Abstract: In this paper we present a new way of approximating higher order derivatives arising naturally in the dynamics derived from the Newton´s second law. This efficient and accurate way of approximation results in reduction in size in the number of unknown variables in the discretized optimal control problems. Fast and convergent solutions will then be guaranteed from the nonlinear programming (NLP) solvers. A numerical example illustrates the difference in the formulation using first order and second order forms and compares the numerical results.

Keywords: Optimal Control, Discretization, Higher Order Derivatives

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Sequential Experimental Design and Extremum Control

L. Pronzato	CNRS-Université Nice, FR
E. Thierry	CNRS-Université Nice, FR

Abstract: We consider the situation where one wants to maximise a $f(q,x)$ with respect to x, with $f(q,x)$ linear in q,q unknown and estimated from observations $y_k = f(q,x_k)+e_k$, where e_k is a random error (linearregression model). Special attention is given to sequences defined by $x_{k+1} = \arg\max_x f(\hat{q}^k,x)+a_k d_k(x)$ with an estimated value of mt obtained from$(xb_1,y_1),ldots,(xb_k,y_k)$ and $d_k(xb)$ a penalty for poorestimation. Asymptotic results are given (strong consistency ofmth^k) for a particular penalty function d_k and suitableweighting sequences ${alpha_k}$. Approximately optimal rulesare suggested for the finite horizon case where one wants tomaximize $sum_{i=1}^N w_i f(mt,xb_i)$, with ${w_i}$ a givenweighting sequence. Various examples are presented.

Keywords: Extremum Control, Adaptive Control, Experimental Design, Response Optimisation, Sequential Design.

Almost Sure Stability of Jump Parameter Systems: Homotopy versus LMI-Based Algorithms

Y. B. Cheikh	Laboratoire ACS, ENIT,TN
J. Ezzine	Laboratoire ACS, ENIT,TN

Abstract: In this paper we present a homotopy method that locally solves an optimization problem subject to bilinear matrix inequality (BMI) constraints. This problem arises while testing the almost sure (a.s.) stability of jump parameter systems. This stability criterion uses the Lyapunov exponent concept and related results. The method linearizes the BMI optimization problem for the calculation of the Lyapunov exponent upper bound using a first order perturbation approximation. This first order perturbation that improves the upper bound is iteratively optimized by solving an optimization problem subject to linear matrix inequality (LMI) constraints. This process is repeated until the performance cannot be improved any further. Several examples are presented and comparisons of the proposed homotopy method with an altering one are discussed.

Keywords: Almost Sure Stability, Jump Parameter Systems, Lyapunov Exponent, Linear And Bilinear Matrix Inequality.

FP 1 (invited)	**15:30 – 17:30**	**Amphitheatre**

NAVIGATION, GUIDANCE AND CONTROL OF AUTONOMOUS VEHICLES, II

Chair: I. Kaminer — Naval Postgraduate School, USA

Aerodynamically Coupled Formation Flight of Aircraft

D.F. Chichka	Univ. Calif. at Los Angeles, USA
J. D. Wolfe	Univ. Calif. at Los Angeles, USA
J. L. Speyer	Univ. Calif. at Los Angeles, USA

Abstract: *not available*

Keywords: *not available*

Path Following Control for an Autonomous Helicopter

R. Cunha	Inst. Superior Tecnico, PT
C. Silvestre	Inst. Superior Tecnico, PT
A. Pascoal	Inst. Superior Tecnico, PT
I. Kaminer	Naval Postgraduate School, USA

Abstract: This paper presents a new methodology for the de-sign of path following controllers for autonomous helicopters. The method builds on three key results: i) the trimming trajectories of helicopters are helices parameterized by the vehicle's linear speed, yaw rate, and flight path angle; ii) steering the vehicle along a trimming path at constant speed is equivalent to driving a tracking error to zero, and iii) the linearization of the error dynamics about any trimming path is time-invariant. The problem is cast and solved in the framework of gain scheduling control theory.

