21st Mediterranean Conference on Control & Automation (MED)

MED 2013

Conference Digest

June 25-28, 2013

Minoa Palace Resort & Spa

Platanias-Chania, Crete – GREECE

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WELCOME

Message from the President of the Mediterranean Control Association

Welcome to the 2013 Mediterranean Conference on Control and Automation (MED'13)!

This year's MED'13 conference, in Chania, Crete, is the 21st MED conference. The very first MED also took place in 1993, here in Chania, and since then the MED has been in Cyprus, Italy, France (Corsica), Croatia, Turkey, Israel, Portugal, Morocco, Spain and several times in Greece, in Athens, Patras, Thessaloniki, Rhodes, Corfu and of course in Chania, Crete (for a complete list of the MED conferences, see: http://med.ee.nd.edu). This year we are back in Chania where it all started 20 years ago!

The objective of MED has always been bringing together researchers, scientists and engineers in the area of Control Systems and Automation from the Mediterranean countries, who share much more than technical interests, among other things, culture and history. Ever since the 1st MED, there has been strong and continuing interest in the MED conferences and the success of recent conferences, including the present one, bears witness to this fact. I must say that attendees as well as organizations do appreciate the value and contributions of the MED to the profession.

The Mediterranean Control Association (MCA) is the sponsoring, parent organization and oversees all the MED conferences. MCA was founded in 1998 and it is registered in Cyprus as a non-profit organization (see: http://www.nd.edu/~pantsakl/MCA).

The MED conferences have been technically co-sponsored by the IEEE Control Systems Society and the IEEE Robotics and Automation Society, and they have consistently kept high quality standards both in the technical program and the conference organization. This is primarily due to the authors, who submit technically sound papers, and to the tremendous effort of all the volunteers involved in the technical evaluation of these papers and in the organization of the conferences. I would like to take this opportunity to thank them for their time, effort and wonderful work.

Remember that the MED Conference Proceedings may be found on line at http://ieeexplore.ieee.org. The Proceedings of early MED Conferences may be found at http://med.ee.nd.edu

I hope you do enjoy MED'13 and take full advantage of your stay in Crete, taking in the archeological sites and also relaxing at the beaches. In 2014 the MED will go to Palermo, Sicily in Italy and I hope to see you all there as well.

Thank you for your participation and contributions to MED'13!

Panos Antsaklis, President

Mediterranean Control Association (MCA)

Welcome Message from the General Chairs

Dear participants and attendees:

On behalf of the 2013 MED Organizing Committee, it is a privilege and a great pleasure to welcome you to this year's Conference. The 2013 MED is coming back to Chania, Crete, the birth place of the Conference. The three day Conference is preceded by a one-day Workshops / Tutorials program. The Conference venue is the luxurious Minoa Palace Resort & Spa, located in Platanias, west of Chania. The venue is one of the top-rated hotels in Crete and Greece. We are certain that you will be very pleased with the conference venue.

This year's Conference attendees represent academia, industry, government agencies and students, all having deep interest in the state-of-the-art and future directions in control and automations. In response to the Call for Papers, we received more than 320 contributed and invited papers. Following a very thorough and in depth peer review process in which each paper had at least three reviews we accepted a total of 248 contributed and invited session papers, and we have assembled a full three-day top quality Technical Program.

In addition to six parallel Technical Sessions each day, we have four Plenary Lectures suitably distributed over the three day Conference. The keynote speakers are authorities in their perspective areas.

The Organizing Committee members have devoted an enormous amount of time and effort to make sure that this Conference is exciting, informative and educational. We are privileged to know all the members. We are honored to have worked with them and we are truly indebted to everyone for their dedication and professionalism. We also extend a wholehearted "thank you" to all reviewers and members of the Technical Program Committees; their help was integral to assembling a top quality Technical Program.

The peer review process was coordinated by the Program Chairs and Vice-Chairs, as well as the Technical Committee members. We thank all of them. Dr. Pradeep Misra has been the essential "glue" that has kept everything together, since all papers were submitted through https://controls.papercept.net, managed by Pradeep. He has been indispensable throughout, and we wouldn't have been able to complete the paper review process without his help.

We thank you for your participation and contributions. We hope you enjoy the Conference, as well as the town of Platanias and the city of Chania.

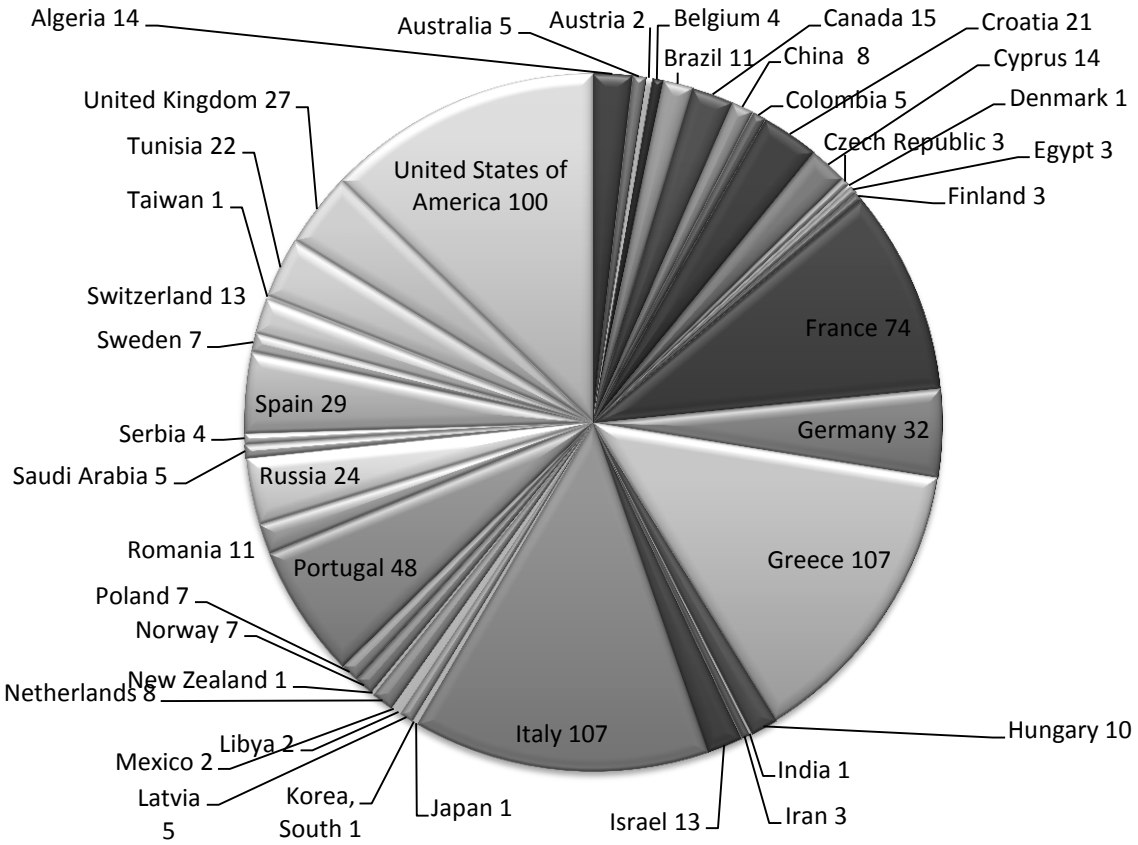
With our warmest regards,

Panos Antsaklis *and* ***Kimon P. Valavanis***

Welcome Message from the Program Chair

I wish you a very warm welcome to the 21st Mediterranean Conference on Control and Automation, here in the majestic island of Crete, the birthplace of MED conferences.

This year's MED conference features four motivating plenary lectures by the distinguished researchers and teachers Anibal Ollero, Frank Lewis, Thomas Parisini and Petros Ioannou. The scientific program contains 248 oral presentations of contributed papers divided into 42 parallel sessions, and 36 presentations of invited papers in 6 sessions. More than 700 authors from 44 countries finally appear in MED'13 program. To come to this end, 49 members of the International Program Committee who served as Associate Editors and several hundreds of reviewers worked voluntarily to assure the scientific quality of the contributions. I am obliged and grateful to all, and especially, to Lefteris Doitsidis our local arrangements chair, and to Primo Zingaretti and Luis Moreno our program co-chairs.



Authors per country in the scientific program of MED'13

I believe that the venue and time schedule will provide to all of you with ample opportunity to meet, discuss and come up with bright new ideas for your future research. In this way we will promote science in our common field, and nevertheless, we, the organizers, will feel that MED'13 contributed positively towards our scientific goals.

After each day's scientific session don't forget (and I am sure you will not) to enjoy the unique Cretan atmosphere in all its appearances. We have prepared a special social program for you, however, best things are waiting to be discovered. Get the chance!

With kind regards,

Nikos Tsourveloudis

COMMITTEES

Conference Organizing Commitee

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PAST MED CONFERENCES

20th IEEE Mediterranean Conference on Control and Automation (MED '12)
July 3-6 2012, Barcelona, Spain

19th IEEE Mediterranean Conference on Control and Automation (MED '11)
June 20-23 2011, Aquis Corfu Holiday Palace, Corfu, Greece

18th IEEE Mediterranean Conference on Control and Automation (MED '10)
June 23-25 2010, Congress Palace, Marrakech, Morocco

17th IEEE Mediterranean Conference on Control and Automation (MED '09)
June 24-26 2009, Makedonia Palace, Thessaloniki, Greece

16th IEEE Mediterranean Conference on Control and Automation (MED '08)
June 25-27 2008, Congress Center, Ajaccio-Corsica, France

15th IEEE Mediterranean Conference on Control and Automation (MED '07)
June 27-29 2007, Divani Caravel Hotel, Athens, Greece

14th IEEE Mediterranean Conference on Control and Automation (MED '06)
June 28-30, 2006, Università Politecnica delle Marche, Ancona, Italy

13th IEEE Mediterranean Conference on Control and Automation (MED '05)
June 27-29, 2005, Hawaii Grand Hotel & Resort, Limassol, Cyprus

12th IEEE Mediterranean Conference on Control and Automation (MED '04)
June 6-9, 2004, Kusadasi, Turkey

11th IEEE Mediterranean Conference on Control and Automation (MED '03)
June 18-20, 2003, Rodos Palace Hotel, Rhodes, Greece

10th IEEE Mediterranean Conference on Control and Automation (MED '02)
July 9-13 2002, Lisbon, Portugal

9th IEEE Mediterranean Conference on Control and Automation (MED '01)
June 27-29, 2001, Hotel Excelsior, Dubrovnik, Croatia

8th IEEE Mediterranean Conference on Control and Automation (MED '00)
July 17-19, 2000, University of Patras, Rio, Greece

7th IEEE Mediterranean Conference on Control and Automation (MED '99)
June 28-30, 1999, Dan Panorama Hotel, Haifa, Israel

6th IEEE Mediterranean Conference on Control and Automation (MED '98)
June 9-11, 1998, Hotel Carlos V, Alghero, Sardinia, Italy

5th IEEE Mediterranean Conference on Control and Systems (MED '97)
July 21-23, 1997, Phaethon Beach Hotel Club, Paphos, Cyprus

4th IEEE Mediterranean Symposium on Control and Automation (MED '96)
June 10-13, 1996, Louis Maleme Beach Hotel, Chania, Crete, Greece

3rd IEEE Mediterranean Symposiumon Control and Automation (MED '95)
July 11-13, 1995, Limassol, Cyprus

2nd IEEE Mediterranean Symposium on New Directions in Control and Automation (MED '94)
June 19-21, 1994, Louis Maleme Beach Hotel, Chania, Crete, Greece
1st IEEE Mediterranean Symposium on New Directions in Control Theory and Applications (MED '93)
June 21-23, 1993, Handris Hotel, Maleme, Chania, Crete, Greece

PRACTICAL INFORMATION

Chania: the atmospheric city

Chania (also spelled: Haniá) is the capital city, a place where different civilizations have flourished throughout the centuries. Wandering around the Old Town's maze-like alleys with the beautiful Venetian mansions, the fountains and the elaborate churches will help you discover well-preserved historical monuments.

The city of Chania is built on the area of Minoan Kidonia, at the end of the homonym gulf between Akrotiri and Onicha peninsulas. It was the former capital city of Crete (from 1847 until 1972). Nowadays, it is the second largest city of Crete after Heraklion and capital of the homonym prefecture.

Chania includes the old and new city. It is one of the most beautiful and picturesque cities in Greece and for food lovers, it's a paradise!

Get familiar with the city of Chania by wandering around in its streets, visiting its museums and admiring the different architectural styles presenting the historical route of the city.

After Arabs and Byzantines it was conquered by Venetians in 1252 and was given to Turks in 1669, later it was annexed to the rest of the Greek State on December 1913 under the administration of Eleftherios Venizelos and King Konstantinos the 1st. The old town is an integral settlement with visible boundaries set by the Venetian walls surrounding it.

Chania has daily boat connection with Piraeus port from Souda port (7 km). Chania is also connected with Athens by airplane which you can take from Akrotiri airport 15 km E of the city.

The old town is built around the Venetian port and is also a relatively integral area where Venetian buildings and later Turkish elements compose a unique architectural style. Due to the historic center of Chania with its Venetian walls defining the borders between the old and new city and its ramparts, the city has been pronounced as preserved. It consists of five connected districts surrounding the Venetian port.

Its design was made by Venetian engineer Michelle Sammichelli. The Lighthouse is located at the end of the rock protecting the port from the north. It was built in 1570 by the Venetians and reconstructed in 1830 by the Egyptians and from there on preserves its current state.

On the east of Palea Poli is Splantzia (or Plaza) district built on the former Turkish district. Here you will see among others Aghii Anargiri church, the only Orthodox church which had the

permission to operate during the period of the Venetian and Turkish occupations. You will also see the Sintrivani square.

Neoria (or Chiones) district on the northeast side is located in the area of the former port of the city and of the Venetian ship yards of 14th and 16th centuries from which it also took its name.

Kastelli district is in the center of Palea Poli (Old Town) west of Neoria. It is the exalted location of the Byzantine citadel where "palatso" (palace) of the Venetian commander and the lodgings of Pashas of Chania were later built. Venetians used to call the area Castello Vecchio.

On the southeast of the old city lies the Hebrew district or else Ovraika. It reminds us the times when the developing Hebrew community of Chania was obliged by the Venetians to move to a delimitated area called judeca where two synagogues were operating.

On the boarders of Ovraika, in Chalides Street, you will see the Folklore Museum of Chania and Aghios Fragkiskos church (14th century) which houses the Archeological Museum of Chania. On the north side is the Turkish bath (chamam). In the south side of Ovraika and on Skridlof Street lies the so called Stivanadika (from stivani, the Cretan boots). Among the shops selling leather items and souvenirs survive some traditional shoe ateliers.

Turquoise waters lap against the white sandy beaches, that lie to the west of the city: Hrissi Akti, Ayia Marina, Áyioi Apóstoloi, Máleme, Kalathás, Stavrós, Plataniás, Kolympári, Falássarna, Ayia Rouméli, Souyiá, Ammoúdi, Fínikas, Vótsala, Loutró, Áyios Pávlos, Pahiá Ámmos, Fragokástello and Gávdos are only some of the beaches where you can bask in the sun. On the islet of Elafonissi, a beach with crystal clear waters and white sand dunes will take your breath away! The whole area forms part of the NATURA network.

No visit to Chania is complete unless you have sampled traditional local specialties: eggs with stáka, Cretan kalitsoúnia (sweet mini cheese pies), lamb served with spiny chicory, dácos (the traditional hard Cretan bread accompanied with tomato, mizithra cheese and plenty of virgin Cretan oil), snails boubouristí(popping fried snails), haniótiko bouréki (patty from Chania, a vegetable specialty), kserotígana (honey dipped spiral pastries) wedding cookies, dry bread wreaths, yraviéra cheese (full fat sheep's cheese with appellation of controlled origin), sweet smelling anthótyros from Sfakiá (fresh, soft, white cheese made of either sheep's or goat's milk), fresh stáka butter (the cream of the butter) for the Cretan wedding rice (rice cooked in meat broth), roasted goat or sea food delights – special ingredients blended in delicious sea-urchin salads, or divine fish soups! Accompany your dinner with a glass of deep-red Cretan wine, the divine marouvás, or drink after your meal an ice-cold rakí, a traditional Cretan spirit distilled from pomace, with a delicate aroma of ripe grapes.

Conference Venue

MED'13 will be held at the Minoa Palace Resort and Spa (http://www.minoapalace.gr), a luxury five star beachside resort. The resort is situated in the cosmopolitan area of Platanias, 12km west of the picturesque town of Chania and about 40 min drive from the Chania International Airport. The resort offers majestic views of its surrounding countryside and the White Mountains. To the north, the resort enjoys panoramic views of the endless golden beach of Platanias with the shimmering sapphire blue Aegean beyond. Guests have immediate access to the sandy beach in front of the resort.

How to get to the hotel

The city of Chania is served by the Chania International Airport (CHQ), around 14km from the city center. There are several daily domestic flights from the Athens International Airport (ATH) by:

1. Aegean Airlines (Star Alliance Member)
2. Olympic Airlines

There are also direct scheduled and charter flights connecting Chania with several European cities.

The conference organizers will arrange a shuttle bus for the transportation to/from the Conference Venue - Minoa Palace Resort & Spa.

If you visit Athens first, you can travel to Chania by ferry. Greek ferries are generally very modern and comfortable, and they connect Athens (Piraeus port) to Chania (Souda port) on a daily basis. The sea trip takes about 8,5 hours. The shipping company that serves Chania is ANEK Lines.

A regular bus service (buses leave every 20 min) connects the Souda port to Chania city.

Registration Desk

The registration desk will be located ath the Imperial room's area (see site map). The working hours will be the following:

Tuesday 25th June: 9:00-18:00

Wednesday 26th June: 8:00-18:00

Thursday 27th June: 9:00-18:00

Friday 28th June: 9:00-14:00

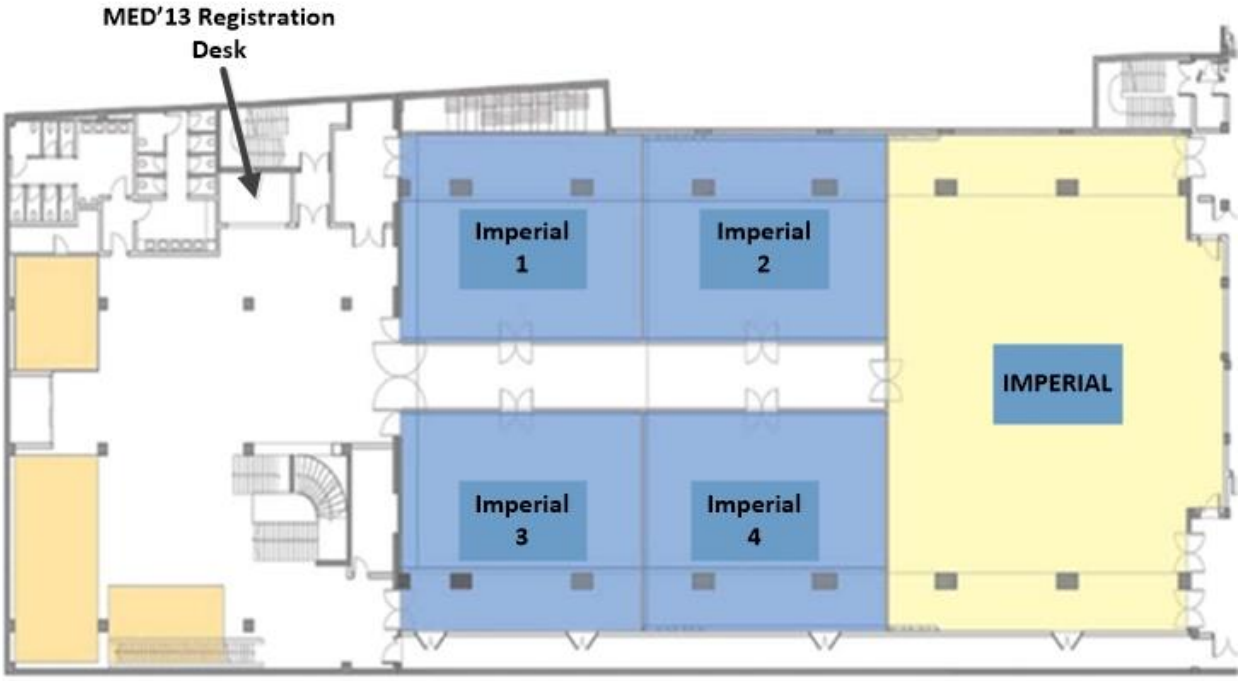
Oral Session Room Facilities

Every room will be provided with a multi-media LCD projector and computer with Windows, Office 2007/2012 and a PDF reader. Electricity will be supplied at 220V, 50Hz AC through standard European sockets.

Internet Facilities

Free wireless connection will be available in the conference area for purticipants during the days of the conference.

Site Map


MED'13 Registration Desk
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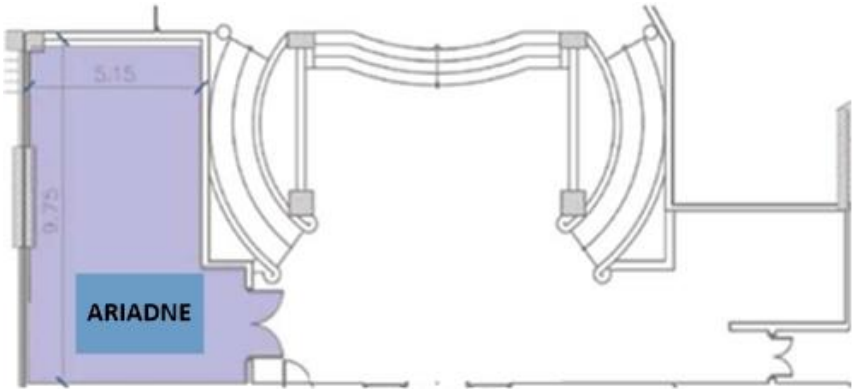
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SOCIAL PROGRAMME

Welcome Reception

A welcome cocktail will be held by the sea at ***Corali Restaurant*** at the Imperial Wing of the Hotel, Tuesday June 25th at 20:00.

Gala Dinner

The Conference Banquet is on Thursday June 27th and will start around 20:30 at the ***Athina Ballroom***

Farewell Reception

A goodbye party with light buffet and finger food will be held at the ***Corali Restaurant*** on Friday June 28th at 16:30

TECHNICAL PROGRAMME

Plenary Lectures

The 21st Mediterranean Conference on Control and Automation includes four Keynote / Plenary Lectures given by leading authorities in their respective fields. We are honored to have their talks as part of this year's Conference program. There will be two keynotes on Wednesday and Thursday, one in the morning and one in the afternoon. The schedule for the Plenary / Keynote lectures is shown next.

Plenary Session Title: Cooperating UAS: From Information Acquisition to Physical Interactions

By ***Anibal Ollero****, Universidad de Sevilla, Spain*

Date: Wednesday 26th June 2013

Time: 9:00-10:00

Room: IMPERIAL Ballroom

Abstract: In this plenary talk we will discuss some control and automation issues related to cooperating multiple Unmanned Aircraft Systems (UAS). We will first consider the exploitation of capabilities of heterogeneous Unmanned Aerial Vehicles (UAVs) in detection and monitoring missions. Then, we will discuss and analyze the integration of UAS with ground wireless sensor and actuator networks. Next, we will present results of the EC-SAFEMOBIL (FP7- ICT - 288082) project dealing with new estimation/prediction and cooperative control methodologies and their practical application to autonomous landing in mobile platforms, surveillance and tracking with multiple UAVs. The MUAC-IREN FP7 project dealing with cooperative long endurance missions with multiple UAVs will also be introduced. The second part of the talk will be devoted to physical interactions among UAVs and interactions between UAVs and objects in the environment. The joint load transportation problem using multiple aerial vehicles will be presented, followed by results of the ARCAS project (FP7-ICT- 287617) dealing with the cooperation of multiple aerial robots with manipulators, including quadrotors and helicopters with arms and hands for grasping and assembly.

Anibal's Ollero Short CV: Anibal Ollero (http://grvc.us.es/aollero) is Full Professor and Head of the GRVC Group (60 researchers) at the University of Seville, and Scientific Advisor of the Center for Advanced Aerospace Technologies in Seville. He has been full professor at the Universities of Santiago de Compostela and Malaga in Spain, and researcher at Carnegie Mellon University (Pittsburgh, USA) and LAAS-CNRS (Toulouse, France). He is author/co-author of 484 publications, including 9 books and 113 papers in SCI journals. He led about 130 projects and he is currently the coordinator of the ARCAS and EC-SAFEMOBIL FP7 Integrated Projects of the European Commission, and associated coordinator of FP7 PLANET and CONET Network of Excellence. He is the recipient of 13 national and international awards for his R&D activities including the second 2010 EUROP-EURON Technology Transfer award and the IV Javier Benjumea award by Scientific Excellence and Social Impact. He has been the advisor of 26 PhD students. He is currently the President of the Spanish Robotics Society SEIDROB.

Plenary Session Title: Cooperative Control: Optimality, Differential Games, and Reinforcement Learning on Graphs

By ***F. L. Lewis****, The University of Texas at Arlington, Texas, USA*

Date: Wednesday 26th June 2013

Time: 14:00-15:00

Room: IMPERIAL Ballroom

Abstract: Distributed systems of agents linked by communication networks only have access to information from their neighboring agents, yet must achieve global agreement on team activities to be performed cooperatively. Examples include networked manufacturing systems, wireless sensor networks, networked feedback control systems, formations, and the internet. Sociobiological groups such as flocks, swarms, and herds have built-in mechanisms for cooperative control wherein each individual is influenced only by its nearest neighbors, yet the group achieves optimal synchronization behaviors. It was shown by Charles Darwin that local interactions between population groups over long time scales lead to global results such as the evolution of species. Natural decision systems incorporate notions of optimality, since the resources available to organisms and species are limited. Optimal feedback control design has been responsible for much of the successful performance of engineered systems in aerospace, industrial processes, vehicles, ships, robotics, and elsewhere since the 1960s. Optimal control design is performed offline by solving optimal design equations including the algebraic Riccati equation and the Game ARE. Optimal design generally requires that the full system dynamics be known, and is limited by the properties of communication topologies.

Optimality on Graphs: Global optimal control of distributed systems on communication graphs is complicated by the fact that, for general LQR performance indices, the resulting optimal control is not distributed in form. Therefore, it cannot generally be implemented on a prescribed communication graph topology by using only local neighbor information. A condition is given for the existence of any optimal LQR controllers that can be implemented on a given graph in distributed fashion. This condition shows that for the existence of global optimal controllers of distributed form, the performance index weighting matrices must be selected to depend on the graph structure.