Keywords: path following, gain-scheduled control, unmanned air vehicles, guidance and control.

Development, Simulation and Flight Test of a Guidance and Control Algorithm for Circular Parachutes

O. Yakimenko	Naval Postgraduate School, USA
V. Dobrokhodov	Naval Postgraduate School, USA
J. Johnson	Naval Postgraduate School, USA
I. Kaminer	Naval Postgraduate School, USA
S. Delliker	U.S. Army (Yuma), USA
R. Benney	U.S. Army (Natick), USA

Abstract: This paper addresses the development of autonomous guidance, navigation and control algorithms for a flat solid circular parachute. This effort is a part of the Affordable Guided Airdrop System (AGAS) that integrates a low-cost guidance and control system into fielded cargo air delivery systems. First the paper describes underlying AGAS concept. Then it suggests a synthesis of a classical optimal control for the AGAS based on Pontrjagin's maximum principle. It also gives an explanation of the practical control algorithm im-plemented in simulations and in flight tests of AGAS and provides some key examples. It pro-ceeds with a brief description of a parachute model developed in MTALAB Simulink environment and used in simulations. Results of the final AGAS flight test performed at the U.S. Army Yuma Prov-ing Ground (YPG) in September 2001 are also pre-sented. The paper ends with conclusions.

Keywords: Controlled Parachute, Optimal Control, Stability, Flight Test

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A Nonlinear Vision Based Tracking for Coordinated Motion Control of Marine Vehicles

P. Oliveira	Inst. Superior Tecnico, PT
A. Pascoal	Inst. Superior Tecnico, PT
I. Kaminer	Naval Postgraduate School, USA

Abstract: This paper proposes a vision based tracking system to estimate the position and velocity of an Autonomous Underwater Vehicle (AUV) relative to an Autonomous Surface Craft (ASC).Nonlinear estimator design builds on the theory of linear parametrically varying (LPV) systems. The theoretical framework adopted provides a powerful tool for regional estimator stability and performance analysis. Simulations illustrate the performanceof the tracker developed.

Keywords: Nonlinear Filters, Lpvs, Autonomous Vehicles, Vision Systems

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FP 2 (invited)	15:30 – 17:30	VA - 4

ADVANCES IN DYNAMICS, CONTROL AND NAVIGATION FOR MOBILE ROBOTIC SYSTEMS

Chair: B.A. White — Cranfield Univ. UK

Intelligent Control Design for Autonomous Mobile Robot

A. Tsourdos — Cranfield University-RMCS
J. T. Economou — Cranfield University-RMCS
B. A. White — Cranfield University-RMCS

Abstract: In this paper, a fuzzy logic Takagi-Sugeno inference algorithm is proposed for a multiple-input multiple-output differentially steered mobile robot. The resulted closed-loop system has an effective control for both the vehicle longitudinal velocity and the vehicle yaw rate without causing actuator saturation. The algorithm developed for the fuzzy logic tracking pole placement control method allows the shaping of the system time response meeting all the design objectives. The proposed scheme shows effectiveness for a realistic simulation scenario.

Keywords: Mobile Robot, Pole-Placement, Fuzzy Logic

Visual-Based Planning and Control for Nonholonomic Mobile Robots

A. De Luca — DIS, Univ. Roma "La Sapienza"
G. Oriolo — DIS, Univ. Roma "La Sapienza"
L. Paone — DIS, Univ. Roma "La Sapienza"
P. R. Giordano — DIS, Univ. Roma "La Sapienza"
M. Vendittelli — DIS, Univ. Roma "La Sapienza"

Abstract: An integrated visual-based approach to motion planning and control of a nonholonomic mobile robot is presented. An A* motion planner generates collision-free paths considering nonholonomic constraints in cost and heuristic functions. Planning results for unicycle and car-like robots are given, with an experiment on the mobile robot SuperMARIO in an unknown indoor environment using visual feedback and a nonlinear trajectory tracking controller.