Graphical Games: A novel form of multi-player game among agents in a communication graph is formulated where each agent is allowed to interact only with its neighbors. A new notion of Nash equilibrium is defined that is suitable for graphical games and guarantees that that all agents achieve synchronization while optimizing their own value functions.

Reinforcement Learning on Graphs: This talk will discuss some new cooperative control structures for learning online the solutions to multi-player differential games on graphs. Techniques from reinforcement learning are used to design a new family of adaptive controllers based on actor-critic mechanisms that converge in real time to optimal control and game theoretic solutions on graphs.

F. L. Lewis' Short CV: Frank Lewis was born in Wurzburg, Germany, subsequently studying in Chile and Gordonstoun School in Scotland. He obtained the BS in Physics/Electrical Engineering and the Master's of Electrical Engineering Degree at Rice University in 1971. He spent six years in the U.S. Navy, serving as Navigator aboard the frigate USS Trippe (FF-1075), and Executive Officer and Acting Commanding Officer aboard USS Salinan (ATF-161). In 1977 he received the MS in Aeronautical Engineering from the University of West Florida. In 1981 he obtained the Ph.D. degree at The Georgia Institute of Technology in Atlanta, where he was employed as a professor from 1981 to 1990. Registered Professional Engineer in the State of Texas and Chartered Engineer, U.K. Engineering Council. Charter Member (2004) of the UTA Academy of Distinguished Scholars. Member UTA Academy of distinguished Teachers. Founding Member of the Board of Governors of the Mediterranean Control Association. Author of 6 U.S. patents and books including Optimal Control, Optimal Estimation, Applied

Optimal Control and Estimation, Aircraft Control and Simulation, Control of Robot Manipulators, and Neural Network Control.

Plenary Session Title: A Distributed Networked Approach to Fault Diagnosis of Large Scale Systems

By ***Thomas Parisini,*** *Imperial College London (U.K) & University of Trieste (IT)*

Date: Thursday 27th June 2013

Time: 9:00-10:00

Room: IMPERIAL Ballroom

Abstract: This lecture deals with a class of systems that are becoming ubiquitous in the current and future "distributed world" made by countless "nodes", which can be cities, computers, people, etc., and interconnected by a dense web of transportation, communication, or social ties. The term "network", describing such a collection of nodes and links, nowadays has become commonplace thanks to our extensive reliance on "connections of interdependent systems" in our everyday life, for building complex technical systems, infrastructures and so on. In an increasingly "smarter" planet, it is expected that such interconnected systems will be safe, reliable, available 24/7, and of low-cost maintenance. Therefore, health monitoring and fault diagnosis are of customary importance to ensure high levels of safety, performance, reliability, dependability, and availability. For example, in the case of industrial plants, faults and malfunctions can result in off-specification production, increased operating costs, production line shutdown, danger conditions for humans, detrimental environmental impact, and so on. Faults and malfunctions need to be detected promptly and their source and severity should be diagnosed so that corrective actions can be taken as soon as possible. In the talk, an adaptive approximation- based distributed and networked fault diagnosis approach for large-scale nonlinear systems will be dealt with, by exploiting a "divide et imperia" approach in which the overall diagnosis problem is decomposed into smaller sub-problems, which can be solved within â€œlocalâ€ computation and communication architectures. The distributed detection, isolation and identification task is broken down and assigned to a network of "Local Diagnostic Units", each having a "local view" of the system. These local diagnostic units are allowed to communicate with each other through an information network to cooperate on the diagnosis of system components that may be shared or interconnected.

Thomas' Parisini' Short CV: Thomas Parisini received the PhD degree in Electronic Engineering and Computer Science in 1993 from the University of Genoa. He was with Politecnico di Milano and since 2010 he holds the Chair of Industrial Control at Imperial College London. Since 2001 he is also Danieli Endowed Chair of Automation Engineering with University of Trieste and in 2009-2012 he was Deputy Rector of the University of Trieste. He authored or co-authored more than 250 research papers in archival journals, book chapters, and international conference proceedings. His research interests include neural-network approximations for optimal control problems, fault diagnosis for nonlinear and distributed systems and nonlinear model predictive control systems. He is a co-recipient of the 2004 Outstanding Paper Award of the IEEE Trans. on Neural Networks and a recipient of the 2007 IEEE Distinguished Member Award. He is involved as Project Leader in several projects funded by the European Union, by the Italian Ministry for Research, and he is currently leading consultancy projects with some major process control companies (ABB, Danieli, Duferco, Electrolux, among others). Thomas Parisini is the Editor-in- Chief of the IEEE Trans. on Control Systems Technology. He was the Chair of the IEEE Control Systems Society Conference Editorial Board and a Distinguished Lecturer of the IEEE Control Systems Society.

He was an elected member of the Board of Governors of the IEEE Control Systems Society and of the European Control Association (EUCA) and a member of the board of evaluators of the 7th Framework ICT Research Program of the European Union. Prof. Parisini is currently serving also as an Associate Editor of the Int. J. of Control and served as Associate Editor of the IEEE Trans. on Automatic Control, of the IEEE Trans. on Neural Networks, of Automatica, and of the Int. J. of Robust and Nonlinear Control. Among other activities, he was the Program Chair of the 2008 IEEE Conference on Decision and Control and he is General Co- Chair of the 2013 IEEE Conference on Decision and Control. Thomas Parisini is a Fellow of the IEEE.

Plenary Session Title: Robust Adaptive Control: Interpretations, Expectations and Reality

By ***Petros A. Ioannou****, University of Southern California, U.S.A*

Date: Thursday 27th June 2013

Time: 14:00-15:00

Room: IMPERIAL Ballroom

Abstract: Adaptive Control has a long history full of exciting results, new algorithms, successful applications but also some disappointments. These disappointments arise due to high expectations in looking for a miracle scheme that treats an unknown plant as a black box and yet meets all robustness and performance requirements. This talk presents a short survey of these developments and separates the drawbacks of some adaptive schemes that are originated from the design assumptions and those that are inherent in any design because of the quality of information in the input/output data. We revisit the MIT rule and sensitivity approaches as well as recent adaptive approaches whose performance and stability properties are limited by design and show how these drawbacks can be removed. We show that adaptive control despite its failure to meet unrealistic expectations it performs, as one would expect it to perform by processing available input/output data. One sophistication of adaptive control is to induce self- excitation when there is limited information about the unknown plant in the input/output data and the estimated parameters drift to values that are destabilizing. We present some successful applications in adaptive disturbance rejection of periodic disturbances for laser beam control and other applications.

Petros ' A. Ioannou Short CV: Petros A. Ioannou received the B.Sc. degree with First Class Honors from University College, London, England, in 1978 and the M.S. and PhD degrees from the University of Illinois, Urbana, Illinois, in 1980 and 1982, respectively. In 1982, he joined the Department of Electrical Engineering-Systems, University of Southern California, Los Angeles, California. He is currently a Professor in the same Department and holds courtesy appointments with the Department of Aerospace and Mechanical Engineering and the Department of Industrial and Systems Engineering. His research interests are in the areas of adaptive control, neural networks, vehicle dynamics and control, aerospace control and intelligent transportation systems. Dr. Ioannou is the recipient of a 1985 Presidential Young Investigator Award for his research in Adaptive Control. In 2009 he received the IEEE ITSS Outstanding Application Award for his work on Adaptive Cruise Control Systems and the 2009 IET Achievement Medal in control systems by the Institute of Engineering and Technology (IET). In 2012 he received the IEEE ITSS Outstanding Research Award. He has been an Associate Editor for the IEEE Transactions on Automatic Control, the International Journal of Control, Automatica and IEEE Transactions on Intelligent Transportation Systems. He served as Associate Editor at Large of the IEEE Transactions on Automatic Control and Chairman of the IFAC Technical Committee on Control of Transportation Systems. He is a member of the Board of Governors of the IEEE Intelligent Transportation Society. Dr. Ioannou is a Fellow of IEEE, IFAC and IET and the

author/co-author of 8 books and over 250 research papers in the area of adaptive systems, nonlinear control, neural networks, nonlinear dynamical systems and intelligent transportation systems.

Workshop – Tutorials

Four tutorials have been scheduled on Tuesday 25th June.

Tutorial 1: Enabling Secure, Scalable Microgrids with High Penetration Renewables

Proposed by: *Dr. Steven Glover*, (Sandia National Laboratories, Albuquerque, NM), *Dr. Rush D. Robinett III*, (Michigan Technological University, Houghton, MI)

Tutorial 2: Who's Afraid of Fractional Order Laplace?

Proposed by: *Dr. Cristina I. Muresan,* (Technical University of Cluj-Napoca, Romania), *Dr. Clara M. Ionescu,* (Ghent University, Belgium)

Tutorial 3: L1 Adaptive Control and Its Transition to Practice

Proposed by: *Dr. Naira Hovakimyan,* (Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign)

Tutorial 4: UAV Autonomy and State-of-the-art Technologies and Applications in Mediterranean Countries

Proposed by: *Dr. George J Vachtsevanos,* (Professor Emeritus, Georgia Institute of Technology), *Dr. Kimon P. Valavanis,* (Professor, ECE, University of Denver)

PROGRAM AT A GLANCE

MED 2013 Technical Program Wednesday June 26, 2013

Track T1	Track T2	Track T3	Track T4	Track T5	Track T6
8:30-9:00 IMPERIAL Opening Ceremony					
09:00-10:00 WePT1 IMPERIAL [Plenary Session: Cooperating UAS: From Information Acquisition to Physical Interactions, A. Ollero]					
10:00-10:30 Coffee Break					
10:30-12:30 WeA1 IMPERIAL Robotics I	10:30-12:30 WeA2 Imperial 1 Fault Tolerant Control	10:30-12:30 WeA3 Imperial 2 Modelling and Simulation I	10:30-12:30 WeA4 Imperial 3 Power Systems	10:30-12:30 WeA5 Imperial 4 Applications of Control in Aerospace	10:30-12:30 WeA6 Ariadne Current Trends and Challenges in Closed Loop Anesthesia
12:30-14:00 Lunch Break					
14:00-15:00 WePdT2 IMPERIAL [Plenary Session: Cooperative Control: Optimality, Differential Games, and Reinforcement Learning on Graphs, F. L. Lewis]					
15:00-16:40 WeB1 IMPERIAL Optimisation	15:00-16:40 WeB2 Imperial 1 Fuzzy Systems	15:00-16:40 WeB3 Imperial 2 Automotive Control	15:00-16:40 WeB4 Imperial 3 Nonlinear Control I	15:00-16:40 WeB5 Imperial 4 Unmanned Systems I	15:00-16:40 WeB6 Ariadne Fault Diagnosis I
16:40-17:00 Coffee Break					
17:00-18:40 WeC1 IMPERIAL Robotics II	17:00-18:40 WeC2 Imperial 1 Networked Systems	17:00-18:40 WeC3 Imperial 2 Aerospace and Automotive Control	17:00-18:40 WeC4 Imperial 3 Nonlinear Control II	17:00-18:40 WeC5 Imperial 4 Education and Training	17:00-18:40 WeC6 Ariadne Fault Diagnosis II

MED 2013 Technical Program Thursday June 27, 2013

Track T1	Track T2	Track T3	Track T4	Track T5	Track T6
09:00-10:00 ThPT1 IMPERIAL [Plenary Session: A Distributed Networked Approach to Fault Diagnosis of Large Scale Systems, T. Parisini]					
10:00-10:30 Coffee Break					
10:30-12:30 ThA1 IMPERIAL Hybrid Systems I	10:30-12:30 ThA2 Imperial 1 Linear Systems I	10:30-12:30 ThA3 Imperial 2 Biomedical Engineering	10:30-12:30 ThA4 Imperial 3 Manufacturing Systems	10:30-12:30 ThA5 Imperial 4 Linear Multivariable Systems I	10:30-12:30 ThA6 Ariadne Invariant Sets in Control Applications
12:30-14:00 Lunch Break					
14:00-15:00 ThPdT2 IMPERIAL [Plenary Session: Robust Adaptive Control: Interpretations, Expectations and Reality, P. Ioannou]					
15:00-16:40 ThB1 IMPERIAL Hybrid Systems II	15:00-16:40 ThB2 Imperial 1 Linear Systems II	15:00-16:40 ThB3 Imperial 2 Wireless Networks	15:00-16:40 ThB4 Imperial 3 Robot Swarms	15:00-16:40 ThB5 Imperial 4 Linear Multivariable Systems II	15:00-16:40 ThB6 Ariadne Distributed Systems I
16:40-17:00 Coffee Break					
17:00-18:40 ThC1 IMPERIAL Robust Control I	17:00-18:40 ThC2 Imperial 1 Modelling and Simulation II	17:00-18:40 ThC3 Imperial 2 Intelligent Control Systems	17:00-18:40 ThC4 Imperial 3 Unmanned Systems II	17:00-18:40 ThC5 Imperial 4 Signal Processing	17:00-18:40 ThC6 Ariadne Robotics III

MED 2013 Technical Program Friday June 28, 2013

Track T1	Track T2	Track T3	Track T4	Track T5	Track T6
10:00-10:30 Morning Coffee					
10:30-12:30 FrA1 IMPERIAL Autonomous Marine Vehicles	10:30-12:30 FrA2 Imperial 1 Renewable Energy and Sustainability	10:30-12:30 FrA3 Imperial 2 Biologically Inspired Systems	10:30-12:30 FrA4 Imperial 3 Predictive Control I	10:30-12:30 FrA5 Imperial 4 Robust Control II	10:30-12:30 FrA6 Ariadne Control Systems
12:30-14:00 Lunch Break					
14:00-15:40 FrB1 IMPERIAL Nonlinear Control III	14:00-15:40 FrB2 Imperial 1 Distributed Systems II	14:00-15:40 FrB3 Imperial 2 Computational Intelligence	14:00-15:40 FrB4 Imperial 3 Predictive Control II	14:00-15:40 FrB5 Imperial 4 Image Processing	14:00-15:40 FrB6 Ariadne [Title not available]
15:40-16:00 Coffee Break					
16:00-17:00 FrPdT2 [Closing Ceremony & Farewell]					

Technical Program for Wednesday June 26, 2013

WeA1 IMPERIAL

Robotics I (Regular Session)

Chair: Kovacic, Zdenko — Univ. of Zagreb

10:30-10:50 WeA1.1

Speed Control of Vibration Micro-Motors of a Micro-Robotic Platform, pp. 1-6

Spartali, Iliana — National Tech. Univ. of Athens
Vlachos, Kostas — National Tech. Univ. of Athens
Papadopoulos, Evangelos — National Tech. Univ. of Athens

In this paper we consider the dynamic modeling and the speed control of vibration micro-motors, under power and sensor hardware constraints due to the centimeter-scale dimensions of the motors. The micro-motors are attached on a centrifugal-force micro-robotic mobile platform. The dynamic model of the low cost motor is presented, and discussed. The experimental procedure for the motors' parameter identification is presented, and the design of a model-based controller aiming at the control of the speed of the motors is analyzed. In addition, the practical implementation of the designed controller is discussed and experimentally evaluated. In order to measure the rotational speed of each centimeter-scale vibration motor, a rotary encoder with one count per revolution is designed and constructed. Despite this sensor hardware limitation, the experimental results indicate that the micro-motors were successfully modeled, and that the proposed controller results in the minimization of the steady-state error and in an increase of the motors' bandwidth by a factor of three. Additional experiments showed that the application of the model-based speed controller results in a motion of the micro- robotic platform of higher precision.

10:50-11:10 WeA1.2

Design and Control of a Four-Flipper Tracked Exploration & Inspection Robot, pp. 7-12

Kovacic, Zdenko — Univ. of Zagreb
Cukon, Marko — Univ. of Zagreb
Brkic, Kristijan — Inteco d.o.o.
Vasiljevic, Goran — Univ. of Zagreb
Mutka, Alan — FER, Univ. of Zagreb
Miklic, Damjan — FER, Univ. of Zagreb
Vuglec, Franjo — Pliva d.d.
Rajkovic, Ivan — ABB d.o.o. Zagreb

We describe the design and control of a prototype of an exploration and inspection robot built as a four flipper/track mobile robot. It is equipped with on-board sensors including standard and thermovision cameras, gas and temperature detectors, etc. The robot maintains wireless video and audio communication with the operator. Its principal aim is to explore buildings, locate people caught in the accidents and detect potential sources of danger in abnormal conditions caused by flood, fire, earthquake or other natural and nonnatural disasters. The robot construction complies to the ATEX norms in order to minimize the risk of interventions of professional units (e.g. fire fighting, civil guard, police, military). Having four independently controlled tracks/flippers, the robot allows easy maneuvering and overtaking of obstacles (including steps). Although dominantly designed as a remote-controlled robot device, advanced control features such as roll-angle compensation and corridor/steps/door centering algorithms help the operator to navigate robot in a much easier and safer way.

11:10-11:30 WeA1.3

Continuous Curvature Constrained Shortest Path for a Car-Like Robot Using S-Roadmaps, pp. 13-18

Xidias, Elias — Univ. of the Aegean
Aspragathos, Nikos — Univ. of Patras

This paper proposes a new approach for motion planning for a car-like robot which is based on a surfaced roadmap concept. A major advantage of our approach is that, it enables the same roadmap to be efficiently utilized for car-like robots with different kinematical constraints or with different starting and ending points. Our approach first represents the 2D environment using the B-Surface concept. Then, build a roadmap onto the B-Surface which does not incorporate any kinematical constraints. The paths encoded in the roadmap consist of poly-geodesic segments. The roadmap assists in the optimization and smoothing of these paths using NURBS curves. We also demonstrate experimental results for a simple model of a car-like robot moving on 2D environments.

11:30-11:50 WeA1.4

Extended and Unscented Kalman Filters for Mobile Robot Localization and Environment Reconstruction, pp. 19-26

Cotugno, Giuseppe — DIMES, Univ. of Calabria
D'Alfonso, Luigi — Univ. della Calabria
Lucia, Walter — Univ. della Calabria
Muraca, Pietro — Univ. della Calabria
Pugliese, Paolo — Univ. della Calabria

In this work we compare the performance of two algorithms, respectively based on the Extended Kalman Filter and the Unscented Kalman Filter, for the mobile robot localization and environment reconstruction problem. The proposed algorithms do not require any assumption on the robot working space: they are driven only by the measurements taken using ultrasonic sensors located onboard the robot. We also devise a switching sensors activation policy, which allows energy saving still achieving accurate tracking and reliable mapping of the workspace. The results show that the two filters work comparably well, in spite of the superior theoretical properties of the Unscented Filter.

11:50-12:10 WeA1.5

Kinematic Control of Robot Manipulators Using Filtered Inverse, pp. 27-33

Vargas, Lucas Vares — COPPE/UFRJ/PEE
Costa, Ramon R. — COPPE - Federal Univ. of Rio de Janeiro
Leite, Antônio Candea — COPPE/UFRJ/PEE

This paper presents a kinematic control scheme for robot manipulators based on an algorithm that dynamically estimates an inverse of the Jacobian matrix. An interesting property of this algorithm is its ability to deal with the problem of kinematic singularities. The output of the algorithm can be interpreted as the filtered inverse of the Jacobian matrix. A case study of a 3-DoF non-redundant manipulator is presented. Some simulation results illustrate the performance of the proposed methodology.

12:10-12:30 WeA1.6

Utilizing Queued Actions to Increase Interaction Efficiency in Robot Control Interfaces, pp. 34-39

Janssen, Mike — UMN
Papanikolopoulos, Nikos — Univ. of Minnesota

We present a robot tasking model using queued actions to enhance a supervisory mobile robot control interface. A model of interaction using this queue of actions is developed and presented with experiments. We develop a general multi-robot interaction model which incorporates queued actions and propose two metrics for measuring directly the number of controllable robots, closely related to the Fan Out metric. An experimental interface was developed incorporating queued actions and an experiment run where participants perform a resource gathering task in an unknown environment. Results from the experiment show that the queued actions significantly improve the interface efficiency.

WeA2 Imperial 1

Fault Tolerant Control (Regular Session)

Chair: Zolotas, Argyrios — Univ. of Sussex

10:30-10:50 — WeA2.1

Fault Tolerant Control Design of Induction Motor Drive in Electrical Vehicle: A Hybrid Control Approach, pp. 40-45

Boukhnifer, Moussa — ESTACA Paris
Raisemche, Aziz — ESTACA Paris
Diallo, Demba — Univ. Paris-Sud, LGEP

In this paper, we propose to design a Fault Tolerant Controller (FTC) that can cope both with performance and robustness by the hybridization of two controllers. The distinguished feature of this architecture is that it shows structurally how the controller design for performance and robustness can be done separately. It has the potential to overcome the conflict between performance and robustness of the traditional feedback framework. The controller design works in such a way that the feedback speed control of the induction motor will be solely controlled by the proportional integral PI controller for a nominal model without disturbances and H-infinity robust controller will only be activated in the presence of the faults, the uncertainties or external disturbances. This FTC is applied to an induction motor drive for electrical vehicle. The simulation results demonstrate the effectiveness of the proposed hybrid fault tolerant control architecture.

10:50-11:10 — WeA2.2

A Fault Compensation Strategy for Consensus Networks Subject to Transient and Intermittent Faults, pp. 46-53

Parlangeli, Gianfranco — Univ. del Salento

In this paper a fault tolerant control strategy is proposed for a consensus network where some nodes can inject unexpected values as a consequence of a temporary fault. Based on an autoregressive elaboration of local data, system evolution is corrected by the counteractions of a monitoring node. The set of time-varying gains satisfying a perfect compensation of the drift caused by the fault on the objective function is shown to be the solution of a suitable autoregressive equation. We further estimate the convergence region of the state vector when the proposed compensation technique is used when the system is subject to a persistent unknown but bounded disturbance. Simulations are made in order to validate theoretical results.

11:10-11:30 — WeA2.3

Reconfigurable Flight Control Laws for Re-Entry Vehicles, pp. 54-59

Poderico, Mariana — Italian Aerospace Res. Centre
Morani, Gianfranco — Italian Aerospace Res. Centre
Ariola, Marco — Univ. degli Studi di Napoli Parthenope

This paper proposes a novel Reconfigurable Control System for reentry vehicles, based on an adaptive control strategy combined with a control allocation approach to deal with a hybrid effectors set, i.e. aerodynamic surface and reaction control system (RCS). This control strategy guarantees improved robustness against uncertain, highly time-variant flight dynamics and at the same time it allows us to deal with effectors failures due to reconfiguration capabilities ensured by control allocation. Furthermore control allocation is also used to optimally distribute the control effort between available control effectors by taking into account the RCS fuel consumption. The effectiveness of the novel solution has been demonstrated through a numerical analysis both in nominal and single failures scenario.

11:30-11:50 — WeA2.4

Optimised Sensor Selection for Control and Fault Tolerance: Comparison and Some New Results, pp. 60-65

Michail, Konstantinos — Cyprus Univ. of Tech.
Zolotas, Argyrios — Univ. of Sussex
Goodall, Roger — Loughborough Univ.

Optimised sensor selection is a non-trivial task to perform for control design especially if the selection is done with respect to complex control requirements like reliability, optimised performance, robustness and fault tolerance. In this paper, a proposed framework is presented aiming to tackle the aforementioned problem. In this context, a Linear Quadratic Gaussian (LQG) controller is presented and applied to an Electro-Magnetic Suspension (EMS) system. Furthermore, the LQG solution is compared to a Multi-Objective (M.O.) H-infinity and H-infinity controller design via loop-shaping method using realistic simulations. A particular contribution is the use of Sensor Fault Accommodation Ratio (SFAR) in the LQG scheme providing useful conclusions on the optimised sensor selection for the EMS system. It is concluted that the framework can be extended to other industrial applications.

11:50-12:10 — WeA2.5

Fault Tolerant Control Design for Polytopic Uncertain LPV Systems, pp. 66-72

Rotondo, Damiano — UPC
Nejjari, Fatiha — Univ. Pol. de Catalunya
Puig, Vicenc — Univ. Pol. de Catalunya

This paper presents a fault tolerant control (FTC) design for polytopic uncertain linear parameter-varying (LPV) systems. Depending on the information available about the fault, the FTC strategy could be passive FTC, active FTC without controller reconfiguration or active FTC with controller reconfiguration. The FTC strategy is designed taking into account the robust LPV polytopic framework extending known results from the robust polytopic and the traditional LPV polytopic control areas. The effectiveness of the proposed method is demonstrated by its application to a two-tank system simulator.

12:10-12:30 — WeA2.6

Italian Unmanned Space Vehicle Mission: Flight Results of the Virtual Air Data Algorithm, pp. 73-81

Nebula, Francesco — Italian Aerospace Res. Centre (CIRA)
Ariola, Marco — Univ. degli Studi di Napoli Parthenope

During the first Dropped Transonic Flight Test mission, carried out by the Italian Aerospace Research Center, although most of the mission objectives were achieved, several failures and operative limitations of the onboard hardware instrumentations were experienced. In order to solve such problems in the successive flight tests and thus to improve the vehicle survival to failures, more robust navigation algorithms were designed. In particular, a novel air data estimation algorithm named Virtual Air Data was designed, providing virtual air data quantities, obtained from a combination of inertial measurements with weather forecast data coming from a meteorological model, representing the onboard virtual sensor. This algorithm was successfully tested during the second mission, and the flight results presented in this article show the effectiveness of the proposed approach. This algorithm may work as a backup solution for conventional air data systems when an Air Data System failure occurs. In addition, the Virtual Air Data architecture appears to be a viable solution to overcome the common limitations of the conventional Air Data Systems. Finally, similarities between the performed second mission and a typical Terminal Area Energy Management flight phase of a re-entry winged vehicle also demonstrate applicability of such technologies to re-entry missions.

WeA3 — Imperial 2

Modelling and Simulation I (Regular Session)

Chair: Adnan, Naseeb Ahmed — Univ. of Alberta

10:30-10:50 — WeA3.1

Modeling and Identification of Spool Dynamics in an Industrial Electro-Hydraulic Valve, pp. 82-87

Aranovskiy, Stanislav — National Res. Univ. of Information Tech. Saint-

Approximate models of spool dynamics are proposed to deal with dynamic delays observed for an industrial electro-hydraulic valve.

The suggested model consists of a linear block and two static nonlinearities. A method for identification of parameters is suggested that allows to deal with a case when only pressure in a hydraulic cylinder is measured but not the displacement of the spool. The approach is verified experimentally.

10:50-11:10 WeA3.2

On Modeling and Simulation of a Cooking System, pp. 88-93

Vera, Davinia — Univ. of Zaragoza
Paesa Garcia, David — Univ. of Zaragoza
Llorente Gil, Sergio — BSH Electrodomésticos España S.A.
Sagues, Carlos — Univ. de Zaragoza

In this paper we present a non-linear state space model for a saucepan-induction hob system, based on the application of the fundamental thermal equations. We divide the whole system in subsystems and we choose as state variables the temperatures of the subsystem, which are able to increase or decrease its internal energy. Through this, we get a solution to study the heat fluxes and the energy losses, taking into account the material and the geometry of the elements. Besides, we consider the fact that in industry the most extended controllers are linear and we get the linear approximation of our model. Both, linear and non-linear models, are compared with real data from a test. Although often this is enough, we evaluate the possibility of using a simpler model and we apply a systematic technique to reduce the model order, without calibrating its parameters again.

11:10-11:30 WeA3.3

Simulation of Ship Maneuvering Behavior Based on the Modular Mathematical Model, pp. 94-99

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

With the rapid development of the computer technology and its successful application in ship engineering, the method of computer simulation based on the mathematical models became more and more popular; it provides a convenient tool for predicting ship maneuverability. One of the preconditions for applying that is the modeling of the dynamic differential equations that represent the ship dynamics in three degrees of freedom. The effectiveness of simulation is guaranteed by how accurate the model is. There are different types of ship mathematical modeling. In this work, the ship modular mathematical model was investigated. Simulink software was utilized to develop the ship subsystems as individual modules. Modules hydrodynamic forces, and moments were implemented in simulating the ship maneuvering behaviors of the ESSO OSAKA tanker class ship. Moreover, different types of maneuvering are tested in particular, turning and zigzag motion.

11:30-11:50 WeA3.4

A Neural Network Approach to Damage Detection in Euler-Bernoulli Beams Subjected to External Forces, pp. 100-103

Almeida, Juliana — Faculdade de Engenharia - Univ. do Porto
Alonso, Hugo — Univ. of Oporto
Rocha, Paula — Univ. of Porto

The aim of this contribution is to present two methods for online damage detection in Euler-Bernoulli beams subjected to external forces. Both methods detect damage by tracking changes in the beam parameters. Here, this change is assumed to occur in time, but not in space; that is, it occurs at a certain time instant, being the same along the beam. The input to the methods consists of the beam vibration data collected at different points. The first method is based on the use of a single Hopfield neural network. At each time instant, this network produces an estimate of the beam parameters and this estimate is the same for all beam points. In turn, the second method combines several Hopfield neural networks. At each time instant, each network produces an initial estimate of the parameters at a certain beam point and the estimates of neighbouring points are then combined to produce a final estimate at each point.

11:50-12:10 WeA3.5

State Estimation for PEM Fuel Cell Systems with Time Delay by an Unscented Kalman Filter and Predictor Strategy, pp. 104-112

Schultze, Martin — Helmut-Schmidt-Univ. Hamburg
Horn, Joachim — Helmut-Schmidt-Univ. / Univ. of the Federal Armed Forces

Polymer electrolyte membrane (PEM) fuel cell systems are investigated as replacement for auxiliary power units (APU) that are currently used for electrical power generation on aircraft. PEM fuel cells are highly efficient energy converters and provide electrical energy, cathode exhaust gas with low oxygen concentration and water. The system investigated is intended for generation of oxygen depleted cathode exhaust air (ODA) on aircraft with ODA-gas having a low oxygen concentration. Measurement of ODA-gas mass flow and oxygen content introduces a significant time delay. For state estimation a reduced order nonlinear model comprising the fuel cell stack, cooling system and cathode exhaust gas dehumidifying system has been derived. In a three steps state estimation strategy involving Unscented Kalman filtering combined with a prediction compensating for the significant time delay the actual system state is estimated. The strategy is implemented in Matlab/Simulink® and has been applied successfully. Experimental results are shown.

12:10-12:30 WeA3.6

On Detection Delays of Filtering in Industrial Alarm Systems, pp. 113-118

Adnan, Naseeb Ahmed — Univ. of Alberta
Izadi, Iman — Univ. of Alberta

To assess performance of a plant's alarm system, it is necessary to evaluate various performances indices. False alarm rates, missed alarm rates and detection delays are considered as important performance measures for univariate alarm design. To reduce false and nuisance alarms, filtering is widely used in industries. However there has been very limited study on performance specifications of various filtering methods, and the quantitative relation between filter properties and these performance indices are not well known. In this paper we investigate the effect of filtering on detection delay as an important alarm performance index.

WeA4 Imperial 3

Power Systems (Regular Session)

Chair: Ippoliti, Gianluca — Univ. Pol. delle Marche

10:30-10:50 WeA4.1

Optimal Fully Electric Vehicle Load Balancing with an ADMM Algorithm in Smartgrids, pp. 119-124

Mercurio, Andrea — Univ. of Rome Sapienza
Di Giorgio, Alessandro — Univ. of Rome "La Sapienza"
Purificato, Fabio — Univ. of Rome "Sapienza"

In this paper we present a system architecture and a suitable control methodology for the load balancing of Fully Electric Vehicles at Charging Station (CS). Within the proposed architecture, control methodologies allow to adapt Distributed Energy Resources (DER) generation profiles and active loads to ensure economic benefits to each actor. The key aspect is the organization in two levels of control: at local level a Load Area Controller (LAC) optimally calculates the FEV's charging sessions, while at higher level a Macro Load Area Aggregator (MLAA) provides DER with energy production profiles, and LACs with energy withdrawal profiles. Proposed control methodologies involve the solution of a Walrasian market equilibrium and the design of a distributed algorithm

10:50-11:10 WeA4.2

Experimental Investigation of an Emulator "Hardware in the Loop" for Electric Naval Propulsion System, pp. 125-130

Marouani, Khoudir — Ec. Militaire Pol. (EMP)
Guendouz, Hani — Pol. Military School (EMP)
Tabbache, Bekheira — Pol. Military School (EMP)

Khoucha, Farid — Pol. Military School (EMP)
Kheloui, Abdelaziz — Pol. Military School (EMP)

The purpose of this paper is the realization of an emulator for electric naval propulsion system. The main objective of an emulator is to reproduce the real system operation. The work consists of two principal parts: the first part concerns the modeling of the propeller and the different resistance forces opposed to the movement of the ship, allowing the estimation of the necessary propulsion power, and the second part presents the emulator of the ship propulsion system, based on the Hardware In the Loop (HIL) principle, using an electric machine operating as a generator to emulate the dynamic characteristic of the ship. The resulting model is validated by numerical simulations and then tested on an experimental test bench constituting the emulator. Different experiments are conducted taking into account the real operation of the ship.

11:10-11:30 WeA4.3

Stable Parameter-Free Nonlinear Controller for AC/DC Voltage Source Converters, pp. 131-136

Konstantopoulos, George — Univ. of Patras
Alexandridis, Antonios — Univ. of Patras

In this paper, a novel nonlinear dynamic regulator for three-phase AC/DC voltage source converters (VSC) is presented. The proposed control design approach is fully independent from the system parameters and simultaneously achieves precise DC bus voltage regulation and unity power factor operation. A traditional PI controller is used to achieve unity power factor, while the proposed nonlinear controller is used to regulate the DC bus voltage to the desired level. Due to the structure of the proposed scheme, closed-loop system stability is proven and an appropriate mathematical analysis shows that the solution remains bounded and converges to the desired equilibrium. Simulation results verify the controller efficiency under DC bus voltage reference and load changes.

11:30-11:50 WeA4.4

Current Sensorless Solution for PFC Boost Converter Operating Both in DCM and CCM, pp. 137-142

Cimini, Gionata — Univ. Pol. delle Marche
Ippoliti, Gianluca — Univ. Pol. delle Marche
Orlando, Giuseppe — Univ. di Ancona
Pirro, Matteo — Univ. Pol. delle Marche

In this paper a current sensorless solution for Power Factor Control (PFC) of an AC-DC boost converter operating in light load condition has been presented. A PI-based control with input voltage feedforward has been implemented in order to increase Power Factor (PF). A current observer, able to operate in either Continuous Conduction Mode (CCM) and in Discontinuous Conduction Mode (DCM), has been adopted in order to eliminate the need for expensive current sensors and to improve boost converter performances under light load conditions. The proposed solution has been numerically tested in three different load conditions using a powerful software simulation platform

11:50-12:10 WeA4.5

Parallel Active Filter to Eliminate Harmonics Generated by Compact Fluorescent Lamps, pp. 143-148

Moulahoum, Samir — Res. Lab. LREA, Univ. of Médéa
Houassine, Hamza — Res. Lab. LREA, Univ. of Médéa
Kabache, Nadir — Res. Lab. LREA, Univ. of Médéa

Use of nonlinear loads, such as power converters, fluorescent lamps and adjustable speed motor drives, is expected to grow rapidly. All of these loads inject harmonic currents. This paper presents the active filtering of the harmonic distortion generated by the compact fluorescent lamps (CFL). The Instantaneous active and reactive power theory (the p-q Theory) is used to design the control of parallel active filter. The control scheme has been verified using Matlab/Simulink with SimPower Systems through a set of simulation tests under different load conditions. Also, the tuning of the active power filter is performed to improve the quality of the electrical power supply.

12:10-12:30 WeA4.6

Model of a Self-Excited Induction Generator for the Design of Capacitor-Controlled Voltage Regulators, pp. 149-154

Kiselychnyk, Oleh — Univ. of Warwick
Bodson, Marc — Univ. of Utah
Wang, Jihong — Univ. of Warwick

The systematic design of voltage regulation systems for self-excited induction generators requires the development of a control-oriented model. The paper considers the situation where the peak magnitude of the stator voltages is regulated through adjustable capacitors connected to the windings. A transfer function model is difficult to obtain, due to the strong nonlinearity of the self-excitation phenomenon, and to unconventional features of the problem. Nevertheless, the paper succeeds in computing a transfer function relating small deviations of the capacitance to small deviations of the voltage magnitude using a clever choice of reference frame. The linearized system is found to be stable for all operating points under consideration, and the eigenvalues of the system predict rapidly-decaying oscillatory transients combined with a slower exponentially decaying component. Results of simulations of the full nonlinear model and of the linearized system demonstrate the validity of the approximation for small deviations. Experimental results also show a good match between measured data and the identified model.

WeA5 — Imperial 4

Applications of Control in Aerospace (Invited Session)

Chair: Tzes, Anthony — Univ. of Patras
Co-Chair: Theodoulis, Spilios — French-German Res. Inst. of Saint-Louis (ISL)
Organizer: Tzes, Anthony — Univ. of Patras
Organizer: Theodoulis, S. — French-German Res. Inst. of Saint-Louis (ISL)

10:30-10:50 WeA5.1

Fixed Structure Robust Control Design for the 155mm Canard-Guided Projectile Roll-Channel Autopilot (I), pp. 155-160

Theodoulis, Spilios — French-German Res. Inst. of Saint-Louis (ISL)
Brunner, Thomas — French-German Res. Inst. of Saint-Louis.
Gassmann, Vincent — French-German Res. Inst. of Saint-Louis
Wernert, Philippe — ISL

This article details a robust control procedure for the design of the roll-channel autopilot of a 155mm fin-guided projectile. A coaxial motor is used in order to control the roll rate and position of its nose throughout the flight. Both the nonlinear and linearized dynamics of the system are given and are also extended to take into account uncertainty into several of its parameters. For the design of the rate and position control loops a combined Hinf disturbance rejection and model matching procedure is followed leading to 2DoF controllers of fixed structure. Results are compared to 1DoF as well as 2DoF full order Hinf controllers. Finally the autopilot proposed is tested for robust stability using structured singular value analysis and implemented on a nonlinear projectile dynamics simulator. Extensive simulation results are given to demonstrate the effectiveness of the proposed solutions.

10:50-11:10 WeA5.2

Robust H2/Hinf Position Tracking Control of an Unmanned Helicopter for Near-Hover Flights (I), pp. 161-166

Marantos, Panos — National Tech. Univ. of Athens
Dritsas, Leonidas — Univ. of Patras
Kyriakopoulos, Kostas J. — National Tech. Univ. of Athens

In this paper, a systematic procedure for designing Position Tracking controllers for Unmanned Helicopters, based on mature

H2/Hinf methodologies, is presented. Firstly, a family of linearized models describing the near-hover flight dynamics is derived which can be formulated as a nominal plant perturbed by norm bounded uncertainties on the system, control and disturbance (wind gust) matrices. The full system dynamics is then decomposed into rotational (Inner) and translational (Outer) subsystems, and separate controllers are subsequently designed. Each controller guarantees stability, robustness and gust disturbance rejection for the whole near-hover flight envelope while appropriately selected closed-loop pole regions, justify the combination of the two controllers into a composite position control scheme. The efficacy of the proposed total control structure is proved by hardware-in-the-loop simulations on an accurate nonlinear helicopter model.

11:10-11:30 WeA5.3

Experimental Passive Fault Tolerant Control for Gyroscope System (I), pp. 167-172

Chaibet, Ahmed ESTACA

Boukhnifer, Moussa ESTACA Paris

This paper is dedicated to the passive fault tolerant control of moment gyroscope. Erroneous sensor reading and actuator faults reduce the performance and may even cause the instability. As a matter of fact, the control of the gyroscope system when these drawbacks are occurred often requires the fault tolerant control design. An H∞ robust control is designed in order to ensure the stability robustness of the system in the presence of the additive faults. Indeed, the passive fault tolerant control (PFTC) strategy is justified by its ability to maintain an acceptable performance in the presence of the noise disturbance as sensor failure. The considered technique is applied to verify the efficient performance of the PFTC controller when the occurrence of faults sensor. Simulation and experiment results are addressed to demonstrate the capability of the proposed PFTC to counteract the effect of the additive fault.

11:30-11:50 WeA5.4

Large Object Pushing Via a Direct Longitudinally-Actuated Unmanned Tri-TiltRotor (I), pp. 173-178

Papachristos, Christos Univ. of Patras

Tzes, Anthony Univ. of Patras

The original application of large object pushing with an Unmanned Aerial Vehicle platform is the subject of this paper. The utilization of an unmanned Tri-TiltRotor is proposed for this application, innovatively employing its direct longitudinal actuation capabilities to attain a large force exertion-capable aerial platform. Via the longitudinal tilting of the aerial vehicle's main rotors, the forward-projected force can be applied via a platform-mounted frame onto a large object, and bring it into motion. Concurrently, moment-compensation, achieved by a properly designed control synthesis exploiting the additional actuation capabilities of the platform, effectively regulates the attitude at stable hovering. Experimental results are provided, demonstrating the effectiveness of the implemented approach.

11:50-12:10 WeA5.5

Unmanned Coaxial Rotorcraft Force and Position Control for Physical Interaction through Contact (I), pp. 179-184

Alexis, Kostas ETH Zurich

Huerzeler, Christoph ETH Zurich

Siegwart, Roland Y. ETH Zürich

This paper addresses the problem of force and position control for an unmanned coaxial rotorcraft physically interacting with its environment through contact. The proposed control strategy equips the unmanned aerial robot with the capability to safely establish contact with the surfaces of its environment and apply desired forces on them while performing sliding maneuvers. A hybrid force/position control scheme is implemented, with the force controller being activated once contact is detected. Contact information is derived from force measurements and a hysteresis–based contact detection strategy. Extended experimental studies are conducted to evaluate the efficiency of the proposed methods.

12:10-12:30 WeA5.6

Two Robust Static Output Feedback Hinf Control Architectures for a Gun Launched Micro Aerial Vehicle (I), pp. 185-190

Drouot, Adrien CRAN - Nancy Univ.

Zasadzinski, Michel CRAN

Souley-Ali, Harouna CRAN - Univ. de Lorraine

Richard, Edouard Nancy Univ.

Boutayeb, M. Lorraine Univ.

In this paper, the design process of two robust Hinf control architectures for a Gun Launched Micro Aerial Vehicle - GLMAV - is presented. The process starts with the developement of a nonlinear dynamic model reflecting the important elements of the GLMAV. This model is then linearized around hover and used for the design of static output feedback Hinf controllers for position and orientation control. Unlike the full-order Hinf controller synthesis case, the Hinf optimization problem of static output feedback (SOF) controllers cannot be parameterized as a convex optimization problem. The cone complementarity linearization algorithm is therefore used to overcome the nonconvexity problem due to the constraint on the controller order. Finally, numerical simulations show the efficiency of the designed controllers

WeA6 Ariadne

Current Trends and Challenges in Closed Loop Anesthesia (Invited Session)

Chair: Mendonça, Teresa Univ. of Porto

Co-Chair: De Keyser, Robin M.C. Univ. of Gent

Organizer: Mendonça, T. Univ. of Porto

Organizer: De Keyser, R. M.C. Univ. of Gent

10:30-10:50 WeA6.1

Assessing Control Performance in Closed-Loop Anesthesia (I), pp. 191-196

Soltesz, Kristian Lund Univ.

Dumont, Guy A. Univ. of British Columbia

Ansermino, J Mark Department of Anesthesiology Pharmacology and Therapeutics

Recently, several control systems for closed-loop anesthesia have been demonstrated both in simulation and clinical studies. A set of performance measures, proposed by Varvel et al., have constituted the standard means of comparing such systems. This paper debates the adequacy of the Varvel measures, as applied to closed-loop anesthesia, and proposes an alternative set of measures. Key features of the proposed measures are: wide acceptance within the control community; reflection of clinical feasibility; separate measures for induction and maintenance of anesthesia; separation of outlier detection and performance evaluation. The proposed measures are descriptive, few, and easy to compute.

10:50-11:10 WeA6.2

New Aspects of the Rostocker Assistant System of Anesthesia Control (I), pp. 197-201

Sievert, Alexander Control Application Center, Inst. of Automation, Univ.

Bajorat, Joern Univ. of Rostock

Janda, Matthias Anaesthesiology and Intensive Care

Hofmockel, Rainer Univ. of Rostock

Simanski, Olaf Hochschule Wismar: Univ. of Applied Sciences: Tech. B

The medical control research group at the Universities of Rostock (Germany) and Wismar has developed an assistant system for anesthesia to support anesthetists in controlling and maintaining

the state of the patient in the operating theatre. The main objectives during general anesthesia are adequate level of hypnosis, analgesia, relaxation, and stable vital functions. During the last 20 years many controllers for the automatic drug delivery in anesthesia were developed. Starting with controllers for keeping a constant level of neuromuscular blockade, controllers for the hypnosis and analgesia were performed. Our research group developed a control system with an adaptive Generalized Controller for the neuromuscular blockade, a fuzzy controller for the control of the level of hypnosis and a fuzzy-system for analgesia control. The current contribution summarizes two studies, the MIMO control of the neuromuscular blockade and the depth of anesthesia which was done with 22 patients and the MIMO control of the depth of anesthesia and the level of analgesia. A model-based predictor for the level of neuromuscular blockade (NMB), to predict the level of NMB after stopping the drug infusion was integrated as a new feature for improving the clinical benefit.

11:10-11:30 WeA6.3

ARX Modeling of Drug Effects on Brain Signals During General Anesthesia (I), pp. 202-205

Nunes, Catarina S.	Centro Hospitalar do Porto
Lobo, Francisco A	Centro Hospitalar do Porto, Serviço de Anestesiologia
Amorim, Pedro	Hospital Geral de Santo António

The effect of drugs' interaction on the brain signal Bispectral Index (BIS) of the EEG, is of great importance for an anesthesia control drug infusion system. In this study, the objective was to investigate if an autoregressive with exogenous inputs model (ARX) could be a suitable approach to predicting BIS according to the anesthetic drugs concentrations. Data were collected in 45 neurosurgeries with total intravenous anesthesia every 5s. A stochastic ARX model was fitted to the data of each patient. The models structure that performed better as predictor used a 30s lag for BIS, 1min lag for propofol and 2min lag for remifentanil. The models had a good performance with statistical zero errors in 31 patients. The average of absolute errors was 8.2, showing that the model captures the brain signal trend. This model proved to be effective in modeling and one step prediction of the BIS signal capturing unique characteristics. The results show that the previous brain response trend has influence on the present value, in addition the drugs concentrations from the previous 2min still have influence. This is an important conclusion for the development of drug infusion controller algorithms.

11:30-11:50 WeA6.4

Fractional Order Impedance Models As Rising Tools for Quantification of Unconscious Analgesia (I), pp. 206-212

Chevalier, Amélie	Ghent Univ.
Copot, Dana	Ghent Univ.
Ionescu, Clara	Ghent Univ.
De Keyser, Robin M.C.	Univ. of Gent

This research focuses on modeling the diffusion process that occurs in the human body when an analgesic drug is taken up, by using fractional-order impedance models (FOIMs). We discuss the measurement of a suitable feedback signal that can be used in a model-based control strategy. With this knowledge an early dawn concept of a pain sensor is presented. The major challenges that are encountered during this development consist of identification of the patient model, validation of the pain sensor and validation of the effect of the analgesic drug.

11:50-12:10 WeA6.5

Design of Depth of Anesthesia Controllers in the Presence of Model Uncertainty (I), pp. 213-218

Caiado, Daniela	INESC-ID
Lemos, Joao M.	INESC-ID
Costa, B.Andrade	INESC-ID/IST/ TU Lisbon
Silva, Margarida M.	Univ. of Porto
Mendonça, Teresa	Univ. of Porto

A major obstacle in the design of controllers to regulate the depth of anesthesia (DoA) consists in the high model uncertainty due to inter-patient variability. Surprisingly, the use of control design methods that explicitly tackle this problem is almost absent from the literature on automatic control of anesthesia. In this work, a DoA controller is designed taking into account model uncertainty to comply with robust stability and robust performance specifications for a patient population undergoing elective general surgery, with hypnosis induced by the drug emph{propofol}. Due to its Wiener nonlinear structure, the DoA model can be linearized around a given operating point. Therefore, using a database with 18 patient models, a non-parametric description of uncertainty for a linearized model is first performed. By using H$_infty$ design methods, a continuous linear controller is then designed so as to ensure robust stability and performance within the uncertainty bounds defined. The controller that results from this procedure is approximated by a controller with a lower order that, in turn, is redesigned in discrete time for computer control application. The final result is tested in nonlinear realistic patient models, with acceptable closed-loop results.

12:10-12:30 WeA6.6

Improvement of the BIS Reference Tracking Performance in the Presence of Parameters Uncertainties (I), pp. 219-224

Nogueira, Filipa	Univ. of Porto
Mendonça, Teresa	Univ. of Porto
Rocha, Paula	Univ. of Porto

In this paper two controllers in parallel, each of them as proposed in Bastin and Provost ["Feedback stabilisation with positive control of dissipative compartmental systems", in Proceedings of the 15th International Symposium on Mathematical Theory of Networks and Systems MTNS 2002, Notre-Dame, USA, August 2002] for the control of the total mass in SISO compartmental systems, are used to control the depth of anesthesia in patients (DoA) by means of the dministration of propofol and remifentanil. These controllers are based on a parameter parsimonious Wiener model recently introduced in the literature. A strategy to solve the problem raised by the existence of uncertainties in the parameters of the patients models is also presented. This technique significantly improves the performance of the controller.

WeB1 IMPERIAL

Optimisation (Regular Session)

Chair: Olaru, Sorin Supelec

15:00-15:20 WeB1.1

Control Synthesis for Switched Systems with Control and State Constraints, pp. 225-230

Nguyen, Hoai-Nam	Tech.
Olaru, Sorin	Supelec
Gutman, Per-Olof	Tech.

In this paper, a new interpolation based control is developed for constrained control of switched linear discrete time systems. The interpolation is done between a global gain-scheduled vertex controller and a local gain-scheduled stabilizing controller in order to achieve both the large domain of attraction and performance. At each time instant a linear programming problem is solved on-line. Proofs of recursive feasibility and asymptotic stability are given.

15:20-15:40 WeB1.2

Convergence of a WMR to the Source of Unknown Signal Distribution in a Cluttered Environment, pp. 231-236

Sredojev, Sonja	The Univ. of New South Wales
Eaton, Ray	The Univ. of New South Wales

Many mechanical systems that suffer from nonholonomic constraints have attracted a lot of attention recently due to the theorem of Brockett. One such system is a wheeled mobile robot (WMR). Equipped with a proper sensors the robot has an advantage over a human since it can easily maneuver in dangerous environments, and could be rapidly modified or improved to fulfill any specific tasks. Thereby, it can be used to detect and track

radioactive, chemical, thermal or any other signal in order to localize and approach its source. This work presents an extremum seeking controller designed with the main aim to safely drive the vehicle towards the source of radiated signal with no prior knowledge about the environment and analytical structure of nonlinear signal distribution. Sliding mode controllers are employed to control WMR during the obstacle free mode, and also while maneuvering within a cluttered environment. To assure the timely convergence to the source, Kalman filter is used to predict the future trajectory evolution over sufficiently long time interval.

15:40-16:00 WeB1.3

Optimal Regulatory Programs for the Control of Metabolic Pathways: The Case of Feedback Inhibition, pp. 237-242

Martin de Hijas, Gundian	IIM-CSIC (Spanish Council for Scientific Res.
Balsa-Canto, Eva	IIM-Spanish National Res. Council
Banga, Julio R.	IIM-CSIC (Spanish Council for Scientific Res.
Kaleta, Christoph	Univ. of Jena

In this work we investigate the influence of feedback regulation on optimal programs of pathway control by means of advanced dynamic optimization techniques. The problem is formulated using a general dynamic optimization framework and solved using a control vector parameterization approach together with a suitable global optimization method. We consider the case of a linear pathway and we compare the resulting pathway regulation strategies with the introduction of feedback-inhibition at different positions in the pathway. Our results show that feedback inhibition is an important component of pathway control that allows to reduce the number of transcriptional regulatory interactions that are required to control the flux through a metabolic pathway. In particular, the presence of a feedback of the product of a pathway on the first enzyme can reduce the total number of transcriptional regulatory interactions (that are required to control the flux) to a single regulatory interaction. Moreover, we find that there is an optimal strength of the feedback inhibition. If inhibition is too strong, there is a large increase in protein cost to maintain the pathway flux. In contrast, if the inhibition is too weak, it does not exert any significant regulatory effect. Overall, these results demonstrate that dynamic optimization is an important tool that allows us to elucidate and understand design principles of biological networks.

16:00-16:20 WeB1.4

Distributed Solution for the Economic Dispatch Problem, pp. 243-250

Binetti, Giulio	Pol. di Bari
Abouheaf, Mohammed	Univ. of Texas at Arlington
Lewis, Frank L.	Univ. of Texas at Arlington
Naso, David	Pol. di Bari
Davoudi, Ali	Univ. of Texas, Arlington
Turchiano, Biagio	DEE - Pol. di Bari

A distributed approach for the economic dispatch of generator units is presented. It is assumed that generators are connected by a communication graph. Each unit has information about itself, and can exchange information only with a few neighboring units in such a graph. Using graph theory and consensus algorithms, the proposed approach solves the economic dispatch problem in a distributed manner instead of existing centralized approaches. The proposed solution is shown to be optimal, independent of the initial power distribution, and to respond automatically to real-time load demand changes. Moreover, it requires only that the communication graph be connected. The effectiveness of the proposed algorithm is verified by simulating a standard IEEE test system.