Keywords: Visual Feedback, Nonholonomic Mobile Robots, Motion Planning, Nonlinear Control

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Cooperation Between Visual and Inertial Information for 3D Vision

J. M. Dias — ISR-University of Coimbra, PT
J. Q. Lobo — ISR-University of Coimbra, PT
L. A Almeida — IPT, Tomar, PT

Abstract: Advanced sensor systems, exploring high integrity and multiple sensor modalities, have been significantly increasing the capabilities of autonomous vehicles and enlarging the application potential of vision systems. The article describes the cooperation between two relevant sensors - vision systems and inertial sensors. Vision and inertial sensing are two sensory modalities that can be explored to give robust solutions on segmentationof images and three-dimensional vision. This cooperation between these two sensory modalities maybe useful for the elaboration of high-level representationssuch as multi-modality 3D maps, segmentation of leveled ground or vertical structures. In this paper we propose a real-time system that extracts information from dense relative depth maps. This method enables the integration of depth cues on higher level processes including segmentation of structures, object recognition, robot navigation or any other task that requires a three-dimensional representation of the physical environment.

Keywords: Computer Vision, Robotics, Sensor Fusion, Inertial Systems, 3D Depth Maps.

Robotic Navigation Through Neurofuzzy Maps Mimicking the Human Hippocampus

P. A. Prokopiou — ICCS/NTUA
E. S. Tzafestas — ICCS/NTUA

Abstract: A major aim of bioengineering research is to provide appropriate interfacing between biological and technical systems. In order to exploit the "expertise" of the evolution process, by initially mimicking the architectural structure of biological maps and in a future stage by being able to "upload" map elements from biological brains to compatible computers, we tested the suitability of a model of the hippocampus for robotic navigation. The proposed system extends the model of Burgess, O´Keefe et al, to incorporate dynamic objects´ and flocks´ modeling, and is reformulated as a Generalized Radial Basis Function Network. The produced mapping is linked in a mathematical way with standard robotic probabilistic map-building tools and neurofuzzy systems, thus enabling the direct interpretation of the map data and its exploitation for the control of robot movement. Inversion of the mapping is discussed. The value of range and visual senses for rodents and primates is highlighted. Experiments and simulations were performed, supporting the above results. Two mobile robots were tested, K-Team´s Khepera and Robosoft´s Robuter III robots.

Keywords: Map Building, Biomimetic Navigation, Mobile Robotics, Neural Networks

FP 3 (invited)	15:30 – 17:30	VA - 1

MODELING, ESTIMATION AND CONTROL INFINITE DIMENSIONAL SYSTEMS, II

Chair: M.A. Demetriou — Worcester Polytechnic Inst., USA

A New Integrated LMI-based Control and Activation Strategy for Transport Processes

M. Demetriou — Worcester Polytechnic Institute, USA
N. Kazantzis — Worcester Polytechnic Institute, USA

Abstract: The present research work deals with the systematic development and implementation of a practical algorithm for an integrated actuator activation and control policy realized by a novel scheme of moving actuators for transport processes modeled by parabolic partial differential equations (PDEs).It should be pointed out, that systems of parabolic PDEs for transport processes are frequently

encountered in practice in a multitude of industrial applications. Under the proposed algorithmic scheme, it is assumed that the process/system of interest has multiple actuators and the desirable arrangement is to activate only one during a given time-interval while keeping the remaining ones dormant. The same algorithm can be applied to transport processes with a single actuator capable of moving at a priori selected positions within the spatial domain. Feedback controller synthesis methods based on linear matrix inequality (LMI) techniques are employed for a finite-dimensional Galerkin approximation of the original distributed parameter system. It should be pointed out that in addition to standard controllability criteria imposed on the set of admissible actuator locations, additional conditions are imposed that not only render the aforementioned LMIs feasible, but also ensure robustness with respect to disturbances (i.e. performing the appropriate gain-minimization in a set of spatially-parameterized polytopic LMIs). The value of an appropriately selected performance functional is then explicitly calculated by solving a location-parameterized family of Lyapunov matrix equations, and then optimized with respect to the set of admissible actuator locations. The above algorithm leads to a systematic and quite transparent integrated control and actuator activation policy that enhances the performance and improves robustness of transport processes. Finally, a representative case study of a typical industrial diffusion process will be presented where the performance-enhancing capabilities of the proposed control and actuator activation algorithmic scheme is evaluated through detailed simulation studies.