16:20-16:40 WeB1.5

Underwater Plume Tracing with an AUV Cooperative Navigation Scheme Based on the Simplex Algorithm, pp. 251-256

Borges Nogueira, Marcelo	Univ. Federal do Rio Grande do Norte
Pereira, Fernando Lobo	Univ.of Porto
Sousa, Joao	Univ. of Porto

Abstract--- This article concerns an approach for cooperative plume tracing in an underwater environment characterized by very strict communication constraints such as delays, low reliability and limited bandwidth, as well as by the absence of natural features which would help localization and navigation. Localization is of utmost importance for plume tracing and remains a challenging area for AUVs in such a difficult environment. The adopted approach requires only relative localization which is satisfactorily achieved by using a SLAM-like scheme based on Extended Kalman Filter that takes into account the communications constraints. In this scheme, for any given AUV, the other elements of the team play the role of ``environmental'' features of a dynamic nature. The vehicles share data - relative localization as well as plume samples data - in order to improve localization estimates and generate motion waypoints according to the well known simplex algorithm. Since in this case the vertices are given by vehicle position estimates, they will have some associated uncertainty. We analyse under what conditions the simplex with uncertain vertices reduces to the regular simplex, and simulations reveal that the uncertainty of the adopted cooperative localization method suffices to ensure that the simplex algorithm ``converges'' to an estimate of the point of minimum of the scalar field of interest, i.e., to the plume source.

WeB2 Imperial 1

Fuzzy Systems (Regular Session)

Chair: Groumpos, Peter	Univ. of Patras
Co-Chair: Boutalis, Yiannis	Democritus Univ. of Thrace

15:00-15:20 WeB2.1

Modeling and Analysis of a Hybrid-Energy System Using Fuzzy Cognitive Maps, pp. 257-264

Karagiannis, Ioannis	Univ. of Patras
Groumpos, Peter	Univ. of Patras

A hybrid energy system is an excellent solution to the problem of not being able to meet the power demand using a single energy source. Such a system incorporates a combination of one or more renewable energy source (RES) such as solar photovoltaic, wind-energy, geothermal, and could also have a conventional generator for backup. This paper discusses different system components of a hybrid energy system and develops a theoretical model to find an acceptable combination of energy components. A theoretical model of a hybrid energy system, using Fuzzy Cognitive Maps (FCMs) and learning algorithms, is presented. FCMs perform well even with missing data and despite nonlinearities, which such systems usually have. The simulation results verified the effectiveness and reliability of the proposed hybrid energy system.

15:20-15:40 WeB2.2

Fuzzy Observer Design for Local Model Network Based Battery State of Charge Estimation, pp. 265-270

Hametner, Christoph	Vienna Univ. of Tech
Jakubek, Stefan M.	Vienna Univ. of Tech

The correct determination of the state of charge (SoC) is an important task in hybrid electrical vehicles. In this paper, a systematic approach to state of charge estimator design using the fuzzy observer architecture is presented. The nonlinear observer is based on a dynamic battery model which describes the nonlinear system behaviour of the cell terminal voltage in dependance of the charge/discharge current. In this paper, a purely data driven modelling approach is chosen in order to to enable the application for any type of battery chemistry. The proposed local model network (LMN) is shortly reviewed, an augmented state space representation of the LMN is derived and the nonlinear observer design and parametrisation is presented. In combination with LMNs, the architecture of the fuzzy observer helps to reduce the computational complexity of the global nonlinear filter significantly. Each of the local models in an LMN is a linear time-invariant dynamic system. The global filter is then derived from a linear

combination of the local filters. The proposed concepts for SoC estimation are validated experimentally by means of a Lithium Ion power cell.

15:40-16:00 WeB2.3

Sum of Squares Approaches for Control of Continuous-Time Recurrent Fuzzy Systems, pp. 271-277

Gering, Stefan — TU Darmstadt
Schwung, Andreas — TU Darmstadt
Gußner, Thomas — TU Darmstadt
Adamy, Juergen — Tech. Univ. Darmstadt

In recent years, a concise theory of recurrent fuzzy systems has emerged and methods for utilizing these fuzzy systems with dynamics for modeling and fault detection were developed. At the same time, sum of squares decompositions in conjunction with semidefinite programming were successfully applied for the synthesis of controllers for polynomial systems. In this paper, we combine both approaches and present sum of squares based control strategies for continuous-time recurrent fuzzy systems. The system dynamics under consideration is defined by gradients at discrete points in the input-state space. An alternative description as piecewise polynomial system is possible. This motivates to utilize a controller switching between local polynomial control laws. We propose three different approaches for controller synthesis based on this idea and demonstrate this new synthesis method by means of an example. In addition, advantages and drawbacks of the approaches are discussed.

16:00-16:20 WeB2.4

Improving the Performance of Multiple Models Fuzzy Control by Using Semi-Fixed and Adaptive Models, pp. 278-283

Sofianos, Nikolaos — Democritus Univ. of Thrace
Boutalis, Yiannis — Democritus Univ. of Thrace

The role of the fixed models which participate in a hybrid switching control scheme is investigated in this paper. The control scheme is based on some semi-fixed and adaptive Takagi-Sugeno (T-S) identification models and its main target is to control efficiently a class of unknown nonlinear dynamical fuzzy systems. These identification models define the control signal at every time instant with their own state feedback fuzzy controllers which are parameterized by using the certainty equivalence approach. A performance index and an appropriate switching rule are used to determine the T-S model which best approximates the plant and consequently to pick the best available controller at every time instant. The identification models bank consists of three kind of models: i. a number of semi-fixed T-S models which are redistributed during the control procedure, ii. a free adaptive T-S model which is randomly initialized and iii. a reinitialized adaptive model which uses the parameters of the best semi-fixed model at every time instant. This combination of these different model categories, offers many advantages to the control scheme. The asymptotic stability of the system and the adaptive laws for the adaptive models are given by using Lyapunov stability theory. The effectiveness and the advantages of the proposed method are illustrated by some computer simulations.

16:20-16:40 WeB2.5

Bilinear Neuro-Fuzzy Modeling for Adaptive Approximation and Indirect Control of Nonlinear Systems, pp. 284-289

Boutalis, Yiannis — Democritus Univ. of Thrace
Christodoulou, Manolis A. — Tech. Univ. of Crete
Andreadis, Filippos — Tech. Univ. of Crete

To cope with the indirect regulation of unknown affine in the control nonlinear systems, this paper proposes a method which is based on a recurrent Neuro-Fuzzy modeling. Initially, the components of the nonlinear plant are approximated by Fuzzy subsystems. Using appropriately defined ``indicating functions'', it is shown that the initial dynamical fuzzy system can be converted to a dynamical neuro-fuzzy model, where the ``indicating functions'' are replaced by High Order Neural Networks (HONNS), trained by sampled system data. Assuming only parametric uncertainty, the parameters to be estimated are the weights of the HONNs and the centers of the output partitions, both arranged in matrices of appropriate dimensions and leading to a bilinear parametric model. Adaptive laws are derived based on this model and using a Lyapunov stability analysis of the error dynamic equations. The a-priori experts information required by the identification scheme is extremely low, limited to the knowledge of the signs of the center of the fuzzy output partitions. Once the system is identified around an operation point, it is regulated to zero adaptively using an appropriate controller that is built according to the neuro-fuzzy model. The weight updating laws guarantee that both the identification error and the system states reach zero exponentially fast, while keeping all signals in the closed loop bounded. Simulation on a well known benchmark illustrates the potency of the method.

WeB3 — Imperial 2

Automotive Control (Regular Session)

Chair: Bogdan, Stjepan — Univ. of Zagreb

15:00-15:20 WeB3.1

On the Efficiency of a Prototype Continuous Variable Transmission System, pp. 290-295

Spanoudakis, Polychronis — Tech. Univ. of Crete
Tsourveloudis, Nikos — Tech. Univ. of Crete

In this paper we explore the performance capabilities of a new variable transmission system installed on a low fuel consumption, zero emission, prototype urban vehicle. Our focus is on measuring the efficiency of the continuous variable transmission system, namely, the Electronic Shift Variable Transmission (ESVT), which is presented here in a lightweight conceptually simple design as part of the powertrain of a hydrogen fuel cell powered urban vehicle, developed at the Technical University of Crete. To evaluate ESVT's operational ability, a laboratory testbed was developed, mainly to imitate full scale driving conditions in terms of power needs for various external loads. Testbed's configuration and experimental measurements are presented, providing insight on technical characteristics and limitations of the proposed prototype transmission.

15:20-15:40 WeB3.2

Experimental Testing of a Traction Control System with On-Line Road Condition Estimation for Electric Vehicles, pp. 296-302

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

In this paper experimental results of testing slip-based traction control system (TCS) with an on-line road condition estimation are presented. TCS is designed for a car with in-wheel electric motors, so that estimation and control are implemented independently for each wheel thus enabling the optimal friction coefficient for every wheel, even if they are on different surfaces or have different tire characteristics. A road condition is approximated using a function which is estimated in the real-time and used as the input to the TCS. The design of the presented TCS is based on the wheel slip ratio, controlled to it's optimal value by a PI controller and with the addition of a feedforward branch for the transition response speed up. System is tested on a newly developed experimental setup consisting of the wheel with embedded (in-wheel) motor rolling on the metal drum loaded by the second motor simulating car behaviour.

15:40-16:00 WeB3.3

Study and Comparison of Non Linear and LPV Control Approaches for Vehicle Stability Control, pp. 303-310

Fergani, Soheib — GIPSA-Lab. Control Systems Dept, Grenoble Univ.
Lghani, Menhour — Mines ParisTech, Centre de Robotique, 60 boulevardSaint-Michel,

Sename, Olivier INPG
Dugard, Luc CNRS-INPG
D'Andrea-Novel, Brigitte Ec. des Mines de Paris

This paper proposes a study and a comparison between two efficient and novel vehicle control dynamics strategies, namely, the non linear Flatness control strategy and the LPV/Hinf control strategy. The first one concerns a controller based on the differential algebraic flatness of non linear systems and an algebraic non linear estimation applied to commercial vehicles. The second one is a LPV/Hinf (Linear Varying Parameter with the H1 norm) control using a stability monitoring system to achieve the vehicle dynamics control objective. These two strategies use Active Steering and Electro-Mechanical Braking actuators and aim at improving the vehicle stability and steerability by designing a multivariable controller that acts simultaneously on the lateral and longitudinal dynamics of the car. Simulations are performed on a complex non linear full vehicle model, the same driving scenario is applied for the two control strategies. The model parameters are those of a Renault Mégane Coupé (see table.I), obtained by identification with real data. Promising simulations results are obtained. Comparison between the two proposed strategies and the uncontrolled vehicle show the reliability and the robustness of the proposed solutions, even if one is governed within the linear control framework while the other one is a non linear control approach.

16:00-16:20 WeB3.4

Design, Experimental Validation, and Comparison of Two Model-Based EKF Observers for Lateral Vehicle Dynamics Estimation, pp. 311-316

Doumiati, Moustapha Univ. Bin Sultan Univ.
Ghandour, Raymond UTC
Charara, Ali UMR CNRS 7253
Victorino, Alessandro Univ. Univ. de Tech. de Compiègne
Lechner, Daniel INRETS

One of the most important tasks of the vehicle dynamics estimation problem is to obtain the longitudinal, lateral, and vertical forces acting upon the wheels. These variables are fundamental for studying vehicle controllability and stability. However, they are difficult to obtain in terms of measurement techniques. Regarding lateral/tire forces, two observers based on the state-observer Extended Kalman Filter (EKF) theory and on the dynamic responses of a vehicle instrumented with standard sensors are proposed, discussed and compared in this study. The first observer estimates the lateral forces per axle using a random walk model, and then calculates the individual lateral tire forces on the basis of the vertical tire forces distribution. The second observer directly estimates the lateral forces per tire using a transient relaxation model. The developed observers are able to work in real-time in normal and in critical driving situations. Performances are tested using a laboratory car running on a wet track.

16:20-16:40 WeB3.5

Vehicle Yaw Stability Control Using Rear Active Differential Via Sliding Mode Control Methods, pp. 317-322

Daniel, Rubin Ben Gurion Univ.
Arogeti, Shai Ben-Gurion Univ. of the Negev

The problem of vehicle yaw control is addressed in this paper using a rear active differential. The controller objective is to minimize the yaw-rate error and body slipangle error of target values. A new Sliding mode controller is designed using a nonlinear 2DOF vehicle model and a sliding surface that integrates the vehicle yaw-rate error and slipangle error. Two control law approaches, namely, saturation control and saturation plus constant gain control where tested. Simulations performed using CarSim and Matlab/Simulink show robust stability in face of model uncertainties and superior performances of the saturation plus constant gain control.

WeB4 Imperial 3

Nonlinear Control I (Regular Session)

Chair: Sourkounis, Const. Ruhr-Univ. Bochum

15:00-15:20 WeB4.1

Economic Model Predictive Control of Nonlinear Two-Time-Scale Systems, pp. 323-328

Ellis, Matthew Univ. of California - Los Angeles
Heidarinejad, Mohsen Univ. of California - Los Angeles
Christofides, Panagiotis D. Univ. of California - Los Angeles

We focus on the development of a Lyapunov-based economic model predictive control (LEMPC) method for nonlinear singularly perturbed systems in standard form arising naturally in the modeling of two-time-scale chemical processes. A composite control structure is proposed in which, a “fast” Lyapunov-based model predictive controller (LMPC) using a quadratic cost function which penalizes the deviation of the fast states from their equilibrium slow manifold and the corresponding manipulated inputs, is used to stabilize the fast dynamics while a two-mode “slow” LEMPC design is used on the slow subsystem that addresses economic considerations as well as desired closed-loop stability properties by utilizing an economic (typically non-quadratic) cost function in its formulation and possibly dictating a time-varying process operation. Through a multirate measurement sampling scheme, fast sampling of the fast state variables is used in the fast LMPC while slow-sampling of the slow state variables is used in the slow LEMPC. Appropriate stabilizability assumptions are made and suitable constraints are imposed on the proposed control scheme to guarantee the closed-loop stability and singular perturbation theory is used to analyze the closed-loop system.

15:20-15:40 WeB4.2

Economic Model Predictive Control of a Transport-Reaction Process, pp. 329-334

Lao, Liangfeng Univ. of California - Los Angeles
Ellis, Matthew Univ. of California - Los Angeles
Christofides, Panagiotis D. Univ. of California - Los Angeles

This work focuses on the development and evaluation of an economic model predictive control (EMPC) system for a non-isothermal tubular reactor where a second-order chemical reaction takes place. The tubular reactor is modeled by two nonlinear parabolic partial differential equations (PDEs). Galerkin's method is initially used to derive finite-dimensional systems that capture the dominant dynamics of the parabolic PDEs which are subsequently used for EMPC design. The EMPC formulation uses as an economic cost function the integral of the reaction rate along the length of the reactor over a certain operation interval subject to constraints on the control action (reactant concentration in the feed to the reactor). Closed-loop simulations in which the low-order EMPC system is applied to a high-order discretization of the PDEs demonstrate that the EMPC operates the process in a time-varying fashion and improves the economic cost over steady-state operation using the same amount of reactant material over a fixed period of operation.

15:40-16:00 WeB4.3

S-Curve Speed Control for Variable Speed Wind Energy Converters, pp. 335-340

Sourkounis, Constantinos Ruhr-Univ. Bochum

In this paper, a novel non-linear method for the operation management, which is designed and investigated by simulation and experiments at a test bed for speed variable wind energy converters, will be described and compared to other MPP-Tracking methods. The novel method allows a dynamical speed flexibility around the estimated optimal operation point, so that additional to an operation with the maximal possible efficiency of wind rotor a smoothing of power output variations caused by the wind is achieved.

16:00-16:20 WeB4.4

Quasi-LPV Gain-Scheduling Control of a Nonlinear Aircraft Pneumatic System, pp. 341-350

Turcio, Wallace — Embraer S.A.
Yoneyama, Takashi — Inst. Tecnologico Aeronautica
Moreira, Fernando Jose — Embraer S.A.

This work presents a Quasi-LPV (Linear Parameter Variation) model for a pressure regulation and shutoff valve(PRSOV) used in aircrafts and proposes a controller based on Quasi-LPV gain-scheduling theory. This Quasi-LPV model was obtained from the PRSOV validated nonlinear mathematical model. Simulation results are presented and discussed. The benefits and difficulties of applying Quasi-LPV gain-scheduling control to this type of system are analyzed.

16:20-16:40 WeB4.5

Comparison of Filter Designs for a Digital Beam-Phase Feedback System in a Heavy-Ion Synchrotron, pp. 351-356

Grieser, Jochen — TU Darmstadt
Bug, Daniel — KTH Stockholm
Lens, Dieter — TU Darmstadt
Klingbeil, Harald — TU Darmstadt,
Adamy, Juergen — Tech. Univ. Darmstadt

The bunched particle beam in a synchrotron can perform various longitudinal oscillation modes of which the dipole mode occurs most frequently. Although naturally damped by Landau damping, these oscillations can become unstable if driven accordingly. In any case Landau damping is accompanied by filamentation of the bunch which leads to rms emittance blow up and thus reduces the beam quality. Therefore a beam-phase feedback is used to damp dipole oscillations. At GSI Helmholtzzentrum für Schwerionenforschung GmbH the feedback is designed as an FIR filter. However, the feedback performance may be improved using a matched filter instead of the current filter setting as is demonstrated in this work by comparing the different filter designs.

WeB5 — Imperial 4

Unmanned Systems I (Regular Session)

Chair: Vachtsevanos, George — Georgia Inst. of Tech.
Co-Chair: Alexis, Kostas — ETH Zurich

15:00-15:20 WeB5.1

Flight Control System for Small-Size Unmanned Aerial Vehicles: Design and Software-In-The-Loop Validation, pp. 357-362

Meola, Daniela — Univ. degli Studi del Sannio
Iannelli, Luigi — Univ. of Sannio in Benevento
Glielmo, Luigi — Univ. of Sannio

Currently there is a large interest in low cost unmanned aerial vehicles (UAV) development aimed to civilian applications. This paper describes the development and the software-in-the-loop validation of a flight control system for a small fixed wing UAV. The proposed approach follows standard tecniques for modeling, linearizing and decoupling the highly nonlinear six degrees-of-freedom dynamics of the vehicle. As a novelty in the UAV field, the participation factors analysis is applied in order to validate the decomposition into longitudinal and lateral-directional dynamics. Thus a linear quadratic regulator is developed for controlling the airspeed and the altitude, while a cascaded proportional-integral-derivative control is adopted for the heading tracking of the lateral dynamics, so to obtain the full waypoint navigation. In this work the lack of ailerons can be considered a peculiar feature of the considered platform since it determines a greater difficulty in controlling the flight of the UAV with respect to other airframe platforms.

15:20-15:40 WeB5.2

Explicit Constrained Optimal Trajectory Control of an Unmanned Coaxial Rotorcraft, pp. 363-368

Huerzeler, Christoph — ETH Zurich
Alexis, Kostas — ETH Zurich
Siegwart, Roland Y. — ETH Zürich

The design and experimental verification of a constrained optimal trajectory tracking control scheme for an unmanned coaxial rotorcraft that respects the vehicle's physical limitations is the subject of this paper. The optimal controller is computed in a finite time horizon fashion and the optimization problem is solved subject to the system dynamics and modeled input and state constraints. The proposed controller is computed explicitly which enables its seamless real–time implementation using high update rates despite the curse of dimensionality that typically follows such control approaches. The capabilities of the platform and the high performance of the control law are evaluated using extended experimental studies.

15:40-16:00 WeB5.3

Trajectory Control of an Unmanned Tri-TiltRotor in Hover Flight Via Direct Longitudinal Actuation, pp. 369-374

Papachristos, Christos — Univ. of Patras
Alexis, Kostas — ETH Zurich
Tzes, Anthony — Univ. of Patras

The experimental trajectory control of a Tri-TiltRotor Unmanned Aerial Vehicle in rotorcraft hovering operation is the subject of this paper. This reconfigurable UAV is designed for autonomous conversion between the Vertical Take-Off and Landing, and the Fixed-Wing flight modes. Via employing the additional control authority gained by rotor-tilting, the full actuation of the UAV longitudinal dynamics is achieved. Based on this novel feature, longitudinal thrust vectoring of the main rotors is performed, and the respective degree-of-freedom is significantly benefited while performing rotorcraft hovering flight. The system custom autopilot is based on a Proportional-Integral-Derivative-double Derivative scheme, exploiting the augmented UAV state vector for control, while the custom-developed sensor suite and state estimation system provides fully autonomous operation. Extensive experimental studies validate the control scheme's efficiency, while remarking the advantageous effects of the longitudinal thrust vectoring-based control authority.

16:00-16:20 WeB5.4

Trajectory Control of Multirotor Helicopters with Thrust Vector Constraints, pp. 375-379

Santos, Davi Antônio — Inst. Tecnológico de Aeronáutica
Saotome, Osamu — Inst. Tecnológico de Aeronáutica
Cela, Arben — Groupe ESIEE

The multirotor control system structure that has mostly been adopted is constituted by an inner and an outer control loop. In this scheme, the inner loop carries out attitude control while the outer loop is responsible for trajectory control. The present work addresses the problem of safely controlling the trajectory of a multirotor helicopter by taking into account specified constraints on both the total thrust magnitude and the inclination of the rotor plane. The proposed solution partitions the whole problem into an altitude and an horizontal position control. The control laws of the two parts combine the feedback linearization principle with saturated proportional-derivative controllers. The proposed method is evaluated by computational simulations, which show its effectiveness to control the vehicle along a spiral trajectory as well as respond to abrupt position commands.

16:20-16:40 WeB5.5

Guidance, Navigation, and Control of an Unmanned Hovercraft, pp. 380-387

Kim, Kilsoo — Georgia Inst. of Tech.
Lee, Young-Ki — Georgia Inst. of Tech.
Oh, Sehwan — Georgia Inst. of Tech.
Moroniti, David — Georgia Inst. of Tech.
Mavris, Dimitri — Georgia Inst. of Tech.
Vachtsevanos, George — Georgia Inst. of Tech.
Papamarkos, Nikos — Democritus Univ. of Thrace
Georgoulas, George — TEI of Epirus

This paper introduces a simulation and evaluation of guidance, navigation, and control algorithms applied to an autonomous hovercraft. A line-of-sight guidance law is adopted in conjunction with a neural network based adaptive dynamic inversion control scheme for the underactuated hovercraft following a prescribed path. Theoretical and simulation results support the efficacy of the proposed methodology.

WeB6 Ariadne

Fault Diagnosis I (Regular Session)

Chair: Nikolakopoulos, G. Luleå Univ. of Tech. Sweden

15:00-15:20 WeB6.1

Broken Rotor Bar Fault Detection Based on Uncertainty Ellipsoidal Intersection for Three Phase Induction Motors, pp. 388-393

Mustafa, Mohammed Obaid Luleå Univ. of Tech.

Nikolakopoulos, George Luleå Univ. of Tech. Sweden

Gustafsson, Thomas Luleå Univ. of Tech.

In this article a fault detection scheme for broken rotor bar fault detection in the case of a three phase induction motor will be presented. In the proposed scheme the induction motor has been transformed in the equivalent two phase ($q-d$) space, while the modeling of the faulty case has been also formulated. The motor has been identified by the utilization of the Set Membership Identification (SMI) algorithm that has the merit of identifying both the parameters of the motor as also providing uncertainty bounds in both the healthy and the faulty cases. Based on the adopted methodology, the uncertainty bounds and the corresponding identified parameters of the induction motor have been presented as 3D--ellipsoids, while a novel fast and efficient fault detection scheme has been proposed that is able to track iteratively the ellipsoid centers, the distance among centers, the intersection between the initial and a priori known converged states of the motor and the current ones, before or after the fault occurrence. Detailed analysis of the proposed approach and the fault detection strategy, as also extended simulation results are being presented that prove the efficiency of the suggested scheme.

15:20-15:40 WeB6.2

Temporal/Spatial Model-Based Fault Diagnosis vs. Hidden Markov Models Change Detection Method: Application to the Barcelona Water Network, pp. 394-400

Quevedo, Joseba Tech. Univ. of Catalonia

Alippi, Cesare Pol. di Milano

Cugueró, Miquel À. Tech. Univ. of Catalonia

Ntalampiras, Stavros Pol. di Milano

Puig, Vicenc Tech. Univ. of Catalonia

Roveri, Manuel Pol. di Milano

García Valverde, Diego UPC

This paper deals with a comparison of two different fault diagnosis frameworks. The first method is based on a temporal/spatial model-based analysis by exploiting a-priori information about the system under study, so fault detection is based on monitoring the residuals of combined spatial and time series models obtained from the network. The second method aims at characterizing and detecting changes in the probabilistic pattern sequence of data coming from the network. Relationships between data streams are modelled through sequences of linear dynamic time-invariant models whose trained coefficients are used to feed a Hidden Markov Model (HMM). When the pattern structure of incoming data cannot be explained by the trained HMM, a change is detected. Here, the performance obtained from this two distinct approaches is examined by using a dataset coming from the Barcelona water transport network.

15:40-16:00 WeB6.3

Distributed Detection and Isolation of Sensor Faults in HVAC Systems, pp. 401-406

Reppa, Vasso Univ. of Cyprus

Papadopoulos, Panayiotis KIOS Res. Center for Intelligent Systems and Networks

Polycarpou, Marios M. Univ. of Cyprus

Panayiotou, Christos Univ. of Cyprus

This paper presents the design of a methodology for distributed detection and isolation of multiple sensor faults in heating, ventilation and air-conditioning (HVAC) systems. The proposed methodology is developed in a distributed framework with the HVAC system modeled as a set of interconnected, nonlinear subsystems. A local sensor fault diagnosis (LSFD) agent is designed for each of the interconnected subsystems. The LSFD agent uses input and sensor output data of its underlying subsystem and it may exchange information with the neighboring agents. The distributed sensor fault detection is conducted using robust analytical redundancy relations, formulated by estimation-based residuals and adaptive thresholds. The distributed sensor fault isolation is carried out by combining the decisions of the LSFD agents and applying a reasoning-based decision logic. Simulation results are used for illustrating the effectiveness of the proposed methodology applied to a two-zone HVAC system.

16:00-16:20 WeB6.4

On Robust Fault-Isolation Observers with Relaxed Structural Constraints, pp. 407-412

Wahrburg, Arne Tech. Univ. Darmstadt

Adamy, Juergen Tech. Univ. Darmstadt

This article is devoted to observer-based fault isolation in linear, time-invariant systems. In contrast to most existing results, fault isolation is achieved by only a single, specifically parameterized observer, yielding a low order fault isolation system. The design is based on eigenstructure assignment methods. By relaxing the structural constraints imposed to the observer eigenstructure, additional degrees of freedom are obtained. These are employed to increase robustness of the fault isolation observer with respect to exogenous disturbances by means of convex optimization problems. The results are verified by simulations of an example system.