Keywords: Infinite-Dimensional Systems; Actuator Activation; Lmis; Spatially Varying Disturbances; Transport Processes; Process Control

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Remarks on the Theory of Turbulence: A Large Deviations Theory Approach

C. D. Charalambous Univ. of Ottawa, CA

Abstract: In this paper, we present some remarks on the general theory of turbulence flow, in which the fluid experiences small viscosity. In particular, starting with a simplified version of the Navier-Stokes equations, we introduce several partial differential equations, whose solutions are described through probabilistic representations using Wiener processes, free energy, relative entropy and stochastic optimization. In the limit as the kinematic viscosity goes to zero, we establish reduced order partial differential equations using the concept of viscosity solutions to partial differential equations, and we describe the limiting behavior using concepts from Large Deviations theory. Subsequently, we introduce deterministic measures with respect to the (max,plus) algebra, which can be used to describe the solution of the Navier-Stokes equations, when the kinematic viscosity is small.

Keywords: Navier-Stokes, Large Deviations, (Max,Plus)-Algebra

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Distributed Parameter Thermal Controllability Through the Green-Galerkin Method: A One Dimensional Optimization Case Study

Tarek Alaeddine Tufts University, USA
Haris Doumanidis Tufts University, USA

Abstract: The Green-Galerkin method has been shown to successfully address the problem of thermal control in heat conduction problems. This article investigates the effect of altering the iterative time step and duration of processing time, on the convergence of the solution generated by the aforementioned method. Various simulations are conducted to prove that despite the variations in numerical processing, the iterative method is able to solve the problem of inverse heat conduction encountered in thermal processing of solids. Furthermore, it is shown that an optimal processing time and iterative time step can be identified, such that the error between the temperature field that is actually achieved and the desired one is significantly reduced.

Keywords: Distributed Parameter Systems

Convergence Results for Discrete and Continuous Descent Methods

S. Reich Israel Institute of Technology, IL
A. J. Zaslavski Israel Institute of Technology, IL

Abstract: We first review our recent convergence results for discrete descent methods for the minimization of convex functions defined on a general Banach space and then present new results regarding continuous descent methods. Our results involve the notion of sigma-porosity which is a refinement of the notion of the first Baire category.

Keywords: Complete Metric Space, Convex Function, Descent Method, Porous Set.

FP 4	15:30 – 17:30	VA - 3

FAILURE DETECTION

Chair: Z. Vukiæ University of Zagreb, CR

Active Failure Detection: Auxiliary Signal Design and On-line Detection

R. Nikoukhah INRIA, FR
S. L. Campbell NC State University, USA

Abstract: This paper describes an active approach for model identificationand failure detection in the presence of quadratically boundeduncertainty. After developing the underlying geometry, two particularexamples of this approach involving static and continuous models aredescribed. Several examples are given.

Keywords: Failure Detection, Auxiliary Signal, Model Identification

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Diagnosability of Hybrid Systems

G. K. Fourlas National Technical University of Athens, GR
K. J. Kyriakopoulos National Technical University of Athens, GR
N. J. Krikelis National Technical University of Athens, GR

Abstract: In this work we introduce the notion of diagnosability of Hybrid Systems. We present a methodology for detection of faults imposing the conditions for a Hybrid System to be diagnosable. The states of the Hybrid System model reflect the normal and the failed status of the system components. The faults in our setting are modeled as either discrete or continuous (detrimental) state changes.