16:20-16:40 WeB6.5

Application of Multi-Model Fault Diagnosis for an Industrial System, pp. 413-418

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

since complete isolation of a fault set in an industrial plant using a single Fault Detection and Isolation (FDI) technique is so difficult, a hybrid fault detection techniques is preferred. An observer based technique is applied to isolate a certain unknown fault in an industrial boiler placed in Sidi Kerir Petrochemicals (SIDPEC) in a previous work [1]. A fault has been detected using single observer based method but it has failed to isolate it. Therefore in this work, a combined method of multi-model and parameter estimation fault diagnosis techniques (hybrid technique) is implemented here to diagnosis a real abnormal situation. The most important part of the boiler, which is called master loop, is addressed. The master loop is identified based on online data. The master loop has been subdivided into three parts named: fuel flow subsystem, airflow and burner subsystem and the whole system. Different fault scenarios are simulated on the identified models in order to validate the fault detection algorithm. Finally the fault diagnosis algorithm is applied on a real abnormal behavior to identify it. The fault is detected and accurately isolated.

WeC1 IMPERIAL

Robotics II (Regular Session)

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

17:00-17:20 WeC1.1

Preliminary Results on the Estimation Performance of Single Range Source Localization, pp. 419-424

Batista, Pedro Inst. Superior Técnico

Silvestre, Carlos Univ. of Macau

Oliveira, Paulo Jorge — Inst. Superior Técnico

In previous work by the authors a novel estimator was introduced, with asymptotic stability guarantees, for the problems of source localization and navigation based on single range measurements. The aim of this paper is to further study these problems in terms of the performance of the proposed estimators and the trajectories that yield best results. To that purpose, the achievable performance with the proposed estimator is compared with the Bayesian Cramér-Rao Bound (BCRB) for different trajectories of the agent and, in addition, the estimates provided by the Extended Kalman Filter are also computed. It is revealed that the performance of the estimator is close to the BCRB theoretical lower bound and some insight is provided on the effect of the agent trajectory on the estimation performance.

17:20-17:40 WeC1.2

Precision Grasp Planning Based on Fast Marching Square, pp. 425-430

Alvarez, David — Univ. Carlos III of Madrid
Lumbier, Alejandro — Univ. Carlos III of Madrid
Gomez, Javier V. — Univ. Carlos III of Madrid
Garrido, Santiago — Univ. Carlos III of Madrid
Moreno, Luis — Univ. Carlos III of Madrid

This paper presents a novel methodology for planning the movements of a robotic hand when a precision grasp wants to be performed. This approach is based on the standard Fast Marching Square (FM2) path planning method recently introduced for robot formations. A three-finger kinematic chain is consider as a robot formation to perform simulations. In order to achieve a precision grasp, the task is divided into two phases. In the first one, the hand has to move towards the object to be grasped and stops at a position from which the grasping points can be reached by the fingers of the hand. In the second one, given the contact points for a precision grasp, the movements of the fingers must be planned so that those points are reached by the corresponding fingertips. In both cases, the path planning method used is FM2, so smooth and fast paths are ensured due to the characteristics of FM2. In each phase, different control strategies for robot formations are used. The changes in the geometry of the formations are based on the velocities map calculated in FM2, ensuring collision avoidance and speeding up the grasping phase. Simulation results show the usefulness of this novel application of the method thanks to a good performance of the chosen planning strategy.

17:40-18:00 WeC1.3

Telemanipulation with the DLR/HIT II Robot Hand Using a Dataglove and a Low Cost Force Feedback Device, pp. 431-436

Liarokapis, Minas — National Tech. Univ. of Athens
Artemiadis, Panagiotis — Arizona State Univ.
Kyriakopoulos, Kostas J. — National Tech. Univ. of Athens

In this paper a series of teleoperation and manipulation tasks are performed with the five fingered robot hand DLR/HIT II. Two different everyday life objects are used for the manipulation tasks; a small ball and a rectangular object. The joint-to-joint mapping methodology is used to map human to robot hand motion, taking into account existing kinematic constraints such as synergistic characteristics and joint couplings. The Cyberglove II motion capture dataglove is used to measure human hand kinematics. A robot hand specific fast calibration procedure is used to map raw dataglove sensor values to human joint angles and subsequently through the mapping procedure, to DLR/HIT II joint angles. A novel low cost force feedback device is developed, in order for the user to be able to detect contact and perceive the forces exerted by the robot fingertips, during manipulation tasks. The design of the force feedback device is based on RGB LEDs that provide visual feedback and vibration motors that provide vibro-tactile feedback.

18:00-18:20 WeC1.4

Experimental Evaluation of Energy Optimization Algorithm for Mobile Robots in Three-Dimension Motion Using Predictive Control, pp. 437-443

Yacoub, Mostafa — Univ. of Ottawa
Necsulescu, Dan — Univ. of Ottawa
Sasiadek, Jurek Z — Carleton Univ.

Torque saturation of DC motors of the wheels of mobile robots is one of the main difficulties during climbing hills. A two-DC motor-driven wheels mobile robot is used in the present work to attempt crossing a ditch-like hindrance using predictive control. The proposed predictive control algorithm is compared with the PID control and the open-loop control. Experimental examination of energy optimization algorithm for mobile robots is presented. The experimental results showed a good agreement with the simulation results confirming the capability of the predictive control to avoid torque saturation and indicating a noticeable reduction in the energy consumption. Additionally, a theoretical parametric study of the predictive control is presented. The effects of the road slope and the prediction horizon length on the consumed energy are evaluated. The analytical study showed that the energy consumption is reduced by increasing the prediction horizon until it reaches a limit at which no more energy reduction is obtained. This limit is proportional to the width of the ditch in front of the mobile robot.

18:20-18:40 WeC1.5

P3P and P2P Problems with Known Camera and Object Vertical Directions, pp. 444-451

D'Alfonso, Luigi — Univ. della Calabria
Garone, Emanuele — Univ. degli Studi della Calabria
Muraca, Pietro — Univ. della Calabria
Pugliese, Paolo — Univ. della Calabria

In this paper the problem of estimating the relative orientation and position between a camera and an object is considered. It is assumed that both the camera and the object are provided with an IMU capable to give their inclinations with respect to the gravity vector. It is moreover assumed that the object contains a feature of 3 points whose position in the object coordinate frame is known. Using the image provided by the camera and the information on the gravity vector by the IMUs we propose an algorithm capable of estimating the relative pose of the object in the camera reference frame by solving a modified P2P or P3P problem. It will be shown that the P2P problem always gives 2 solutions, except in a few singular configurations, while the P3P problem usually gives a single solution. The effectiveness of the proposed approach will be shown by contrasting it with other algorithms presented in the literature.

WeC2 — Imperial 1

Networked Systems (Regular Session)

Chair: Antsaklis, Panos — Univ. of Notre Dame

17:00-17:20 WeC2.1

Model-Based Control of Continuous-Time Systems with Limited Intermittent Feedback, pp. 452-457

Garcia, Eloy — Infoscitex Corp.
Antsaklis, Panos J. — Univ. of Notre Dame

This paper presents a practical alternative for the implementation of Model-Based Networked Control Systems (MB-NCS) with intermittent feedback. Our approach does not require continuous communication over a limited bandwidth channel during the closed-loop time intervals; instead, we propose a communication format that implements a fast rate for updating the state of the model. During the closed-loop interval the sensor transmits measurements at a fast rate but without assuming continuous communication. We consider uncertain continuous-time systems and study the state feedback and output feedback cases. For both cases, we provide necessary and sufficient conditions for stability as a function of the update periods.

17:20-17:40 WeC2.2

Internet Delays and Packet Losses Sensor/actuator for UDP Based Networked Control Systems, pp. 458-463

Diaz-Cacho Medina, Miguel — Univ. of Vigo
Delgado, Emma — Univ. of Vigo
Barreiro, Antonio — Univ. of Vigo

The performance of networked control systems (NCS) in non-deterministic networks, such as the Internet depends largely on the network delays and packet losses. The reproduction of these delays and packet losses in a NCS implies the use of network simulators and emulators. In this paper, a system that performs as a sensor and as an actuator of Internet delays and packet losses is presented. It collects these parameters from the Internet and reproduces them into a local network data flow. The paper presents some comparative results and makes a performance analysis of the whole system.

17:40-18:00 WeC2.3

Packet-Based Dynamic Control of a Furuta Pendulum Over Ethernet, pp. 464-470

Fenucci, Davide — Univ. of Pisa
Fabbri, Tommaso — Univ. of Pisa
Falasca, Stefano — Univ. of Pisa
Gamba, Massimiliano — Univ. of Pisa
Bicchi, Antonio — Univ. di Pisa

This paper presents experimental results of the application of Packet-Based Control approach with dynamic controller on a real plant: the Furuta Pendulum. Despite its easiness of realization, Furuta Pendulum presents some features useful for our purposes, such as pretty non-linear dynamics, unstable equilibrium point and heavy dynamical inaccuracies. The network communication channel has been implemented using an Ethernet network. Packet-Based controller has been tested and compared with a classic local controller for different time-varying actuation delays. Results obtained corroborate the validity of the proposed architecture and highlight the robustness of this approach in the presence of actuation delays.

18:00-18:20 WeC2.4

Fundamental Limits on Performance of Autocatalytic Pathways with Chain Topologies, pp. 471-476

Siami, Milad — Lehigh Univ.
Motee, Nader — Lehigh Univ.

In this paper, we develop some basic principles to study dynamical networks and exploit their structural properties in order to characterize their existing hard limits and essential tradeoffs. Our main focus is on an important class of interconnected network of dynamical systems so called autocatalytic networks. In an interconnected dynamical system with autocatalytic structure, the system's output is necessary to catalyze its own production. We study cascade interconnection of autocatalytic pathways with chain topologies. It is shown that whenever autocatalytic feedbacks are active in all pathways, some fundamental tradeoffs between transient behavior of the network and its net production emerges. We use glycolysis pathway as our motivating example and develop our network models around this canonical model.

18:20-18:40 WeC2.5

Control Structure Design for Complex Energy Integrated Networks Using Graph-Theoretic Methods, pp. 477-482

Heo, Seongmin — Univ. of Minnesota
Georgis, Dimitrios — Univ. of Minnesota
Daoutidis, Prodromos — Univ. of Minnesota

In this paper, we propose a mixed integer program (MIP) formulation which can be used to synthesize multi-loop hierarchical control structures for tightly energy integrated plants, which are known to exhibit multiple-time scale energy dynamics. First, we represent the network as an energy flow graph, and perform graph reduction using graph-theoretic algorithms that we have previously developed, to analyze the time scale properties of the network and obtain energy flow subgraphs for each time scale. Then, from each energy flow subgraph, we construct an equation graph from which we can extract relative degree information. Using the proposed MIP, optimal input/output pairing sets are obtained, which minimize the structural coupling in each time scale. We illustrate the application of the proposed work through a case study of a benchmark chemical process.

WeC3 Imperial 2

Aerospace and Automotive Control (Regular Session)

Chair: Koutsoukos, Xenofon — Vanderbilt Univ.

17:00-17:20 WeC3.1

A Case Study on the Model-Based Design and Integration of Automotive Cyber-Physical Systems, pp. 483-492

Shang, Di — Vanderbilt Univ.
Eyisi, Emeka — ISIS Vanderbilt Univ.
Zhang, Zhenkai — Vanderbilt Univ.
Koutsoukos, Xenofon — Vanderbilt Univ.
Porter, Joseph — Vanderbilt Univ.
Karsai, Gabor — Vanderbilt Univ.
Sztipanovits, Janos — Vanderbilt Univ.

Cyber-physical systems (CPS), such as automotive systems, are very difficult to design due to the tight interactions between the physical dynamics, computational dynamics and communication networks. In addition, the evaluation of these systems at the early design stages is very crucial and challenging. Model-based design (MBD) approaches have been applied in order to manage the complexities due interactions. In this paper, we present a case study to demonstrate the systematic design, analysis and evaluation of an integrated automotive control system. The system is composed of two independently designed controllers, a lane keeping controller and an adaptive cruise controller, which interact as a result of the integration. The integrated system is deployed on a hardware-in-the-loop simulator for evaluation under realistic scenarios. We present experimental results that demonstrate the effectiveness of the approach.

17:20-17:40 WeC3.2

A LPV EMS Regulator for the Parallel HEV with Battery Life Prolongation, pp. 493-500

Wang, Tinghong — Grenoble Inst. of Tech.
Sename, Olivier — INPG
Martinez, John-Jairo — Gipsa-Lab. INP-Grenoble

This paper is concerned with the design of a discrete-time linear parameter varying (LPV) regulator for a parallel hybrid electric vehicle (PHEV) based on an already exist optimal energy management strategy (EMS). The aim is to determine the regulating quantity of battery current and the power split ratio between engine and battery with respect to the achieved optimal ones by the exist optimal EMS, according to the driving cycle variation and battery capacity degradation. The system is modelled under linear fractional transformation (LFT) form with varying velocity and battery capacity represented as an uncertainty blocks. The discrete-time linear parameter varying (LPV) regulator which is scheduled by the varying parameters is synthesized using the approach proposed in [1]. The battery state of charge (SOC) estimation method based on the Kalman Filter and the battery capacity estimation method based on the Least Mean Square (LMS) are also given.

17:40-18:00 WeC3.3

Control of a Simulated Wing Structure with Multiple Segmented Control Surfaces, pp. 501-506

Boussalis, Helen — California State Univ.
Valavanis, Kimon — Univ. of Denver
Guillaume, Darrell — SPACE Center, California State Univ. Los Angeles
Pena, Francisco — NASA Univ. Res. Center
Alvarenga, Jessica — Univ. of Denver

The main objective of this paper is to demonstrate that a wing with

segmented control surfaces can redistribute its load, inboard or outboard, in order to perform active shape control while still maintaining level flight. Methods will be presented for controlling the plunge deflections of an aircraft wing structure. One possible solution to improving the flight envelope is a wing design with multiple segmented control surfaces all along its span. This will give an aircraft far more control over its lift distribution in comparison to a typical wing. In order to construct a wing with segmented trailing edges, it must first be shown that deflections under lift loads can be controlled. This paper introduces the research performed by the Structures Propulsion and Controls Engineering (SPACE) Center using a Fiber-Optic Strain-Sensing (FOSS) system that is currently implemented on the Odyssey UAV. The research will use a set of strain-based Displacement Transfer Functions (DTF) and the FOSS System which were both developed at the NASA Dryden Flight Research Center (DFRC). Aerodynamic loads are obtained through the use of Athena Vortex Lattice (AVL) software. In addition, structural modeling is carried out with the use of finite element software. The results indicate that the shape of a wing structure can be controlled through the manipulation of segmented control surfaces to re-distribute lifting loads.

18:00-18:20 WeC3.4

Trajectory Tracking Control for a Quadrotor Helicopter Based on Backstepping Using a Decoupling Quaternion Parametrization, pp. 507-512

De Monte, Paul — Tech. Univ. München
Lohmann, Boris — Tech. Univ. München

This paper presents a trajectory tracking control for the position and heading angle of a quadrotor helicopter. The control design is based on the backstepping approach and proves the asymptotic stability of the tracking problem. We use a beneficial quaternion-based attitude parametrization, which is composed of two rotations. The first describes the orientation of the thrust vector independently from the second, which describes the quadrotor's heading. As a result, the translational dynamics and the yaw dynamics decouple from each other, which augments the control design. In addition, this decoupling allows an analytical derivation of all control signals within the backstepping procedure with reasonable expense. Experimental results show the practical use of the suggested control design.

18:20-18:40 WeC3.5

GPS/INS Integration in a S&A Algorithm Based on Aircraft Performances Estimation, pp. 513-518

Melega, Marco — Cranfield Univ.
Lazarus, Samuel Borthwick — Cranfield Univ.
Savvaris, Al — Cranfield Univ.
Tsourdos, Antonios — Cranfield Univ.

In this paper the fusion between the data derived from the Global Positioning System (GPS) and the Inertial Navigation System (INS) is integrated in a Sense And Avoid (S&A) system for Unmanned Aerial Vehicle (UAV) to increase its performances. The avoidance manoeuvre is defined in order to provide a minimum separation between the ownship and all the other agents during its overall execution in multiple flying threats scenarios. This is achieved by aiding the GPS measurements with the INS to estimate the ownship position using an Extended Kalman Filter (EKF) which uses a linear error model to estimate the errors in the INS states. The resolution manoeuvre are defined as step variations in the heading angle and altitude commands of the Flight Path Control System (FPCS). The value of these commands is optimised in order to get the minimum step command value necessary to keep a minimum predefined separation between the ownship and all the threats.

WeC4 Imperial 3

Nonlinear Control II (Regular Session)

Chair: Goodwine, Bill — Univ. of Notre Dame

17:00-17:20 WeC4.1

In the Large Certainty Equivalence Control with Quaternion Measurements, pp. 519-524

Schlanbusch, Rune — Narvik Univ. Coll.
Grøtli, Esten Ingar — Norwegian Univ. of Science and Tech.

In this paper, we solve the in the large control problem of rigid bodies with quaternion measurements only, by applying any hybrid certainty equivalence tracking controller satisfying a set of certain assumptions, along with a in the large hybrid nonlinear velocity observer, by using theory of cascades. Strictly speaking, we show that the origin of the class of proposed controllers in closed loop with the observer is uniformly asymptotically stable in the large1 i.e. for all available initial conditions associated with the quaternion space. Simulation results for the proposed scheme are presented with the particular case of the PD+ controller, showing that all states converge as expected from our theoretical findings.

17:20-17:40 WeC4.2

Stabilization in the Supremum Norm of Wave PDE/Nonlinear ODE Cascades, pp. 525-530

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

In a recent result we solved the problem of stabilization of the cascade of a wave PDE with a general nonlinear ODE in the $H_2times H_1$ norm of the wave PDE state. In this article we present stability results in the lower $C^1times C^0$ norm for general nonlinear ODEs. In our stability analysis we use arguments based on both Lyapunov functionals and explicit solutions. We specialize our general design for wave PDE-ODE cascades to the case of a wave PDE whose uncontrolled end does not drive an ODE but is instead governed by a nonlinear Robin boundary condition (a ``nonlinear spring,'' as in the friction law in drilling). This is the first global stabilization result for wave equations that incorporate non-collocated destabilizing nonlinearities of superlinear growth.

17:40-18:00 WeC4.3

An Algorithm for Stopping a Class of Underactuated Nonlinear Mechanical Robotic Systems, pp. 531-536

Goodwine, Bill — Univ. of Notre Dame
Nightingale, Jason — Univ. of Notre Dame

We provide a constructive global discontinuous control law with state dependent switches for a class of underactuated nonlinear mechanical robotic systems that will drive the system to an arbitrarily small neighborhood of rest from all initial configurations and velocities in arbitrarily small time. Because all physical mobile robotic systems are mechanical in nature, control methodologies which exploit the fact that the system is governed by principles of mechanics which are particularly important for robotic engineers. The philosophy of the approach is that instead of using control algorithms which start with a completely generic dynamical system, we constrain the structure of the system to be one which is a Lagrangian control system. To the extent the structure of the mechanical system can be exploited, stronger control results are possible to obtain, such as the stopping algorithm in this paper. Specifically, for control of general nonlinear systems, there are many unsolved problems for the case when the system is not at an equilibrium, and the results in this paper are an initial contribution to this area. The robot is assumed to be underactuated by one in the configuration space; hence, in the state space it is underactuated by twice the dimension of the configuration space plus two. Our method can easily be extended to construct a global discontinuous control law with state dependent switches that will drive the system to an arbitrarily small neighborhood of any velocity from any initial configuration and velocity in arbitrarily small time.

18:00-18:20 WeC4.4

Immersion of Nonlinear Systems through Power Geometry, pp. 537-544

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

This paper surveys results of Power Geometry, which allow to rewrite in different forms some continuous-time nonlinear systems, those that that can expressed by means of elementary functions

(e.g., polynomial, exponential, sinusoidal, logarithmic). In particular, by using coordinate transformations or state immersions, possibly in power form, it is possible to rewrite such nonlinear systems in quasi-polynomial form and in the Lotka-Volterra form.

18:20-18:40 WeC4.5

A Robust Nonlinear Semi-Active Control for Base Seismically-Isolated Structures, pp. 545-550

Teodorescu, Catalin-Stefan CEA Saclay
Diop, Sette CNRS
Politopoulos, Ioannis CEA Saclay
Benidir, Messaoud L2S-Supelec-UPS-11

This paper proposes a robust nonlinear semi-active control for base seismically-isolated structures. The control is based upon an extension of works of Leitmann~et al. on the stabilization of nonlinear systems with uncertain models. For usual models of structure dynamics it is shown that applying a specific control law drives the state variables into a ball of specified radius in finite time. The radius of the ball may be arbitrarily chosen as long as it is not lower than a limiting value. In addition, estimates of this limiting ball radius is provided. The time to reach the ball is also provided. The semi-active control thus provides the control designer with interesting design parameters. The efficacy of proposed semi-active control is illustrated by its application to simple models of structures focusing in particular to the attenuation of excitation transmitted from floor to equipment mounted on them.

WeC5 Imperial 4

Education and Training (Regular Session)

Chair: Demetriou, Georgios Frederick Univ.

17:00-17:20 WeC5.1

Testing Controllers on ALE III: A Low Cost Mini Autonomous Underwater Vehicle, pp. 551-557

Piperidis, Savas Tech. Univ. of Crete
Tsourveloudis, Nikos Tech. Univ. of Crete

This paper presents ALE III, a low cost Autonomous Underwater Vehicle and its potential for experimentation inside a typical research laboratory. ALE III is equipped with sensors and actuators that facilitate real, not simulated, testing. The vehicle uses custom made as well as 'off the self' components and minimalistic design solutions suitable for experimentation, as evidenced from various control methodologies tested.

17:20-17:40 WeC5.2

Microcontroller-Based Learning Kit Course Design Using Constructive Alignment Principles, pp. 558-566

Dabroom, Ahmed RC Coll. and Inst. Div. Yanbu
Refie, Wael Moustafa RC Coll. and Inst. Div. Yanbu
Matmti, Ridha YIC

Abstract— Microcontroller based system course became an essential course in the engineering and industrial colleges. Such courses are usually attended by a wide range of students who came not only from different background but also with different programming skills. The challenge in teaching such a course is that, in one hand the course should meet the latest technology, while on the other hand the course should be interesting and attractive for all students with different characteristics and study skills. For that reason, a well designed course, and selecting the appropriate microcontroller kit to teach such courses are very critical. In this paper, we present a course design approach and our new designed microcontroller kit which can be used in teaching such a course. To help students deepen their knowledge using a learning by doing approach, the designed kit comprises a dsPIC microcontroller based main board and many E-blocks. Those E-blocks can be easily connected to the main board to form different microcontroller based systems. In order to minimize students "fears" of low level programming, the kit can be programmed using flow code software which is a graphical programming tool that allows those with little or no programming experience to develop complex electronic systems quickly. The kit also can be programmed using high level C language for those who have reasonable experience and programming skills and wish to do so. The intended outcome is to help students not only to learn how to program the microcontroller to execute certain tasks but also to deepen their learning and sharpen their software and hardware engineering skills by assembling different Eblocks with the main board to form a complete microcontroller based system.

17:40-18:00 WeC5.3

The Engino Robotics Platform (ERP) Controller for Education, pp. 567-572

Demetriou, Georgios Frederick Univ.
Lambrou, Antonis Frederick Univ.
Eteokleous, NIkleia Frederick Univ.
Sisamos, Costas Engino.net

The Engino Robotics Platform Controller, which is presented in this paper, is a control box intended for primary and early secondary education students. It is used to teach basic control, robotics and technology based courses. Along with the controller a series of external sensors have been developed that can be directly connected to the controller. The controller and the sensors allow students to build robots and other automated or interactive systems using the Engino components.

18:00-18:20 WeC5.4

Interactive Animations for Learning by Playing Concepts of Control Systems, pp. 573-577

Ramírez-Ramírez, Mauricio Univ. del Valle
Ramirez, Jose Miguel Univ. del Valle
Fernández-Samacá, Liliana Univ. Pedagógica y Tecnológica de Colombia

This paper introduces interactive animations as a support resource for learning concepts of control systems. The animations are focused on three dynamic systems: a tank, a spring-damping-mass system and a roller-plane. The user can adjust the parameters and input variables, and observe the output variable behavior. The animations offer a learning environment, which allows students develop different activities to learn basic control concepts like Feedback, Modeling, time and frequency domain Analysis, Stability and Compensation without a detailed mathematical explanation. The animations propose an active learning environment through playing that engages students in the subject. The animations are developed by using Easy Java Simulations.

18:20-18:40 WeC5.5

Establishing Regional Competence Centre for Life Long Learning in Electrical Engineering, pp. 578-583

Zabasta, Anatolijs Riga Tech. Univ.
Kunicina, Nadezhda Riga Tech. Univ.
Zhiravecka, Anastasija Riga Tech. Univ.
Patlins, Antons Riga Tech. Univ.
Ribickis, Leonids Riga Tech. Univ.

The rapid technology development in the electrical engineering requires to promote life long learning concept in practice. The industrial needs and future carrier perspectives are not limited to the college or university degree for electrical engineers. The sharing of advanced research results, the development IT platform for education allows to achieve sufficient methodological base for engineers training at all stages of career. The case study of the Institute of Industrial Electronics and Electrical Engineering (IEEI) of Riga Technical University is discussed in this paper.

WeC6 Ariadne

Fault Diagnosis II (Regular Session)

Chair: Fourlas, George K. TEI of LAMIA

17:00-17:20 WeC6.1

Power Transformer Fault Diagnosis Using Fuzzy Logic

Technique Based on Dissolved Gas Analysis, pp. 584-589

Abdel-geliel, Mostafa	Arab Acad. for Science & Tech.
Rashad Ahmed, Mahmod	Arab Acad. for Science & Tech.
Khalil, Alaa Eldin Ahmed	Arab Acad. for Science & Tech.

The most common fault diagnosis method of power transformer is based on the Dissolved Gas-in-oil Analysis (DGA) of transformer oil. It is a sensitive and reliable technique for the detection of incipient fault condition within oil-immersed transformers. There are a number of methods developed for analyzing these gases and interpreting their significance such as Key Gas, Roger gas ratio, Doernenburg, IEC gas ratio and Duval Triangle. Although DGA has widely been used in the industry, this conventional method fails to diagnosis in some cases. This normally happens for those transformers which have more than one type of fault at the same time [6, 7]. To overcome this limitation, an expert system based on DGA for diagnosis of power transformer condition is proposed in this paper. The proposed technique combines three different DGA methods in one diagnosis scheme in order to overcome the limitation of each method stand alone. The three selected methods are Rogers, IEC and Duval. Moreover, this paper investigates the accuracy and consistency of three methods in interpreting the transformer condition by applying fuzzy logic technique in addition to a new final combined fuzzy system. The evaluation is carried out on DGA test data obtained from different literatures as a test data with size 100 cases. Finally, test was applied on DGA data of utility power transformers of MIDOR Refinery Company located in Alexandria, Egypt.

17:20-17:40 WeC6.2

Stochastic Subspace Identification of Linear Systems with Observation Outliers, pp. 590-596

ALMutawa, Jaafar	Informatics, Kyot Univ.

We propose a diagnostic for the state space model fitting time series formed by deleting observations from the data and measuring the change in the estimates of the parameters. A method is proposed for distinguishing an observational outlier from an innovational one.Thus we present a robust subspace system identification algorithm that is less sensitive to outliers. We give a numerical result to show effectiveness of the proposed method.

17:40-18:00 WeC6.3

Theoretical Approach of Model Based Fault Diagnosis for a 4-Wheel Skid Steering Mobile Robot, pp. 597-602

Fourlas, George K.	TEI of LAMIA

In this paper we present a theoretical approach of a model based fault diagnosis for a four wheel skid steering mobile robot (SSMR). The basic idea is to use structural analysis based technique in order to generate residuals. For this purpose we develop the kinematic model of the mobile robot that serves to the creation of the structural model of the system. This technique provides the parity equations which can be used as residual generators. The advantage of the proposed method is that can offers feasible solution to residual generation for nonlinear systems. Pioneer 3-AT was used as a robotic platform.

18:00-18:20 WeC6.4

Performance Evaluation of Neural Network Based Approaches for Airspeed Sensor Failure Accommodation on a Small UAV, pp. 603-608

Gururajan, Srikanth	West Virginia Univ.
Fravolini, Mario Luca	Univ. of Perugia
Chao, Haiyang	West Virginia Univ.
Rhudy, Matthew	West Virginia Univ.
Napolitano, Marcello	West Virginia Univ.

Traditional approaches to sensor fault tolerance for flight control systems have been based on triple or quadruple physical redundancy. However, recent events have highlighted the criticality of “common mode” failures on the Air Data System (ADS). In fact, since the parameters of flight control laws are typically scheduled as a function of airspeed, incorrect readings from the ADS can lead to potentially catastrophic conditions. In this paper, we describe the evaluation of an analytical redundancy-based approach to the problem of Sensor Failure Accommodation following simulated failures on the ADS of a research UAV, using Artificial Neural Networks (ANNs). Specifically, two different neural networks are evaluated - the Extended Minimal Resource Allocating Network and a Multilayer Feedforward NN. These neural networks are trained and validated using experimental flight data from the WVU YF-22 research aircraft which was designed, manufactured, instrumented, and flight tested by researchers at the Flight Control Systems Laboratory at West Virginia University. The performance of the two approaches is evaluated in terms of the statistics of the tracking error in the estimation of the airspeed, as compared to actual measurements from the ADS, operating under nominal conditions.

18:20-18:40 WeC6.5

Online Observability Optimization for State Affine Systems with Output Injection and Observer Design, pp. 609-614

Rubio Scola, Ignacio Eduardo	GIPSA-Lab.
Besancon, Gildas	Ense3 - Grenoble INP
Georges, Didier	Grenoble Inst. of Tech.

Observability being in general subject to the applied input for a nonlinear system, the aim of the present work is to propose an input selection strategy for a special class of systems, so as to make them observable. The considered systems are those admitting a state-affine structure with output injection. For such systems, an online algorithm is proposed to compute an appropriate input in real time. It guarantees observability by ensuring a lower bound on the related Gramian, and minimizes at the same time the input variations with respect to some reference value required for the system operation. This computation is updated at each time with the new output measurements becoming available. The proposed methodology is illustrated on a piping system example, for which an exponential observer is finally obtained.

ThA1 IMPERIAL

Hybrid Systems I (Regular Session)

Chair: Grøtli, Esten Ingar — Norwegian Univ. of Science and Tech.

10:30-10:50 ThA1.1

In the Large Hybrid Observer Design for Rigid Body with Quaternion Measurements, pp. 615-621

Grøtli, Esten Ingar — Norwegian Univ. of Science and Tech.
Schlanbusch, Rune — Narvik Univ. Coll.

In this paper we present a hybrid observer for rigid body angular velocity estimation, which equilibrium point in closed loop with the system is asymptotically stable in the large, i.e. we prove that the error states are stable and asymptotically converging towards the origin for all initial rotations and angular velocities. Stability results for quaternion based observers have until now typically only been valid for a bounded set of initial conditions. To overcome this issue our observer design is based on dynamic scaling and switching logic. Simulation results for the proposed observer together with a PD-based state feedback control law are presented to corroborate our theoretical findings.

10:50-11:10 ThA1.2

Ultimate Boundedness Conditions for a Hybrid Model of Population Dynamics, pp. 622-627

Aleksandrov, Alexander — Saint-Petersburg State Univ.
Aleksandrova, Elena — Saint-Petersburg State Univ.
Platonov, Alexey — Saint-Petersburg State Univ.

This paper addresses the ultimate boundedness and permanence analysis for a Lotka--Volterra type system with switching of parameters values. Two new approaches for the constructing of common Lyapunov function for the family of subsystems corresponding to the switched system are suggested. Sufficient conditions in terms of linear inequalities are obtained to guarantee that the solutions of the considered system are ultimately bounded or permanent for an arbitrary switching signal. An example is presented to demonstrate the effectiveness of the proposed approaches.

11:10-11:30 ThA1.3

Stability Analysis of Nonlinear Mechanical Systems with Switched Force Fields, pp. 628-633

Aleksandrov, Alexander — Saint-Petersburg State Univ.
Lakrisenko, Polina — Saint-Petersburg State Univ.
Platonov, Alexey — Saint-Petersburg State Univ.

The stability of the trivial equilibrium position of a nonlinear mechanical system with switched dissipative and potential forces is studied. It is assumed that dissipative forces are linear, while potential forces are nonlinear and homogeneous. By the use of multiple Lyapunov functions approach and dwell time approach, the conditions on switched law guaranteeing asymptotic stability and practical stability of the equilibrium position are obtained. An example is presented to demonstrate the effectiveness of the proposed approaches.

11:30-11:50 ThA1.4

Unknown Inputs Observer Applied to an Alternating Activated Sludge Process, pp. 634-639

Manâa, Imen — National Engineering School of Monastir
M'Sahli, Faouzi — Monastir Engineering School

This work deals with the design of an unknown inputs observer for MIMO nonlinear hybrid systems. It consists in a switching between different observer to a simultaneous estimate of the unavailable states and inputs. A nonlinear reduced model of an alternating activated sludge process, which is decomposed on an aerobic phase and an anoxic phase, is presented. They are the results of a nitrification and de-nitrification phases. The principal goal of the observer is directed to cure the problem of unavailable input of the influent ammonia concentration and non-measured states of every sub-model. Simulation results verify the effectiveness of the proposed hybrid observers.

11:50-12:10 ThA1.5

Intersection-Based Piecewise Affine Approximation of Nonlinear Systems, pp. 640-645

Zavieh, Amin — Concordia Univ.
Rodrigues, Luis — Concordia Univ.

This paper presents a new algorithm for PWA approximation of nonlinear systems. Such an approximation is very important to enable a reduction in the complexity of models of nonlinear systems while keeping the global validity of the models. The paper builds on previous work on piecewise affine (PWA) approximation methods, in particular on the work done by Casselman and Rodrigues, known as the Set of Linearization Points (SLP) PWA approximation. The proposed extension method can be used to approximate any continuous function of one variable by a PWA function. The algorithm is based on the points at which the linearization lines intersect with each other. The method assumes that a desired approximation error and one linearization point are given. The algorithm then performs several linearizations. It is shown that the new linearization points are optimal in the sense of decreasing the error between the exact function and the approximation. The main advantages of this methodology compared to previous approaches are the reduction of the number of pieces of the PWA function, the guarantee that the approximation is continuous, elimination of the numerical optimization to find the point of maximum error, and that the derivative of the approximation and the derivative of the exact function are equal at all linearization points.

12:10-12:30 ThA1.6

Modelling and Frequency Separation Energy Management of Fuel Cell-Battery Hybrid Sources System for Hybrid Electric Vehicle, pp. 646-651

Alloui, Hamza — Ec. Militaire Pol.
Becherif, Mohamed — Femto-ST/FCLab UTBM UMR CNRS 6174
Marouani, Khoudir — Ec. Militaire Pol. (EMP)

This paper presents a hybrid system of fuel cellbattery power sources for electric vehicle. Because fuel cell (FC) and battery have advantages and disadvantages of their own, it should be beneficial to have hybrid sources, in which FC supplies the base energy while battery supplies peak power for fast acceleration and captures the braking energy regeneration. In this paper a state space model for the Fuel Cell-Battery Hybrid Electric Vehicle (FCEV) power system is given and an energy management based on frequencies separation is discussed and validated by Matlab simulation.

ThA2 Imperial 1

Linear Systems I (Regular Session)

Chair: Galeani, Sergio — Univ. Di Roma Tor Vergata

10:30-10:50 ThA2.1

Stability of Discrete Descriptor Time Delay Systems on Finite Time Interval: New Delay Dependent Conditions, pp. 652-657

Debeljkovic, Dragutin — Univ. of Belgrade
Stojanovic, Sreten — Univ. of Nis
Jovanovic, Aleksandra — Univ. of Belgrade
Misic, MIlan — Univ. of Pristina

This paper gives sufficient conditions for the practical and finite time stability of linear singular continuous time delay systems of particular form . When we consider finite time stability concept, these new, delay independent conditions are derived using approach based on Lyapunov – like functions and their properties on sub-space of consistent initial conditions.

10:50-11:10 ThA2.2

Linearization of a Nonlinear Geometric System Model for Robust Controller Design, pp. 658-662

Diaz, Eric	Univ. of Southern California
Balboa, Cheyenne	California State Univ.
Juan Escobar, Juan Escobar	California State Univ.
Zarah Jane B. Espano	California State Univ.
Rad, Khosrow	California State Univ.
Boussalis, Helen	California State Univ.

A large order flexible space structure, such as a segmented reflector space telescope, requires a high degree of precision and accuracy in order to maintain its nominal shape in order to form clear images. The tracking control for the pointing of such a large complex multiple-input multiple-output (MIMO) system requires a robust controller to maintain the telescope pointing accurately and reliably at it's target. The segmented space telescope testbed at the Structures, Propulsion, And Controls Engineering (SPACE) NASA University Research Center (URC) of Excellence at California State University, Los Angeles, utilizes a segmented primary mirror and a novel motorized laser platform for simulating the testbed's intended target and demonstrating the testbed's pointing accuracy. The motorized platform along with two sets of accessory mirrors comprises a Peripheral Pointing Architecture (PPA). In order to design a suitable controller, the highly nonlinear geometric model describing the laser paths from source to optical detector plane was linearized to produce an LTI state-space model for controller design.

11:10-11:30 ThA2.3

Root Locus Rules for Polynomials with Complex Coefficients, pp. 663-670

Dòria-Cerezo, Arnau	Tech. Univ. of Catalonia
Bodson, Marc	Univ. of Utah

Applications were found recently where the analy- sis of dynamic systems with a special structure could be simpli- fied considerably by transforming them into equivalent systems having complex coefficients and half the number of poles. The design of controllers for such systems can be simplified in the complex representation, but requires techniques suitable for systems with complex coefficients. In the paper, the extension of the classical root locus method to systems with complex coefficients is presented. The results are applied with some advantages to a three-phase controlled rectifier.

11:30-11:50 ThA2.4

On the Use of Inversion Formulae for the Synthesis of Discrete PID Controllers, pp. 671-676

Cuoghi, Stefania	Univ. of Modena and Reggio Emilia
Ntogramatzidis, Lorenzo	Curtin Univ.

This paper presents a new set of formulae for the design of discrete proportional-integral-derivative (PID) controllers under requirements on steady-state performance and robustness specifications, such as the phase and the gain margins, as well as the gain crossover frequency. The proposed technique has the advantage of avoiding trial-and- error procedures or approximations connected to an a posteriori discretisation. This method can also be implemented as a graphical design procedure in the Nyquist plane.

11:50-12:10 ThA2.5

Computation of the General Solution of a Multivariate Polynomial Matrix Diophantine Equation, pp. 677-682

Tzekis, Panagiotis	Alexander Tech. Educational Inst. of Thessaloniki
Antoniou, Efstathios	Alexander Tech. Educational Inst. of Thessaloniki
Vologiannidis, Stavros	Aristotle Univ. of Thessaloniki

The algorithm presented in [1] provides a method for the computation of the general solution of a polynomial matrix Diophantine equation. In this work we extend this algorithm for the n-D PMDE. We present a method to efficiently address the division of multivariate polynomials. The theory is implemented via illustrative examples.

12:10-12:30 ThA2.6

Nonlinear Regulation for Linear Fat Plants: The Constant Reference/disturbance Case, pp. 683-690

Galeani, Sergio	Univ. Di Roma Tor Vergata
Valmórbida, Giórgio	Univ. of Oxford

In this paper, the output regulation problem for linear time invariant systems is considered, for the case of fat plants and constant exogenous signals, including both references to be tracked and (measured or unmeasured) disturbances to be rejected. It is shown that nonlinear (in particular, piecewise linear solutions) of the regulator equations are optimal solutions when either (input or state) constraints or very reasonable performance indices are introduced; hence, such solutions might be preferable to the standard, well known and easy linear solutions.

ThA3 Imperial 2

Biomedical Engineering (Regular Session)

Chair: Tzes, Anthony Univ. of Patras

10:30-10:50 ThA3.1

Parameter Estimation and Identifiability of a HIV-1 Model, pp. 691-696

Portelo, Ana I.	INESC-ID
Lemos, Joao M.	Inesc-id
Vinga, Susana	INESC-ID
Ribeiro, Ruy M.	Los Alamos National Lab.
Cruz, João Paulo	Univ. of Lisbon, Res. Inst. for Medicines and Pharm
Valadas, Emilia	Faculty of Medicine, Univ. of Lisbon

In this work, some identifiability and sensitivity properties of a reduced complexity model for the Human Immunodeficiency Virus 1 (HIV-1) infection are considered. In addition to study the effect of parameters on the model states, the impact of the data sampling frequency on a cost used for parameter estimation is also addressed. The conclusions are used as guidelines to identify models from clinical data in two case studies in which the patients did not follow the prescribed therapy.

10:50-11:10 ThA3.2

Design of an Innovative Prosthetic Hand with Compact Shape Memory Alloy Actuators, pp. 697-702

Andrianesis, Konstantinos	Univ. of Patras
Tzes, Anthony	Univ. of Patras

Shape memory alloy actuation is one of the emerging technologies that shows up remarkable advantages compared to conventional actuation. In this research work, this technology is exploited in driving an innovative prosthetic hand designed to meet most of the requirements of the upper limb amputees. Compact and totally silent linear actuation units are developed and integrated within a lightweight housing closely replicating the shape and size of the average human hand. In addition, a tendon-driven underactuated mechanism provides the necessary dexterity without compromising the simplicity of the device. The physical implementation of the hand chassis is accomplished using rapid prototyping techniques. Experiments with a single-finger testbed are conducted in order to evaluate speed performance and investigate the feasibility of a resistance feedback control scheme.

11:10-11:30 ThA3.3

Quantification of the Multiplicative Uncertainty in the Linearized Minimally Parameterized Parsimonious Wiener Model for the Neuromuscular Blockade in Closed-Loop Anesthesia, pp. 703-708

Silva, Margarida M.	Univ. do Porto
Wigren, Torbjorn	Uppsala Univ.
Medvedev, Alexander V.	Uppsala Univ.
Mendonça, Teresa	Univ. do Porto

In this paper the multiplicative uncertainty in the linearized minimally parameterized parsimonious Wiener model for the neuromuscular blockade is quantified. A set of model parameters was identified from input-output data collected in the surgery room from a population of fifty patients undergoing general anesthesia. The nominal model was considered to be the average of the transfer functions over all fifty realizations. The non-parametric and parametric methods that were implemented delivered similar beta-tolerance regions in the frequency domain for the multiplicative model uncertainty to be used in e.g. robust control design.

11:30-11:50 ThA3.4

NonLinear Hebbian Learning Techniques and Fuzzy Cognitive Maps in Modeling the Parkinson's Disease, pp. 709-715

Anninou, Antigoni	Univ. of Patras
Groumpos, Peter	Univ. of Patras

A new soft computing method using Fuzzy Cognitive Maps for modeling and predicting Parkinson's disease has been proposed. A decision support system based on human knowledge and experience, with a Fuzzy Cognitive Map trained using unsupervised Nonlinear Hebbian Leanring algorithm are proposed. The basic theories of this learning method are reviewed and presented. The initial values of concepts are represented as fuzzy membership values and trained to get new updated weight matrix and new concept values. Simulations are performed and very interesting results are obtained and discussed. A comparison between the results with and without a learning algorithm is considered.

11:50-12:10 ThA3.5

EMG Based Classification of Basic Hand Movements Based on Time-Frequency Features, pp. 716-722

Sapsanis, Christos	Univ. of Patras, Electrical & Computer Engineering Departme
Georgoulas, George	Dept. of Informatics and Communications Tech.
Tzes, Anthony	Univ. of Patras

This paper proposes an integrated approach for the identification of daily hand movements with a view to control prosthetic members. The raw EMG signal is decomposed into Intrinsic Mode Functions (IMFs) with the use of Empirical Mode Decomposition (EMD). A number of features are extracted in time and in frequency domain. Two different dimentionality methods are tested, namely the Principal Component Analysis (PCA) technique and the RELIEF feature selection algorithm. The outputs of the dimensionality reduction stage are then fed to a linear classifier to perform the detection task. The approach was tested on a group of young individuals and the results appear promising.

12:10-12:30 ThA3.6

Self-Calibrating Total-Mass Controller for the Neuromuscular Blockade Matching the Anesthesiologists' Mindset (I), pp. 723-728

Paz, Luis	Univ. of Porto
Silva, Margarida M.	Univ. do Porto
Esteves, Simao	Hospital Geral Santo Antonio
Mendonça, Teresa	Univ. do Porto

A self-calibrating total-mass controller for the neuromuscular blockade (NMB) based on the minimally parameterized parsimonious (MPP) Wiener model is presented. Using input-output data collected from the initial bolus administration until recovery, the parameters of the MPP model that are used for the controller design are chosen from a set of fifty realistic models for the effect of the muscle relaxant rocuronium in the NMB. In order to overcome modeling uncertainties a numeric self-calibration of the parameters in the MPP model nonlinearity was implemented. This step matches the anesthesiologists' mindset. The controller was extensively tested in simulation and in real cases. The good reference tracking results show the reliability of the proposed strategy and supports its use in the clinical practice.

ThA4 Imperial 3

Manufacturing Systems (Regular Session)

Chair: Nikolakopoulos, G.	Luleå Univ. of Tech. Sweden
Co-Chair: Ioannidis, Stratos	Tech. Univ. of Crete

10:30-10:50 ThA4.1

Non-Linear Control of Pneumatic Artificial Muscles, pp. 729-734

Andrikopoulos, George	Univ. of Patras, Greece
Nikolakopoulos, George	Luleå Univ. of Tech. Sweden
Manesis, Stamatis	Univ. of Patras

In this article, a non-linear PID structure is being synthesized, providing ameliorated compensation of the Pneumatic Artificial Muscle's (PAM) non-linear hysteretic phenomena and advanced robustness. Experimental studies are being utilized to prove the overall efficiency of the non-linear control scheme regarding: a) set-point tracking performance for the position control of a single PAM and torsion angle control of an antagonistic PAM setup, as well as b) disturbance rejection in both single and antagonistic control scenarios.

10:50-11:10 ThA4.2

Distributed Model Based Thermal Control for Optimal Curing of the Large Composite Structures, pp. 735-740

Shevtsov, Sergey	South Center of Russian Acad. of Science
Zhilyaev, Igor	South Center of Russian Acad.
Flek, Michail	Rostvertol Helicopters
Chinchan, Levon	Rostvertol Helicopters
Shevtsova, Varvara	Rostvertol Helicopters

The high loaded aircraft composite structures are produced by the autoclave and closed mould processes at which the consolidation of the fibers and matrix is done at the same time as the component is shaped. Full curing schedule include a pre-warming to the resin viscosity reaches a minimum, next applying of pressure to remove the gas bubbles and removal of excess resin, and finally consolidation of resin at elevated temperature to its full polymerization. The change in the states of the composite should be made as possible uniformly across the thick-walled products. The main processing problems encountered in closed molding of articles with large variations in thickness include porosity, resin-rich areas, resin-dry areas, insufficient consolidation, degraded mechanical properties, and distortion which can arise from uneven cure. Many of the problems can be resolved by correct timing of application of temperature and pressure. But the process control is complicated due to unobservability of the rheological state and temperature of material in a closed volume of a mould. In this paper we propose a mathematical model for epoxy-based thick-walled composite structure curing. PDE system linking a kinetic equation of the resin cure with heat transfer equation, take into account heating caused by excessive exothermic reactions, a phase transition of resin from liquid to gel and further to the solid state, where required temperature field is supported by the independently controlled heat sources. To synthesize the optimal control law we use the genetic algorithm which performs the transient analysis of the developed model on each iteration steps.

11:10-11:30 ThA4.3

A Min-Max ANT Colony Algorithm for Machine Loop Layout Problem, pp. 741-747

Manita, Ghaith	MARS
Korbaa, Ouajdi	Unité MARS, ISITCom, Univ. of Sousse

This paper handles a problem of loop machine layout using one load and unload machine. The goal of this problem is to minimize the total cost of transporting parts within each manufacturing cell. The novelty of this study is based on the reformulation of the problem taking into consideration new variables which are generally neglected by recent researches like proximity constraints and machine dimensions. Hence, we aim to place these machines on a grid that represents the surface of the cell, in order to construct a loop layout while respecting proximity constraints. This new formulation led us to propose a two-stage approach to solve this problem. The first step consists in positioning the machines on a grid while respecting the proximity constraints and machines dimensions. The second step aims to optimize the path between these machines already positioned in order to minimize number of the loops travelled by parts. In this paper, the second step will be the center of our interesting. To solve this problem, we use ant colony optimization algorithm. The effectiveness of our approaches is demonstrated through numerical examples.

11:30-11:50 ThA4.4

OntoMoPS: A Modular Production System Description Ontology, pp. 748-753

Tsinarakis, George — Tech. Univ. of Crete
Tsinaraki, Chrisa — TUC/MUSIC

A modular Petri net based methodology for the modeling, analysis and performance evaluation of production systems has been introduced in our previous works. According to this methodology, production systems are decomposed in a small number of fundamental subsystems and the models of the individual subsystems are connected to synthesize the overall system model. The modeling and further processing of the production systems can be accomplished using standard Semantic Web technologies. This allows the utilization of standard tools and supports the interoperability of different production system designs. In this work we introduce an ontology for the semantic description of modular production systems, which is the basis for the development of a semantic-based framework for modular production system simulation and processing.

11:50-12:10 ThA4.5

Inventory and Order Admission Control in Manufacturing Systems with Two Customer Classes and Setup Times, pp. 754-760

Ioannidis, Stratos — Tech. Univ. of Crete
Sarantis, Ioannis — Tech. Univ. of Crete

In this paper we examine a Markovian single-stage manufacturing system, with setup times producing a single item to satisfy demand of two different customer classes. We investigate numerically the structure of the optimal inventory and order admission control policy. Due to the complexity of the optimal policy a simple heuristic policy is proposed. Numerical results show that the proposed policy can be a very good approximation of the optimal policy.

12:10-12:30 ThA4.6

Analysis of Control Strategies for Systems with Input-Induced Nonlinearities, pp. 761-769

Cochior, Carmen — Eindhoven Univ. of Tech.
van den Bosch, P. P. J. — Eindhoven Univ. of Tech.
Weiland, Siep — Eindhoven Univ. of Tech.

In this paper we consider the design of a nonlinear predictive controller based on a nonlinear dynamic model of the system so as to achieve tracking control for systems with input-induced nonlinearities. The economic performance under nonlinear dynamic behavior and changing operating conditions is discussed. The closed-loop properties are analyzed under suitable assumptions on the model of the plant. Control strategies are discussed and compared to different implementations in the literature. Simulation examples show the effectiveness of the proposed approaches. The approach has been validated on the example of an industrial printing system with large variations in the input print queue. Keywords: MPC, plants with input-induced nonlinearities, economical criterion, printers, switched systems.

ThA5 Imperial 4

Linear Multivariable Systems I (Invited Session)

Chair: Karampetakis, Nikos — Aristotle Univ. of Thessaloniki
Co-Chair: Antsaklis, Panos — Univ. of Notre Dame
Organizer: Karampetakis, N. — Aristotle Univ. of Thessaloniki
Organizer: Antsaklis, Panos — Univ. of Notre Dame

10:30-10:50 ThA5.1

Distributed Cooperative Control of Nonlinear and Non-Identical Multi-Agent Systems (I), pp. 770-775

Bidram, Ali — The Univ. of Texas at Arlington
Lewis, Frank L. — Univ. of Texas at Arlington
Davoudi, Ali — Univ. of Texas, Arlington
Guerrero, Josep — Aalborg Univ.

This paper exploits input-output feedback linearization technique to implement distributed cooperative control of multi-agent systems with nonlinear and non-identical dynamics. Feedback linearization transforms the synchronization problem for a nonlinear and heterogeneous multi-agent system to the synchronization problem for an identical linear multi-agent system. The controller for each agent is designed to be fully distributed, such that each agent only requires its own information and the information of its neighbors. The proposed control method is exploited to implement the secondary voltage control for electric power microgrids. The effectiveness of the proposed control is verified by simulating a microgrid test system.

10:50-11:10 ThA5.2

Parameterization of All Controllers That Stabilize a Given Plant (I), pp. 776-781

Kucera, Vladimir — Czech Tech. Univ. in Prague

A simple and insightful method to teach the Youla-Kučera parameterization of all controllers that stabilize a given plant is presented. The text is intended for first-year graduate students in engineering. The result is derived first using transfer functions. A state-space representation of all stabilizing controllers then naturally evolves from the transfer function result. Thus, the transfer functions and the state-space techniques are presented as connected approaches rather than isolated alternatives.