Keywords: Fault Detection, Fault Diagnosis, Diagnosability, Hybrid Systems

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Fault Detection and Classification for Underwater Vehicles

J. H. Kim George Mason University, USA
G. O. Beale George Mason University, USA

Abstract: This paper describes the application of the Hotelling´s T^2 statistic to the detection and classification of the failures that may occur in underwater vehicles. The number of fault classes is five. The study confirms that there exists an inherent classification capability built in principal component analysis associate with T^2 statistic.

Keywords: Failure Detection, Failure Classification, Reconfigurable Control, Principal Component Analysis, T-Squared Statistic

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Simultaneous fault detection and control

M. J. Khosrowjerdi K.N.Toosi Univ. of Tech., IR
R. Nikoukhah INRIA, FR
N. Safari-Shad University of Wisconsin, USA

Abstract: In this paper, we consider a problem of Simultaneous Fault Detection and Control (SFDC). After presenting a fundamental separation result, we show that this problem is naturally modeledin terms of a mixed H_2/H_infinity optimization problem. We present a constructive method for obtaing the solution to this problem leading to the design of a reduced-order implementablecontroller/detector system.

Keywords: Fault Detection, Fault Isolation, Robust Control, Mixed H_2/H_Infinity Optimization

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Adaptive Observer Based Fault Diagnosis Approach Applied to a Thermal Plant

L. Palma UNL-FCT-DEE, PT
F. Coito UNL-FCT-DEE, PT
R. Silva UNL-FCT-DEE, PT

Abstract: This paper presents an on-line model-based procedure for the detection and diagnosis of sensor and process faults in plants. The detection and diagnosis method proposed is based on parity equations and on an adaptive observer based approach. The authors propose the use of dynamic features (static gain and bandwidth) of black-box (AutoRegressive with eXogenous input - ARX) models, as features for fault detection and diagnosis purposes. The ARX models of the thermal process under investigation are obtained by close-loop recursive identification techniques. Residual analysis and geometrical tests are then used for fault detection and diagnosis, respectively. The proposed procedure has been evaluated using a benchmark thermal process.

Keywords: On-Line Fault Detection And Diagnosis, Thermal Plants, Closed-Loop Identification, Adaptive Observers.

Simplified Life Cycle Models for Industrial Equipment

T. L. Johnson GE Global Research Center, USA

Abstract: Principles of dynamic and hybrid system modelling can be used to provide simplified wear, aging, and repair processes for industrial systems. These models are of potential use in condition based maintenance and predictive diagnostics for such equipment. This paper explores a very simple class of models that can be used to represent a variety of wear and aging phenomena with a small number of parameters.

Keywords: Wear Models, Life Cycle, CBM, Hybrid Systems.

FP 5	**15:30 – 17:30**	**VA - 2**
PROCESS CONTROL		
Chair: P. Lima	Instituto Superior Técnico, PT	

Method for Steady-State Optimal Control of an Ion Exchange Column

R. Tzoneva Peninsula Technikon, ZA

Abstract: The problem for steady state optimisation of ion exchange column is considered. State space model and a decomposition method are developed to solve the problem for steady state optimisation of a counter-current ion exchange process for desalination of water. The goal is minimum of the quadratic criterion for the errors between the real values of the state and control variables and their set points. The method is based on a function of Lagrange and its full decomposition on the basis of prediction of the dual variables. The method is applied for the pilot ion exchange plant for desalination of water.

Keywords: Counter Current Ion Exchange Process, Process Model, Steady State Optimization, Lagrange Function, Hierarchical Structure

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An Operation System for Industrial Processes: Application to a Glass Furnace

J. M. Pina Faculdade de Ciências e Tecnologia, PT
P. U. Lima Instituto Superior Técnico, PT

Abstract: An architecture for the operation of industrial processes is presented in this paper. It is based on an expert controller whose main functions are process optimisation and

fault detection. Only process optimisation is detailed here. The operation system has two main sub-systems: a Multiobjective Optimisation System, based on genetic algorithms, and a Learning System, based on fuzzy rules, which are both described. A glass furnace application is described as a case study, including some results with real data.

Keywords: Process Operation Architecture, Glass Furnaces, Fuzzy Logic, Genetic Algorithms, Multiobjective Optimisation

Binary Distillation Column Control Based on State and Input Observability

A. Rios-Bolivar Universidad de Los Andes, VE
F. Szigeti Universidad de Los Andes, VE

Abstract: In this paper, a method for the design of nonlinear observers and input reconstruction is proposed. The state and input observers is computed following the Diop´s differential algebraic state elimination approach. In the input reconstruction case the input observability is equivalent to system inversion condition. The elimination procedure is utilized for dual composition control of binary distillation columns. The particular observer allows us to recover the unmeasured feed composition, i.e., the input reconstruction, which is used in the controller design in order to maintain desired compositions. The method is an alternative against the disturbance decoupling procedure.

Keywords: Nonlinear Observers, Input Observability, State Elimination, Binary Distillation Column Control, System Inversion

Cell-Shaped Actuator Model from Electrochemistry Theory

A. G. Garcia Instituto Superior Técnico, PT

Abstract: The study of electro mobility in human cells andits structure states that they use liquid solutionsto obtain movement. In this work it is proposeda model of an artificial cell composed of liquidsolutions that permit flexibility of its completestructure. These kind of actuators can generatein the future real robotic arms towards theimplementation of inmunologically skeleticprothesis.

Keywords: ICPF, Solution, Action Potentials, Plasmatic Membrane

Synchronization Mechanism in Integrated Simulation for Manufacturing Systems

K. Furusawa Mitsubishi Electric Corp., JP
T. Yoshikawa Mitsubishi Electric Corp., JP

Abstract: We are developing an integrated simulation environment for manufacturing systems. We propose a synchronization mechanism between multiple integrated simulators, which effectively guarantees timed consistency among the simulators. In this paper, we illustrate the proposed synchronization mechanism which is based on message passing, and we show its validity using examples.

Keywords: Distributed Systems, Integrated Simulation, Manufacturing, Synchronization

Modelling of Communication in a Distributed Robotic System by use of Rose RealTime UML

I. Schojølberg SINTEF, N-7465 Trondheim, NO
E. Kyrkjebø SINTEF, N-7465 Trondheim, NO
G. Mathinsen SINTEF, N-7465 Trondheim, NO

Abstract: This paper explores aspects concerning the design of distributed robotic systems with strict time constraints. Real-time properties affecting the co-ordinated control of a manipulator arm and a high speed-manufacturing tool is considered. The system is modelled by use of Unified Modelling Language (UML). The main result is a model of the total system with focus on the communication structure in the system. This model gives the possibility to simulate the system and to verify consistency and completeness of system specification. The main contribution of this work is to show how the given system can be modelled so that the critical real-time properties of the system can be investigated.

Keywords: Robotic System, Time-Critical, Uml, Real-Time, Distributed.

FP 6	**15:30 – 17:10**	**VA - 6**
OPTIMAL CONTROL		
Chair: M. R. de Pinho		FEUP, PT

The Use of Gauge-Function in Direct Methods Based on Canonical Equations

Z. D. Jelicic Faculty of Engineering, YU
D. P. Petrovacki Faculty of Engineering, YU

Abstract: The extension of the specific optimal control method is presented. This method is direct method based on a canonical equations of dynamic optimization, and as a result supplies closed loop control. In order to expand capabilities in integration of this canonical equation we propose their gauge-function generalisation. The efficiency of extended method is illustrated on a Van de Vusse reaction model.