11:10-11:30 ThA5.3

The Role of 2D Linear Systems Theory in the Design and Experimental Verification of Iterative Learning Control Algorithms (I), pp. 782-787

Galkowski, Krzysztof — Univ. of Zielona Gora
Rogers, Eric — Univ. of Southampton

Iterative learning control algorithms are applicable to the many industrial processes that complete the same finite duration task over and over again. One example is a gantry robot executing a pick and place operation in synchronization with a moving conveyor. The novel feature of these algorithms is the use of information from previous executions to update the control input for the next one and hence iterative learning control updates a signal as opposed to adaptive control where it is the controller, which is a system, that is updated. Iterative learning control therefore has a 2D systems structure and this paper will give an overview of recent progress in the design of iterative learning control laws in this setting. A particular focus will be on the relative merits of this approach to design over alternatives and also experimental verification. Open research questions will also be discussed, including the transfer of design algorithms for use in next generation healthcare and, in particular, robotic-assisted upper limb stroke rehabilitation.

11:30-11:50 ThA5.4

Properties and Classification of Generalized Resultants and Polynomial Combinants (I), pp. 788-793

Karcanias, Nicos — City Univ.

Polynomial combinants define the linear part of the Dynamic Determinantal Assignment Problems, which provides the unifying

description of the frequency assignment problems in Linear Systems. The theory of dynamic polynomial combinants have been recently developed by examining issues of their representation, parameterization of dynamic polynomial combinants according to the notions of order and degree and spectral assignment. Dynamic combinants are linked to the theory of "Generalised Resultants", which provide the matrix representation of polynomial combinants. We consider coprime set polynomials for which assignability is always feasible and provides a complete characterisation of all assignable combinants with order above and below the Sylvester order. The complete parameterization of combinants and coresponding Generalised Resultants is prerequisite to the characterisation of the minimal degree and order combinant for which spectrum assignability may be achieved.

11:50-12:10 ThA5.5

Notions of Equivalence for Linear Multivariable Systems (I), pp. 794-800

Vardulakis, Antonis	Aristotle Univ. of Thessaloniki
Karampetakis, Nikos	Aristotle Univ. of Thessaloniki
Antoniou, Efstathios	Alexander Tech. Educational Inst. of Thessaloniki
Vologiannidis, Stavros	Aristotle Univ. of Thessaloniki

The present paper is a survey on linear multivariable systems equivalences. We attempt a review of the most significant types of system equivalence having as a starting point matrix transformations preserving certain types of their spectral structure. From a system theoretic point of view, the need for a variety of forms of polynomial matrix equivalences, arises from the fact that different types of spectral invariants give rise to different types of dynamics of the underlying linear system. A historical perspective of the key results and their contributors is also given.

12:10-12:30 ThA5.6

Regions of Attraction and Recursive Feasibility in Robust MPC (I), pp. 801-806

Fleming, James	Univ. of Oxford
Kouvaritakis, Basil	Oxford Univ.
Cannon, Mark	Univ. of Oxford

For linear systems with multiplicative uncertainty, a formulation of robust model predictive control in a lifted space is given and is proven to give better or equal performance than any tube MPC approach that uses the same parameterization of the input. Then a tube MPC controller is formulated that ensures recursive feasibility through the use of terminal sets in the degrees of freedom available to the controller. In a numerical example this is shown to give performance comparable to the lifted approach while avoiding an exponential growth in computation.

ThA6 Ariadne

Invariant Sets in Control Applications (Invited Session)

Chair: Athanasopoulos, Nikolaos	Eindhoven Univ. of Tech.
Co-Chair: Lazar, Mircea	Eindhoven Univ. of Tech.
Organizer: Athanasopoulos, Nikolaos	Eindhoven Univ. of Tech.
Organizer: Lazar, Mircea	Eindhoven Univ. of Tech.

10:30-10:50 ThA6.1

Fault Detection and Isolation Based on the Combination of a Bank of Interval Observers and Invariant Sets (I), pp. 807-813

Xu, Feng	Tech. Univ. of Catalonia
Stoican, Florin	Pol. Univ. of Bucharest (UPB)
Puig, Vicenc	Univ. Pol. de Catalunya
Ocampo-Martinez, Carlos	Tech. Univ. of Catalonia (UPC)
Olaru, Sorin	Supelec

In this paper, a fault detection and isolation (FDI) approach using a bank of interval observers is developed. From the methodological point of view, a bank of interval observers is designed according to different dynamical models of the system under different modes (healthy or faulty). Each interval observer matches one system mode while all the interval observers monitor the system simultaneously. In order to guarantee FDI, a set of FDI conditions based on invariant set notions are established. These conditions ensure that the considered faults can be accurately isolated after a period of monitoring time. Finally, simulation results are used to present the effectiveness of the approach.

10:50-11:10 ThA6.2

Constrained Switching Stabilization of a Dc-Dc Boost Converter Using Piecewise-Linear Lyapunov Functions (I), pp. 814-823

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

This paper describes a new methodology for designing robust and efficient control laws for power converters. In addition to guaranteed closed-loop robust stability, the proposed design is capable of addressing a number of further key issues, i.e. low complexity of the implementation, accurate nonlinear dynamics incorporation, nonconservative handling of hard state and control constraints, and robustness to supply voltage variations and setpoint changes. The control design is of a set-theoretic nature. The iterative algorithms used for controller generation are based on the ray-gridding approach, that generates piecewise-linear Lyapunov functions and corresponding controlled invariant polytopes, induced by systematic conic decompositions of the state-space and state-dependent switching control actions. The proposed technique is evaluated on a boost converter case study. Simulation results in the MATLAB/SIMULINK environment are reported. The bifurcation behaviour of the system is further studied by numerical and analytical nonlinear stability analysis.

11:10-11:30 ThA6.3

Further Results on the Linear Constrained Regulation Problem (I), pp. 824-830

Bitsoris, Georges	Univ. of Patras
Olaru, Sorin	Supelec

The problem of constrained regulation of linear systems around an equilibrium lying in the interior of a domain of attraction has been extensively investigated. In many engineering problems however, like obstacle avoidance problems, the regulation around an equilibrium lying on the boundary of the domain of attraction is necessary. For this kind of problems, the classical methods cannot be applied and design control methods are missing. Using invariant set techniques, the present paper proposes design methods for guaranteeing convergence to an equilibrium lying on the boundary of the feasible region, all by respecting the state constraints. A collision avoidance numerical example is presented for illustrating the theoretical results of the paper.

11:30-11:50 ThA6.4

On Constrained Stabilization of Discrete–time Linear Systems (I), pp. 831-839

Athanasopoulos, Nikolaos	Eindhoven Univ. of Tech.
Doban, Alina Ionela	Tech. Univ. of Eindhoven
Lazar, Mircea	Eindhoven Univ. of Tech.

The concepts of controlled (k,lambda)-contractive sets and set-induced finite-time control Lyapunov functions are introduced in this paper. These tools are then employed to derive new synthesis methods for constrained stabilization of linear systems. Two classes of state-feedback control strategies are proposed, namely, periodic conewise linear control laws and periodic vertex-interpolation control laws. The benefits of these synthesis methods are demonstrated for the constrained stabilization of a DC-DC buck converter.

11:50-12:10 ThA6.5

Further Results on Merging Control Lyapunov Functions for Linear Differential Inclusions (I), pp. 840-845

Grammatico, Sergio — ETH Zurich
Blanchini, Franco — Univ. degli Studi di Udine
Caiti, Andrea — Univ. of Pisa

For the robust stabilization of constrained linear differential inclusions, we consider non-homogeneous, smooth, composite control Lyapunov functions (CLFs) which belong to the class of ``merging'' CLFs. Previous work showed the equivalence between the possibility to always merge two given CLFs and the fact that these two share a common control law. In presence of state and control constraints, this latter property may hold only in a small domain of the state space. For such cases, we provide a novel constructive procedure to merge a CLF having a large controlled invariant set and a CLF with locally-optimal performance but with a smaller controlled invariant set. Our merging allows the explicit derivation of a Lyapunov-based, robustly stabilizing, continuous control law with the large controlled invariant set of the former CLF and the locally-optimal performance of the latter. The theoretical results are illustrated via a numerical example.

12:10-12:30 ThA6.6

Invariant Sets and Guaranteed Cost Control of Nonlinear Quadratic Systems (I), pp. 846-851

Amato, Francesco — Univ. degli Studi Magna Graecia di Catanzaro
Colacino, Domenico — Univ. degli Studi Magna Græcia di Catanzaro
Cosentino, Carlo — Univ. degli Studi Magna Græcia di Catanzaro
Merola, Alessio — Univ. degli Studi Magna Graecia di Catanzaro

This paper addresses the problem of designing a guaranteed cost controller for continuous-time nonlinear quadratic systems. The main result is a sufficient condition for the existence of a linear state feedback controller achieving an assigned guaranteed cost, whenever the state trajectories remain within a suitable invariant set. The conditions are cast in the form of Linear Matrix Inequalities (LMIs), which can be efficiently solved via available optimization algorithms. The effectiveness of the devised approach is illustrated through an example concerning the attitude control of an unmanned aerial vehicle.

ThB1 IMPERIAL

Hybrid Systems II (Regular Session)

Chair: Conte, Giuseppe — Univ. delle Marche

15:00-15:20 ThB1.1

A Geometric Approach to Output Regulation for Discrete-Time Switched Linear Systems, pp. 852-857

Conte, Giuseppe — Univ. delle Marche
Perdon, Anna Maria — Univ. Pol. delle Marche
Zattoni, Elena — Alma Mater Studiorum - Univ. of Bologna

This paper considers the problem of asymptotic output regulation by dynamic feedback for discrete-time switched linear systems, with the requirement of asymptotic stability of the regulation loop. Using the methods of the geometric approach, sufficient conditions for solvability of the problem, under suitable assumptions, are shown. A synthesis procedure is outlined.

15:20-15:40 ThB1.2

A Case Study for Hybrid Regulation: Output Tracking for a Spinning and Bouncing Disk, pp. 858-867

Carnevale, Daniele — Univ. of Rome
Galeani, Sergio — Univ. Di Roma Tor Vergata
Menini, Laura — Univ. di Roma 'Tor Vergata'

In this paper, a spinning and bouncing disk is used to illustrate some issues in regulation for a class of hybrid systems. The use of variables having a clear physical meaning allows to give a nice interpretation of the mechanism that can be used, for fat plants, to generate admissible trajectories.

15:40-16:00 ThB1.3

On Semiclassical Solutions of Hybrid Regulator Equations, pp. 868-876

Carnevale, Daniele — Univ. of Rome
Galeani, Sergio — Univ. Di Roma Tor Vergata
Sassano, Mario — Univ. of Rome, Tor Vergata

In this paper, a special class of hybrid regulation problems is considered, which can be solved by using a class of steady-state inputs essentially coinciding with the class used in standard output regulation problems (for non hybrid systems), although the corresponding state evolution happens on a genuinely hybrid invariant manifold; hence the name “semiclassical”. The main advantage of using such solutions lies in easier implementation and the possibility of robust design.

16:00-16:20 ThB1.4

State Feedback Switched Control of Discrete-Time Switched Linear Systems with Application to Networked Control, pp. 877-883

Deaecto, Grace S. — UNIFESP
Souza, Matheus — FEEC - Unicamp
Geromel, Jose C. — UNICAMP

This paper treats the state feedback switched control design problem for discrete-time switched linear systems. More specifically, the control goal is to design a set of state feedback gains together with a state dependent switching function assuring stability and H2, Hoo performance indexes. The conditions are based on Lyapunov or Riccati-Metzler inequalities which although are difficult to solve for a large number of subsystems, allow the derivation of simpler alternative conditions expressed by LMIs whenever a scalar variable is fixed. This theory is well adapted to treat an important networked control problem known as discrete-time self-triggered control design problem, where the switching rule is responsible for the scheduling of the sampling periods to be considered in the communication channel at each sampling time instant in order to improve performance. This method is compared theoretically with others from literature. Academical examples are used for comparisons and to show the validity of the proposed technique in both contexts, switched and networked control systems.

16:20-16:40 ThB1.5

Hybrid Identification of Time-Varying Parameter with Particle Filtering and Expectation Maximization, pp. 884-889

Hartmann, Andras — INESC-ID
Vinga, Susana — INESC-ID
Lemos, Joao M. — INESC-ID

The problem of time-varying parameter identification is considered on a class of nonlinear hybrid systems. It is assumed that inputs and outputs are directly measured, and a subset of system parameters can take different values from a finite set at each time instance. An offline (batch) algorithm that combines particle filtering and the expectation maximization is introduced for the identification of such systems. The efficiency of the proposed method is illustrated through simulated examples.

ThB2 Imperial 1

Linear Systems II (Regular Session)

Chair: Koumboulis, Fotios — Halkis Inst. of Tech.

15:00-15:20 ThB2.1

I/O Decoupling with Simultaneous Disturbance Rejection of General Neutral Time Delay Systems Via a Measurement

Output Feedback Dynamic Controller, pp. 890-895

Koumboulis, Fotios — Halkis Inst. of Tech.

Kouvakas, Nikolaos — Halkis Inst. of Tech.

The problem of Input – Output (I/O) Decoupling with simultaneous Disturbance Rejection (DDR) is studied for the class general linear neutral multi-delay differential systems with measurable disturbances. The problem is solved using a dynamic multi-delay controller with proper and realizable feedback of the measurement outputs, a realizable precompensator and a realizable dynamic controller matrix mapping the measurable disturbances to the system inputs. For this system case and controller type the necessary and sufficient conditions for the problem to have a solution are established and the general analytical expression of the controller matrices solving the problem is derived.

15:20-15:40 ThB2.2

Relations between Denominator Assigning Proper Feedback Compensators and Pole Assignment by State Feedback, pp. 896-902

Vardulakis, Antonis — Aristotle Univ. of Thessaloniki

Kazantzidou, Christina — Aristotle Univ. of Thessaloniki

We examine relations between denominator assigning proper compensators in the feedback path of linear, time invariant (LTI) multivariable systems, described by square strictly proper transfer function matrices, and pole assignment by state variable feedback. Through these results we establish conditions for the existence and computation of such compensators.

15:40-16:00 ThB2.3

Deformations for Linear Control Systems in Polynomial Matrix Form, pp. 903-909

Menini, Laura — Univ. di Roma 'Tor Vergata'

Tornambe, Antonio — Univ. Di Roma Tor Vergata

The aim of this paper is to extend the use of deformations, to obtain a simplified description, to linear control systems in polynomial matrix form, which depend on a vector of parameters. The obtained simplified form is called adjoint normal form, since the theory is based on the properties of an adjoint mapping.

16:00-16:20 ThB2.4

A Two-Step Procedure for Optimal Constrained Stabilization of Linear Continuous-Time Systems, pp. 910-915

Shafai, Bahram — Northeastern Univ.

Ghadami, Rasoul — Northeastern Univ.

This Paper considers the problem of constrained stabilization of linear continuous-time systems when a quadratic cost criterion is imposed in the design of state feedback control law. The linear quadratic regulator (LQR) is solved under positivity constraint, which means that the resulting closed-loop systems are not only optimally stable, but also positive. We focus on the class of linear continuous-time positive systems (Metzlerian systems) and use the interesting properties of Metzler matrix to provide the necessary ingredients for the main results of the paper. A two-step procedure is proposed to solve the problem. First, some necessary and sufficient conditions are presented for the existence of controllers satisfying the Metzlerian constraint, and the constrained stabilization is solved using linear programming (LP) or linear matrix inequality (LMI). Second, a sufficient condition is outlined for the existence of a solution to maintain the positivity of the first step while achieving the optimality of LQR. Finally, the robustness of the design is analyzed and possible extension of the design is proposed for an uncertain interval systems. A numerical example is included to illustrate the procedure.

16:20-16:40 ThB2.5

Delayless Dynamic Controllers for Disturbance Rejection of General Neutral Time Delay Systems, pp. 916-921

Koumboulis, Fotios — Halkis Inst. of Tech.

Kouvakas, Nikolaos — Halkis Inst. of Tech.

Skarpetis, Michael — Halkis Inst. of Tech.

The problem of Disturbance Rejection (DR) for MIMO general neutral multi-delay systems, is studied for the case of left invertible systems with measurable disturbances. The controller used is of the delayless dynamic type feeding back the measurable disturbances and the plant measurement outputs. The necessary and sufficient conditions for the problem to have a solution are established and the general analytical expression of the delayless dynamic controller matrices is derived. The present results cover the solution of the Robust DR problem with uncertain delays.

ThB3 Imperial 2

Wireless Networks (Regular Session)

Chair: Rutherford, Matthew — Univ. of Denver

15:00-15:20 ThB3.1

Distributed Scheduling of Wireless Networks: A Message Passing Approach, pp. 922-929

Paschalidis, Ioannis — Boston Univ.

Huang, Fuzhuo — Boston Univ.

Lai, Wei — Columbia Management

We consider the problem of scheduling wireless networks with stochastic packet arrivals on the links and constant transmission rates. We propose a scheduling policy based on solving a Maximum Weighted Independent Set (MWIS) problem at each time slot on a conflict graph that incorporates all the interference constraints. Due to the computational difficulty of solving the MWIS on general graphs, we design a novel, low-complexity and distributed two-phase algorithm which solves the linear programming relaxation of the MWIS and then constructs a feasible solution to the original problem. We show that the two-phase algorithm always produces a maximal schedule for general networks, thus, achieving network stability. Numerical results show that our scheduling policy achieves significantly smaller aggregate long-run average queue lengths than some state-of-the-art scheduling algorithms.

15:20-15:40 ThB3.2

A Distributed Multi-Path Algorithm for Wireless Ad-Hoc Networks Based on Wardrop Routing, pp. 930-935

Oddi, Guido — Univ. of Rome "Sapienza"

Pietrabissa, Antonio — Consorzio per la Ricerca nell'Automatica e nelle Telecomunicazio

Wireless ad-hoc networks are collections of devices which are able to communicate each other through wireless links. Those networks differ from infrastructure-based wireless networks for the absence of a centralized coordinator which handles all the communications among the devices. This leads to higher probability of packets collision, congestion of links, etc. Moreover, wireless links are characterized by an intrinsic high and time varying packet loss ratio, due to external noise and interferences. The objective of this paper is to present a new distributed multi-path algorithm (i.e., traffic is split among multiple paths) for wireless ad-hoc networks with the aims of (i) increasing the throughput of the applications running onto the network (ii) explicitly accounting for the packet loss of the wireless links and (iii) guaranteeing that the routing process converges to stable paths. The algorithm is developed by using the concept of Wardrop equilibrium. Simulation results show the higher throughput achieved by the proposed routing algorithm, compared to shortest path routing protocols, based on hop count and on packet loss metrics.

15:40-16:00 ThB3.3

A Characterization of the Relative Positioning of Mobile Agents for Full Sensorial Coverage in an Augmented Space with Obstacles, pp. 936-941

Strutu, Mircea-Ionel — Pol. Univ. Bucharest

Stoican, Florin — Pol. Univ. of Bucharest (UPB)

Prodan, Ionela — SUPELEC

Popescu, Dan — Univ. Pol. of Bucharest

Olaru, Sorin Supelec

This paper addresses the coverage problem considering a collection of agents and fixed obstacles. A set of conditions over the positions of the agents are provided such that whenever these are verified there is no ``blind'' region in the feasible space. These conditions are expressed by making use of hyperplane arrangements. Lastly, the constraints are reformulated in a mixed-integer formalism. These novel results are examined over the case of wireless sensor networks. Also, various limitations and practical details are discussed.

16:00-16:20 ThB3.4

A Practical and Functional Approach to Wireless PID Control, pp. 942-947

Friman, Mats Metso
Nikunen, Joona Metso

A practical and functional wireless PID controller, which is based on a measurement estimator is suggested. The estimator acts as an interface between the wireless measurements and the discrete PID controller, and estimates missing measurements when needed. With the suggested structure, no dedicated wireless controller is needed, but the same PID block can be used for both wired and wireless control. The functionality of the suggested control structure is experimentally verified on a flow control loop with Wireless HART and WLAN communication.

16:20-16:40 ThB3.5

Coordination-Free Deterministic Communication for Embedded System Using the BBC Encoding, pp. 948-955

Martins, Goncalo Univ. of Denver
Barata, Manuel Inst. Superior de Engenharia de Lisboa (ISEL)
Rutherford, Matthew Univ. of Denver
Valavanis, Kimon Univ. of Denver

A major problem in the field of communication is the management of the shared transmission medium. For example, if multiple radios are transmitting simultaneously on the same frequency the signals may overlap, leading to interference. Some wireless techniques require the sender to sense before transmitting, introducing non-determinism as they wait a random delay before trying again. In real-time systems, unpredictable delays are undesirable and numerous techniques have been developed to organize the behavior of transmitters to eliminate this problem. Existing techniques to eliminate “sensebefore- send” rely on cooperation and coordination among all senders. The technique demonstrated in this paper uses the BBC encoding scheme to achieve deterministic wireless communications. With this technique, senders can transmit without regard for the state of the medium or coordination with other senders, and receivers can tease apart messages sent simultaneously with a high probability of success. We evaluate implementations of the technique in a wired environment using a simple unmanaged, single-wire bus, and also a wireless implementation with a simple AM radio.

ThB4 Imperial 3

Robot Swarms (Regular Session)

Chair: Tsourdos, Antonios Cranfield Univ.
Co-Chair: Doitsidis, Lefteris Tech. Educational Inst. of Crete

15:00-15:20 ThB4.1

Distributed Coverage of Mobile Heterogeneous Networks in Non--Convex Environments, pp. 956-962

Thanou, Michalis Univ. of Patras
Stergiopoulos, Yiannis Univ. of Patras
Tzes, Anthony Univ. of Patras

The article discusses the problem of distributed deployment of the nodes in a heterogeneous mobile sensor network in order to achieve optimum coverage of a non--convex environment. The members of the network are assumed to have unequally scaled sensing abilities reflected in their maximum geodesic range. The geodesic disc allows for modelling the sensors' reduced performance in non--visible areas. The proposed control scheme is based on proper partitioning of the space via the geodesic power distance, incorporating the reachability issue in the environment, along with the heterogeneity of the network. The mobile team is proven to lead towards a locally area optimum configuration, where restriction of the nodes in the accessible regions is guaranteed by the control framework. Simulation results indicate the efficiency of the proposed scheme, in comparison to the deployment, based on the Euclidean--metric.

15:20-15:40 ThB4.2

Distributed Multi-Robot Coverage Using Micro Aerial Vehicles, pp. 963-968

Renzaglia, Alessandro Univ. of Minnesota
Doitsidis, Lefteris Tech. Educational Inst. of Crete
Chatzichristofis, Savvas Democritus Univ. of Thrace
Martinelli, Agostino INRIA Rhone Alpes
Kosmatopoulos, Elias Democritus Univ. of Thrace and CERTH

In this paper we present a solution to the problem of positioning a team of Micro Aerial Vehicles for a surveillance task in an environment of arbitrary and unknown morphology. The problem is addressed taking into account physical and environmental constraints like limited sensor capabilities and obstacle avoidance. The goal is to maximize the area monitored by the team, by identifying the best configuration of the team members. The proposed method is a distributed extension of our previous work based on the Cognitive Adaptive Optimization (CAO) algorithm. This distributed and scalable approach allows us to obtain coordinated and safe trajectories to accomplish the task in 3D environments. The different formulation of the problem considered in this paper allows also dealing with communication constraints. We provide extensive experimental results using data collected by a team of aerial robots and compare the efficiency of the distributed and centralized approach.

15:40-16:00 ThB4.3

Coordinated Standoff Tracking of Groups of Moving Targets Using Multiple UAVs, pp. 969-977

Oh, Hyondong Univ. of Surrey
Kim, Seungkeun Chungnam National Univ.
Shin, Hyo-Sang Cranfield Univ.
Tsourdos, Antonios Cranfield Univ.
White, Brian A. Cranfield Univ.

This paper presents a coordinated standoff tracking methodology of groups of moving targets using multiple UAVs. The vector field guidance approach is first applied to track a group of targets for a single UAV by defining a variable standoff orbit to be followed, which can keep all targets within the field-of view of the UAV. A new feedforward term is included in the guidance command considering variable standoff distance, and the convergence of the vector field to the standoff orbit is analysed and enhanced by adjusting radial velocity using two active measures associated with vector field generation. Moreover, for multiple group tracking by multiple UAVs, a two-phase approach is proposed as a suboptimal solution for an NP-hard problem, consisting of target clustering/assignment and cooperative standoff group tracking with online local replanning. Lastly, localisation sensitivity to the group of targets is investigated for different angular separations between UAVs and sensing configurations. Numerical simulations are performed using randomly moving ground vehicles with four UAVs to verify the feasibility and benefit of the proposed approach.

16:00-16:20 ThB4.4

Decentralized Control for Maintenance of Strong Connectivity for Directed Graphs, pp. 978-986

Sabattini, Lorenzo Univ. of Modena and Reggio Emilia
Secchi, Cristian Univ. of Modena
Chopra, Nikhil Univ. of Illinois

In order to accomplish cooperative tasks, decentralized systems are required to communicate among each other. Thus, maintaining the connectivity of the communication graph is a fundamental issue. Connectivity maintenance has been extensively studied in the last few years, but generally considering undirected communication graphs. In this paper we introduce a decentralized control and estimation strategy to maintain the strong connectivity property of directed communication graphs. The control strategy is initially developed for balanced digraphs, and is then extended to generic strongly connected digraphs, introducing a decentralized balancing algorithm. The control strategy is validated by means of analytical proofs and simulation results.

16:20-16:40 ThB4.5

Formation Control of a Large Group of UAVs with Safe Path Planning, pp. 987-993

Regula, Gergely — Inst. for Computer Science and Control, Hungarian Acad. of

Lantos, Béla — Budapest Univ. of Tech. and Ec.

In this article we propose a hierarchical control structure for multi-agent systems. The main objective is to perform formation change manoeuvres, with guaranteed safe distance between each two vehicles throughout the whole mission. The key components that ensure safety are a robust control algorithm that is capable of stabilising the group of vehicles in a desired formation and a higher level path generation method that provides all the vehicles with safe paths, based on graph theoretic considerations. The method can efficiently handle a large group of any type of vehicles. As an illustration, the results are applied to a group of quadrotor UAVs.

ThB5 Imperial 4

Linear Multivariable Systems II (Invited Session)

Chair: Karampetakis, Nikos — Aristotle Univ. of Thessaloniki

Organizer: Karampetakis, N. — Aristotle Univ. of Thessaloniki

Organizer: Antsaklis, Panos — Univ. of Notre Dame

15:00-15:20 ThB5.1

Adaptive Suppression of Periodic Disturbances in MIMO Linear Systems (I), pp. 994-1001

Jafari, Saeid — Univ. of Southern California

Ioannou, Petros A. — Univ. of Southern California

Suppression of unknown periodic disturbances with time-varying characteristics has many industrial applications. The purpose of this paper is to propose a robust adaptive control scheme to suppress noise-corrupted disturbances with unknown and possibly time-varying characteristics in multi-input multi-output LTI systems. First, by considering the ideal (non-adaptive) case when complete information about the characteristics of the disturbance is available, the level of the performance that can be achieved in the case of known disturbances is demonstrated. Then, the adaptive case (unknown disturbance) is examined. It is shown under what conditions the unknown periodic disturbances can be suppressed and what parameters contribute to the performance of the overall adaptive control scheme. The stability and performance of the adaptive schemes is analyzed, and finally numerical simulations are given to show the effectiveness of the proposed scheme.