Keywords: Specific Optimal Control, Direct Methods, Gauge-Function, Nonlinear Dynamics

Necessary Conditions in Euler-Lagrange Form for Constrained Nonconvex Optimal Control Problems

M. R. de Pinho FEUP, PT
M. M. A. Ferreira FEUP, PT
F. A. C. C. Fontes Universidade do Minho, PT

Abstract: Necessary conditions of optimality in the form of anEuler Lagrange Inclusion are presented for optimal control problemswith state constraints. A feature of these conditions is that they allow nonconvex velocity sets, generalizing

previously results.These conditions are then applied to a more general problem,comprising not only state constraints but also mixed constraintsin the form of equalities, also known as bilateral state dependent control contraints.

Keywords: Optimal Control, Maximum Principle, State Constraints, Mixed Constraints, Nonsmooth Analysis

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Parametric Dynamic Programming for Discrete event Systems

J. J. Cardillo Universidad de Los Andes, VE
J. C. Hennet LAAS-CNRS, FR
J. L. Calvet LAAS-CNRS, FR
F. Szigeti Universidad de Los Andes, VE

Abstract: This paper proposes a method based on formal calculus to optimize trajectories described by a succession of discrete states, by means of combining the Dynamic Programming technique with the formal approach presented in [4]. This method allows to obtain an explicit form of the optimal control sequence, based on formal calculus. It also allows to introduce parameters in the system model as well as in the cost function. The control law is then expressed as an explicit function of these parameters.

Keywords: Formal Calculus, Dynamic Programming, Discrete Optimization, Discrete Event Systema

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Whether and in What Sense the Observer Based LQ Regulator is Optimal

R. S. Gessing Silesian Univ. of Technology, PL

Abstract: It is shown, that in multi-variable systems, the usual observers used with the state feedback LQ regulator law are optimal for some adequate initial conditions. It is also shown, that for the systems with determined excitations the optimal for transients LQ regulator with output feedback results from the Deterministic Equivalence Principle, formulated and proved in the paper. The principle says that the regulator equations result from substituting in the LQ state control law the state estimate obtained from the reduced order, Luenberger observer. Both the problems: control and observer may be solved separately. The continuous- and discrete-time problems are described, in parallel.

Keywords: Linear-Quadratic Regulator; Continuous-Time Systems; Multi-Variable Systems; Observers; Optimal Control

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Solvability of Linear-Quadratic Discrete Optimal Control Problems for Descriptor Systems in Hilbert Space

G. A. Kurina Voronezh State Forestry Academy, RU

Abstract: The solvability of the linear-quadratic optimal control problem is established for descriptor systems with variable coefficients in a Hilbert space. The basic result is the theorem on reducing of the implicit discrete system, following from the control optimality condition, to the explicit non-negative standard Hamiltonian system.

Keywords: Discrete Descriptor Systems, Hilbert Space

FP 7	**15:30 – 17:30**	**VA - 5**
NON-LINEAR CONTROL		
Chair: I. Eksin	Istanbul Technical University, TR	

Sliding Mode Control Using a Nonlinear Time-Varying Sliding Surface

S. Tokat Istanbul Technical University, TR
I. Eksin Istanbul Technical University, TR
M. Guzelkaya Istanbul Technical University, TR

Abstract: In this study, the performance of a classical sliding mode controller with a constant, linear sliding surface is improved by using a nonlinear function that has an effect on the discontinuous control part of the sliding mode control law. Furthermore, the equivalent control is calculated at each time step by considering a linear sliding surface passing through the origin and the representative point. An important property of the nonlinear function that has been used in the discontinuous part is that it has a simple geometric interpretation and the parameters related to it are easily determined. Simulations are performed on a typical second order linear system with bounded disturbance. Simulated results have shown an improved performance of the proposed method in terms of a decrease in the reaching time, robustness to disturbances and smoother phase plane trajectory as compared with the classical sliding mode controller.

Keywords: Sliding Mode Control, Sliding Surface Design, Nonlinear Time-Varying Surface

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On Non-linear Control Systems and an Associated System of PDEs

J. D. Stefanovski HS Strezevo, MK
G. M. Dimirovski Dogus University, TR

Abstract: A class of systems of PDEs has been studied in conjunction with the model of general non-linear control systems with state vector x on an n-dimensional maniforld M, f(x,u) vector field for all control vectors u with values in an open set ´Omega´ included in m-dimensional space of reals, m less or equal n, and u=u(t) all piece-wise time-constant. The PDE solutions ´Phi´ and ´Psi´, also satisfying a certain system of ODEs, are shown to be determined by a suitable functional expansion and a constructive algorithm for the vector fields, provided exist. These are shown to reaval the conditions when the control system is not controllable. An example illustrates these new results.

Keywords: Controllability, Non-Linear Control Systems, Ordinary Differential Equations, Partial Differential Equations, Solutions

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Static Output Feedback for Takagi-Sugeno Systems: An LMI Approach

M. Chadli	Centre de Recherche en Automatique de Nancy, FR
D. Maquin	Centre de Recherche en Automatique de Nancy, FR
J. Ragot	Centre de Recherche en Automatique de Nancy, FR

Abstract: This paper studies the design of a static output feedback controller for nonlinear systems described by Takagi-Sugeno (T-S) models. Motivated by stability result developed for parallel distributed compensation (PDC) controller, an Output PDC (OPDC) controller that corresponds to a nonlinear static output feedback control law is proposed. Both stabilisation and poles placement are addressed. An example is given to illustrate the result.

Keywords: T-S Model, Nonlinear Systems, Regulators, Lyapunov Method, LMI Formulation.

The Output Feedback Saturated Controller Design for Linear Systems

B. Abdellah	UCA Marrakech Morocco, MA
M. Driss	University of Poitiers, FR

Abstract: This paper deals with the saturated regulator by output feedbackcontrol for linear discrete time and continuous time systems by using thepositive invariance concept. For square systems, the resolution of equationXCA + XCBXC = HXC is given.

Keywords: Saturated Controller, Output Feedback, Positive Invariance Concept, Square Systems.

Further Results on the Saturated Controller Design for Linear Continuous-Time Systems

B. Abdellah	UCA Marrakech Morocco, MA

Abstract: In this paper, we deal for the first time with linearcontinuous-time systems with non symmetrical constrained control,the vector constraint being non negative. Necessary and sufficientconditions allowing us to obtain the largest non symmetricalpolyhedral positively invariant domain w.r.t. the system in theclosed loop are given. The case of symmetrical constrained controlis obtained as a particular case.

Keywords: Positive Invariance, Saturated Regulator, Non Negative Vector Constraints

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A Feedback Linearization Control Technique Based on Iterative Learning Parameter Identification for an Electrically Driven Stabilized Pointing System of Heavy Turreted Vehicles

D. Lee	Agency Defense Development, KR
T-H Kang	Agency Defense Development, KR
H-S Kim	Agency Defense Development, KR
J-H Ko	Agency Defense Development, KR

Abstract: In this paper, a feedback-linearization(FL) control technique based on the parameter identification using the iterative learning control concept is proposed and experimentally verified for an electrically driven stabilized pointing system of heavy turreted vehicles. As an effective way of dealing with the undesirable effects of hard non-linearities inherently existing in the heavy turreted system, this kind of nonlinear control technique is investigated and results in an improved accuracy and a reduced stabilized error compared to those of the conventional controller. Since the FL technique generally requires an accurate parameter information, a parameter estimation algorithm is also investigated to identify the unknown system parameters such as the viscous and coulomb frictions, stiffness and inertia etc. In the identification process, a regression analysis method using the least-square criterion is basically adopted and an iterative learning control concept is also applied to effectively overcome errors-in-variables(EIV) problem. Through the computer simulations and related experiments, it is shown that the stabilized pointing performances against the wide-band stochastic disturbances induced by vehicle running on the rough terrain are notably improved by effectively counteracting the non-linearities and disturbances.

Keywords: Disturbance Rejection, Feedback Linearization, Iterative Learning Control, Parameter Identification, Stabilized Pointing System

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