15:20-15:40 ThB5.2

Distribution of Invariant Indices and Static Output Feedback Pole Placement (I), pp. 1002-1007

Yannakoudakis, Aristotle — TEI of CRETE

Abstract— This paper deals with the static output feedback pole placement problem, examined via the eigenstructure assignment method. We transform the so-called Sylvester equations, occurring in the static output feedback (SOF) eigenstructure assignment problem, to a block Hankel matrix equation. This way we get rid of the redundant data and we treat only the significant ones. As a result, important properties of SOF-assignability appear to have an expression in terms of the distributions of the controllability and observability indices. First of all we present a necessary condition for the solvability of the Sylvester equations and we show of its relations with Kimura's condition and Plucker's matrix rank deficiency. According the distributions of invariant indices, the set of systems is partitioned into categories. For some of them SOF-assignability is impossible, for others is a linear and for the rest a non linear problem. For the linear case we present a parameterization of the eigenvectors related to a specific pole placement. For the non-linear one, the equations are weakly coupled and allow an analytic solution in relatively simple cases. Index Terms— Linear systems, pole placement, stabilizability, static output feedback.

15:40-16:00 ThB5.3

The Spectrum of Dynamical Systems Possessing Non Convex Positively Invariant Sets (I), pp. 1008-1013

Bitsoris, Georges — Univ. of Patras

Stability of linear systems is equivalent to the existence of ellipsoidal positively invariant or contractive sets. Stable systems are also characterized by the location of the spectrum of system matrix on the complex plane. Such a characterization has also been established for stable systems possessing convex polyhedral positively invariant sets. In this paper the class of unstable systems possessing expansive convex polyhedral and nonconvex polyhedral invariant sets is studied. For this type of systems, encountered in obstacle avoidance control problems, necessary and sufficient conditions for the expansiveness of polyhedral sets are developed. Then the spectral characterization of this class of systems is presented.

16:00-16:20 ThB5.4

On the Descriptor Variable Observation of Rectangular Implicit Representations (I), pp. 1014-1022

Bonilla, Moises E. — CINVESTAV-IPN

Malabre, Michel — IRCCyN - CNRS

Martinez Garcia, Juan Carlos — CINVESTAV-IPN

Recently, it has been shown that the implicit rectangular descriptions can be successfully used for modelling and controlling broad classes of linear systems, including systems with internal switches. This technique consists in finding first the degree of freedom, characterizing the internal variable structure, and then making it unobservable by means of a proportional and derivative descriptor variable.Up to now, there is no descriptor variable observer scheme for implicit rectangular systems.In this paper we propose two different ways for observing the descriptor variable: a descriptor variable observer based on fault detection and a descriptor variable observer based on adaptive structure detection. The first proposition is realized by continuous linear filters, which is performed for minimum phase systems.The second proposition is based on an adaptive structure detection which guarantees detection in a finite time.

16:20-16:40 ThB5.5

Robust Control and Computation Issues for a Class of Linear Multivariable Uncertain Systems (I), pp. 1023-1028

Kosmidou, Olga — Democritus Univ. of Thrace

Robust control of dynamic linear systems with parametric uncertainties in the LQG context often leads to the so-called guaranteed cost control approaches. In such cases it is based on the solution of generalized Riccati equations. This paper presents an overview of robust control problems related to the guaranteed cost control approach and the corresponding solutions. It is shown that different uncertainty descriptions and design specifications lead to various forms of generalized Riccati equations that may admit either analytical or computational positive definite solutions. The associated closed-loop systems' robustness features are also discussed.

ThB6 Ariadne

Distributed Systems I (Regular Session)

Chair: Casavola, Alessandro — Univ. Della Calabria

Co-Chair: Demetriou, Michael A. — Worcester Pol. Inst.

15:00-15:20 ThB6.1

A Controls-CFD Approach for Estimation of Concentration from a Moving Aerial Source: Comparisons between Switched and Dynamically Adapted Grids in 2D, pp. 1029-1034

Gatsonis, Nikolaos A. — Worcester Pol. Inst.

Demetriou, Michael A. — Worcester Pol. Inst.

Egorova, Tatiana — Worcester Pol. Inst.

Examining control and estimation algorithms from the computational perspective, this work proposes a dynamic grid adaptation scheme for the concentration estimation of a mobile gaseous source. The guidance of a moving sensor on board a sensing aerial vehicle, is solely dictated by the performance of the estimation scheme. To further improve the estimator performance, a dynamic grid adaptation scheme is proposed and which adapts the grid via local refinement and coarsening by using the current position of the sensor to enable this grid adaptation. This essentially renders the state matrix of the state estimator time varying and this time variation is dictated by the sensor spatial location. Extensive numerical studies for both stationary and mobile sources are considered to provide a convincing argument on the performance-based guidance of mobile sensors.

15:20-15:40 ThB6.2

Boundary Moving Horizon Estimator for Approximate Models of Parabolic PDEs, pp. 1035-1041

Dubljevic, Stevan — Univ. of Alberta

Yang, Yu — Univ. of Alberta

In this work, we focus on the state estimation of parabolic stochastic partial differential equations (PDEs) with boundary observation. The standard Kalman filter as an optimal estimator with the assumption of stochastic process features and known variances on state and output disturbances can not account for the naturally present constraints on the estimated states and state disturbances. Therefore, the motivation to explore the moving horizon estimator (MHE) in the distributed parameter system setting comes from the idea to synthesize an estimator that provides the best state estimate in a deterministic sense when process and measurement disturbances are with unknown statistics and when process constraints on states and disturbances are present. We explore the parabolic PDEs model with boundary observation, whereas the spectral decomposition approach is employed to yield a finite dimensional system which incorporates low dimensional approximation of the original infinite-dimensional system. The boundary moving horizon estimator (MHE) combined with the Kalman filter is built to reconstruct accurately the low dimensional approximation of the PDE state based on the noise corrupted boundary observations and estimated bounds arising from the infinite-dimensional parabolic PDEs state representation. The issue of the parabolic PDEs state constraints inclusion in the MHE with the Kalman filter is demonstrated by relevant simulation studies of the reaction-diffusion parabolic PDEs process with disturbance constraints and demonstration of an accurate PDE state reconstruction.

15:40-16:00 ThB6.3

Discrete-Time Infinite-Dimensional Adaptive Control and Rejection of Persistent Disturbances: To D or Not to D?, pp. 1042-1049

Balas, Mark — Univ. of Wyoming

Frost, Susan — NASA Ames Res. Center

In many cases an adaptive control must be implemented in discrete-time rather than continuous-time, aerospace applications. In the case of infinite-dimensional systems, the adaptive control theoretic problem becomes substantially different; we will emphasize those anomalies here. Given a linear discrete-time infinite dimensional plant on a Hilbert space and disturbances of known waveform but unknown amplitude and phase, we show that there exists a stabilizing discerete-time direct model reference adaptive control law with certain disturbance rejection and robustness properties. Our central result is a discrete-time version of Barbalat-Lyapunov result for infinite-dimensional Hilbert spaces. This is used to determine conditions under which a linear infinite-dimensional system can be directly adaptively regulated. Our results are illustrated on a system described by a compact self-adjoint operator; such a description fits many discrete-time applications.

16:00-16:20 ThB6.4

A Numerical Test of Positiveness on the Unit Circle Based on the Fast Fourier Transform, pp. 1050-1054

Augusta, Petr — Czech Acad. of Sciences

The paper presents an algorithm for checking positiveness of symmetric polynomial matrix on the unit circle. The algorithm is based on the sampling polynomial matrices using of the fast Fourier transform. The aim of the paper is to show that this approach is significantly faster than commonly used method based on semi-definite programming expression.

16:20-16:40 ThB6.5

Distributed Parallel Coordination-By-Constraint Strategies in Networked Multi-Area Power Systems, pp. 1055-1062

Tedesco, Francesco — Univ. della Calabria

Casavola, Alessandro — Univ. Della Calabria

A parellel distributed constrained supervisory strategy for Load/Frequency control problems in networked multi-area power systems is presented. The aim is at proposing a novel coordination strategy that is more effective with respect to the sequential distributed scheme presented in [1]. The proposed method is able to reconfigure, whenever necessary in response to unexpected load changes and/or faults, the nominal set-point on frequency and generated power to the generators of each area so that viable evolutions arise for the overall power system during transients and a new post-fault sustainable equilibrium is reached. In order to demonstrate the effectiveness of the strategy an example on a four-area power system is presented.

ThC1 IMPERIAL

Robust Control I (Regular Session)

Chair: Bobtsov, Alexey — Saint Petersburg National Res. Univ. of Information Tech.

17:00-17:20 ThC1.1

Output Controller for Nonlinear and MIMO Systems with Delay, pp. 1063-1068

Pyrkin, Anton — SPbNRU ITMO, NTNU

Bobtsov, Alexey — Saint Petersburg National Res. Univ. ofInformation Tech.

Kolyubin, Sergey — Saint Petersburg National Res. Univ. of Information Tec

In the paper the recent advantages in the development of adaptive output control approach using high-gain principle named by the authors as ``consecutive compensator'' is applied for SISO channels. The new approach for a class of nonlinear MIMO systems with parametric uncertainties and state-delays is proposed. The mathematical model is divided on two parts: static MIMO transformation and a few SISO channels that allows to design the control law in two steps. At the first step we design the virtual controls for each SISO channel and then after the inverse MIMO transformation we propose the control law for considered system. We present also the robotic setup designed for analysis of control algorithms oriented to complex technical objects.

17:20-17:40 ThC1.2

Robust Control of Pneumatic Clutch Actuators Using Simulated Annealing Techniques, pp. 1069-1075

Skarpetis, Michael — Halkis Insitute of Tech.
Koumboulis, Fotios — Halkis Inst. of Tech.
Ntellis, Achilleas — Halkis Inst. of Tech.

The position control problem of an electro pneumatic clutch actuator is formulated as a robust asymptotic tracking control problem. To solve the problem the Internal Model Principle is appropriately modified to a Hurwitz invariability problem solved through a constructive robust stability algorithm which is numerically integrated via a Simulated Annealing Algorithm. The problem is proven to be always solvable and the controller parameters providing a suboptimal solution are computed. Simulation results for the nonlinear model of the actuator and for all the expected range of model and load uncertainties illustrate the satisfactory control.

17:40-18:00 ThC1.3

Simultaneous Stabilization of a Segment of Systems by a Parameterized Compensator, pp. 1076-1081

Meddeb, Houda — Univ. de Lorraine
Fonte, Christophe — CNRS
Zasadzinski, Michel — CRAN

In this paper, a particular parametrization of controllers is proposed to study the simultaneous stabilization of a segment of systems. A necessary and sufficient condition for simultaneously stabilizing this segment is produced. This condition is converted into an optimization problem with one bilinear matrix inequality (BMI)constraint. Finally, an algorithm is given to solve the nonconvex problem that permits to compute the simultaneous controllers.

18:00-18:20 ThC1.4

Robust Control of Quadratic Systems with Norm Bounded Uncertainties, pp. 1082-1086

Amato, Francesco — Univ. degli Studi Magna Graecia di Catanzaro
Colacino, Domenico — Univ. degli Studi Magna Græcia di Catanzaro
Cosentino, Carlo — Univ. degli Studi Magna Græcia di Catanzaro
Merola, Alessio — Univ. degli Studi Magna Graecia di Catanzaro

This paper deals with the problem of the stabilization of uncertain quadratic systems via state feedback. The main contribution of the paper is a control design methodology which enables to find a robust controller guaranteeing for the closed-loop system: i) the local asymptotic stability of the zero equilibrium point; ii) the inclusion of a given polytopic region into the domain of attraction of the zero equilibrium point. This design procedure involves the solution of a Linear Matrix Inequalities (LMIs) feasibility problem, which can be efficiently solved via available optimization algorithms. A numerical example shows the effectiveness of the proposed methodology.

18:20-18:40 ThC1.5

Simple Output Controller for Nonlinear Systems with Multisinusoidal Disturbance, pp. 1087-1091

Pyrkin, Anton — SPbNRU ITMO, NTNU
Bobtsov, Alexey — Saint Petersburg National Res. Univ. ofInformation Tech.
Kolyubin, Sergey — Saint Petersburg National Res. Univ. of Information Tec

The problem of control design for a class of nonlinear system with multisinusoidal disturbance is considered. It is assumed that the linear part is unknown and minimum phase. The nonlinear part is known inaccurately, it is irreducible to an input of the linear block, and generally does not satisfy sector restrictions. An output controller ensuring semiglobal stability is designed. Controller was supplemented with the cancellation scheme of a multisinusoidal external disturbance that improves performance without its significant complication.

ThC2 Imperial 1

Modelling and Simulation II (Regular Session)

Chair: Stavrou, Demetris — Univ. of Cyprus

17:00-17:20 ThC2.1

Performance-Model Abstraction in a Synthesis-Centric Model-Driven Systems Engineering Framework, pp. 1092-1097

Markovski, Jasen — Eindhoven Univ. of Tech.
Reniers, Michel — TU/e

Supervisory control theory deals with automated synthesis of models of supervisory controllers that coordinate and control discrete-event high-level system behavior. These controllers ensure safe and nonblocking functioning of the system, but there do not exist efficient synthesis procedures for controllers that can ascertain complex liveness and performance guarantees. To this end, the supervised system must be validated to ensure that the desired functionality and performance is preserved. To verify that the supervised system also satisfies the performance requirements, a performance model is derived by abstracting the model of the supervised system. The latter is modeled by stochastic extensions of discrete-events systems with Markovian (exponential) delays. The resulting performance model is a continuous-time Markov chain with state labels. There exist algorithms for extraction of the Markov process, which optimize the number of states of the performance model. We show that this optimization leads to an abstraction that is not always suitable for performance evaluation by stochastic model checking. The abstracted states form paths that are not justifiable in the original system, which may lead to wrong performance metrics. We formalize the relationship between the original stochastic discrete-event and the performance model, and we propose a new abstraction that does not introduce these insupportable properties in the performance model.

17:20-17:40 ThC2.2

Structural Health Monitoring Application of Errors-In-Variables Identification, pp. 1098-1103

Guidorzi, Roberto — Univ. of Bologna
Diversi, Roberto — Univ. of Bologna

Structural Health Monitoring denotes a set of methodologies oriented to the description of the dynamical behavior of a structure in view of damage detection. These methodologies have taken advantage from the development of sensor, modeling and network techniques and constitute, today, a well established area. One of the most used methods consists in deducing dynamic models from the observations and in comparing these models with reference ones, concerning integrity conditions of the monitored structure. In many cases the excitations can be considered as white noise in the range of frequencies of interest and, in these cases, the structure can be described by means of autoregressive models. When this approximation is not realistic it is necessary to use input/output models that take into account also the characteristics of the excitation. This last case is considered in this paper making reference to the use of Errors-in-Variables (EIV) models and to data collected on a real structure during a small seismic event.

17:40-18:00 ThC2.3

FPGA Implementation of the V-Disparity Based Obstacles Detection Approach, pp. 1104-1111

Irki, Zohir — Ec. Militire Pol.
Devy, Michel — LAAS

In this paper we present an implementation of the whole V-disparity obstacles detection approach on an FPGA component. This approach is based on the use of stereoscopic images for the construction of an image called the V-disparity image from which obstacles can be easily extracted using a particular Hough transform. FPGA represents a good alternative for the use of the approach on an embedded system. The implementation of the approach on an FPGA component requires parallelizing all its steps which are the stereoscopic matching, the V-disparity image construction and obstacles extraction using a unidirectional Hough transform. These steps have been described with VHDL language

using the ISE 9.2 software. Finally, the entire approach has been implemented on a Virtex-II type XC2V1000 FG456-4 placed on an RC200 board.

18:00-18:20 ThC2.4

Nonlinear Set-Membership Identification: Bayesian Approach vs Subpavings Approach, pp. 1112-1118

Fernandez, Rosa M. UPC
Tornil-Sin, Sebastian Univ. Pol. de Catalunya (UPC)
Blesa, Joaquim Univ. Pol. de Catalunya (UPC)
Puig, Vicenc Univ. Pol. de Catalunya

This paper deals with the problem of nonlinear set-membership identification. To solve this problem, the Bayesian approach and the subpavings approach are presented. The paper illustrates how the Bayesian approach can be used to determine the feasible parameter set and to check the consistency between measurement data and model. In particular, it is shown that the Bayesian approach, assuming uniform distributed estimation error and flat model prior probability distributions, leads to the same feasible parameter set than the subpavings technique. Main issues and performance of both approaches are compared and discussed by means of an application example.

18:20-18:40 ThC2.5

A Path Correction Module for Two-Wheeled Service Robots under Actuator Faults, pp. 1119-1126

Stavrou, Demetris Univ. of Cyprus
Eliades, Demetrios Univ. of Cyprus
Panayiotou, Christos Univ. of Cyprus
Polycarpou, Marios M. Univ. of Cyprus

Autonomous wheeled robots have received significant interest in the previous years, and are typically used for security monitoring of remote or hazardous locations, as well as for moving goods in warehouses, with the minimum human intervention. At some unknown time, the operation of these robots may be affected due to some actuator fault, which causes the robot to partially lose the ability to navigate and to achieve its goals. In this work, a model-based Fault Detection, Isolation and Path Correction Module (FDI-PC) is presented, suitable for non-holonomic two-wheeled service robots. The first step of the FDI-PC is to determine whether an actuator fault has occurred, based on the measured states and the control inputs. The second step is to isolate the type of fault that has occurred, i.e. whether the fault affects the left or right wheel, and to identify its magnitude by using online learning. The third step is to modify the control input using a path-correction algorithm so that the robot maintains its ability to reach its goal. Simulation results on a realistic model of a two-wheeled service robot demonstrate the effectiveness of the FDI-PC Module.

ThC3 Imperial 2

Intelligent Control Systems (Regular Session)

Chair: Ioannou, Petros A. Univ. of Southern California

17:00-17:20 ThC3.1

AI-Based Low Computational Power Actuator/Sensor Fault Detection Applied on a MAGLEV Suspension, pp. 1127-1132

Michail, Konstantinos Cyprus Univ. of Tech.
Deliparaschos, Kyriakos NTUA
Tzafestas, Spyros National Tech. Univ. of Athens
Zolotas, Argyrios Univ. of Sussex

A low computational power method is proposed for detecting actuators/sensors faults. Typical model-based fault detection units for multiple sensor faults, require a bank of observers (these can be either conventional observers of artificial intelligence based). The proposed control scheme uses an artificial intelligence approach for the development of the fault detection unit abbreviated as `iFD'. In contrast with the bank-of-estimators approach, the proposed iFD unit employs a single estimator for multiple sensor fault detection. The efficacy of the scheme is illustrated on an Electromagnetic Suspension system example with a number of sensor fault scenaria.

17:20-17:40 ThC3.2

Constrained State-Feedback Control of an Externally Excited Synchronous Machine (I), pp. 1133-1140

Carpiuc, Sabin - Constantin Tech. Univ. "Gheorghe Asachi" of Iasi
Lazar, Mircea Eindhoven Univ. of Tech.

State-feedback control of externally excited synchronous machines employed in applications such as hybrid electric vehicles and full electric vehicles is a challenging problem. Indeed, these applications are characterized by fast dynamics that are subject to hard physical and control constraints. The goal of this paper is to provide a controller synthesis method that can answer these challenges effectively. To this end, firstly, a linear control law is obtained for the unconstrained dynamics via a standard control Lyapunov function (CLF), along with an admissible basin of attraction. Then, a piecewise affine control law defined on a cubic partition of the state-space is obtained for the constrained dynamics via a flexible CLF. An a posteriori test for checking stability and invariance of a set of initial conditions for the resulting closed-loop dynamics is also proposed. The effectiveness of the developed synthesis method is demonstrated in a realistic simulation scenario.

17:40-18:00 ThC3.3

Reachability Analysis for Managing Platoons at Intersections, pp. 1141-1147

Ben Makhlouf, Ibtissem RWTH Aachen
Diab, Hilal Software for Embedded Systems
Kowalewski, Stefan RWTH Aachen Univ.

In this work we address the management of a platoon of vehicles passing an intersection. In such a situation we have to decide under which conditions the platoon can pass the intersection in its entirety while avoiding collisions. If this cannot be assured, the platoon should be stopped at the intersection line or possibly split. For this purpose a decision about the vehicle from which the platoon should be divided in two subplatoons must be taken. In this case, the part ahead can drive safely through the intersection, while the second part must wait at the stop line for a permission to pass. The decision is made based on the results of reachability analysis of hybrid systems. The dynamics of the controlled platoon and the vehicle on the other side of the intersection is modeled as a linear time invariant system with uncertain input. For the computation of reachable sets we use our method based on zonotopes as approximation sets. We show how decisions to manage the platoon at the intersection under safety guarantees can be supported by the results of the reachability analysis and information about the intersection infrastructure.

18:00-18:20 ThC3.4

Grammatical Evolution and Network Operator Methods for Control System Synthesis, pp. 1148-1155

Diveev, Askhat Inst. of Russian Acad. of Sci.
Kazaryan, David People's Friendship Univ. of Russia
Sofronova, Elena Peoples' Friendship Univ. of Russia

Control system synthesis problem is considered. We have to find a control function as a function of the system's state. Synthesized control system should provide meeting a goal objective for the set of initial conditions. Grammatical evolution and network operator methods were considered as means for control systems synthesis. Computational experiments were performed for the non-linear control system synthesis for the Duffing oscillator.

18:20-18:40 ThC3.5

Intelligent Parking Assist, pp. 1156-1161

Rajabioun, Tooraj Univ. of Southern California
Foster, Brandon Univ. of Southern California
Ioannou, Petros A. Univ. of Southern California

In this paper a new parking guiding and information system is described. The system assists the user to find the most suitable parking space based on his/her preferences and learned behaviour. The system takes into account parameters such as driver's parking duration, arrival time, destination, type preference, cost preference, driving time, and walking distance as well as time-varying parking rules and pricing. Moreover, a prediction algorithm is proposed to forecast the parking availability for different parking locations for different times of the day based on the real-time parking information, and previous parking availability/occupancy data. A novel server structure is used to implement the system. Intelligent parking assist system reduces the searching time for parking spots in urban environments, and consequently leads to a reduction in air pollutions and traffic congestion. On-street parking meters, off-street parking garages, as well as free parking spaces are considered in our system.

ThC4 Imperial 3

Unmanned Systems II (Regular Session)

Chair: Kosmatopoulos, Elias — Democritus Univ. of Thrace and CERTH, Greece

17:00-17:20 ThC4.1

Mobile Robots Formation: Graph-Force Approach, pp. 1162-1167

Bazoula, Abdelouahab — Ec. militaire Pol.

Nemra, Abdelkrim — EMP

In this paper, we address the problem of mobile robots formation, the idea behind this work is the use description of the formation in a graph. Each node of the graph represents a mobile robot, which is connected to its neighbors thru adjacency matrix, where each node has some effects on its neighbors; these effects are in the form of forces of repulsion and attraction. The proposed approach is proven using a group of mobile robots based on double integrator model which is simulated in MATLABTM. We use in this paper artificial potential field for both sensing and avoiding obstacles.

17:20-17:40 ThC4.2

Fast Underwater Vehicle Manipulator System Motion Planning in GPUs, pp. 1168-1173

Sotiropoulos, Panagiotis — Univ. of Patras

Kolonias, Vasileios — Univ. of Patras

Aspragathos, Nikos — Univ. of Patras

Housos, Efthymios — Univ. of Patras

In this paper, we present a method for global motion planning of underwater vehicle manipulator systems (UVMS). The algorithm can derive a feasible path for UVMS equipped with an n-degree of freedom manipulator for performing autonomous underwater operations. The environment of the system is represented by a 4D Bump-surface that is used for obstacle avoidance. To improve the performance of the proposed method, the parallel calculation of the computationally intensive part of the algorithm is considered, leading to a 46-230 times faster implementation using a Graphics Processing Unit. A path following task in an environment cluttered with obstacles is considered for the validation of the method, while a UVMS with a mounted 6-dof manipulator performs the task. Both parallel and serial computational methods are evaluated and discussed.

17:40-18:00 ThC4.3

Control of Quadrotor Aerial Vehicles Equipped with a Robotic Arm, pp. 1174-1180

Arleo, Giuseppe — Univ. degli Studi della Basilicata

Caccavale, Fabrizio — Univ. degli Studi della Basilicata

Muscio, Giuseppe — Univ. degli Studi della Basilicata

Pierri, Francesco — Univ. degli Studi della Basilicata

In this paper a novel hierarchical motion control scheme for quadrotor aerial vehicles equipped with a manipulator is proposed. The controller is organized into two layers: in the top layer, an inverse kinematics algorithm computes the motion references for the actuated variables; in the bottom layer, a motion control algorithm is in charge of tracking the motion references computed by the top layer. A simulation case study is developed to demonstrate the effectiveness of the approach in the presence of disturbances and unmodeled dynamics.

18:00-18:20 ThC4.4

Autonomous Navigation of Teams of Unmanned Aerial or Underwater Vehicles for Exploration of Unknown Static Dynamic Environments}, pp. 1181-1188

Kapoutsis, Athanasios — Democritus Univ. of Thrace

Chatzichristofis, Savvas — Democritus Univ. of Thrace

Doitsidis, Lefteris — Tech. Educational Inst. of Crete

Sousa, Joao — Univ. do Porto - Faculdade Engenharia

Kosmatopoulos, Elias — Democritus Univ. of Thrace and CERTH, Greece

In this paper, we present a new approach that is able to efficiently and fully-autonomously navigate a team of Unmanned Aerial or Underwater Vehicles (UAUV's) when deployed in exploration of unknown static and dynamic environments towards providing accurate static/dynamic maps of the environment. Additionally to achieving to efficiently and fully-autonomously navigate the UAUV team, the proposed approach possesses certain advantages such as its extremely computational simplicity and scalability, and the fact that it can very straightforwardly embed and type of physical or other constraints and limitations (e.g., obstacle avoidance, nonlinear sensor noise models, localization fading environments, etc).

18:20-18:40 ThC4.5

Design and Implementation of an H∞ Controller for a Quadrotor Helicopter, pp. 1189-1198

Rich, Matthew — Iowa State Univ.

Elia, Nicola — Iowa State Univ.

Jones, Phillip — Iowa State Univ.

In this paper, we present a six degree of freedom model of a quadrotor helicopter, onboard electronics, and a networked control system. We follow this with a procedure for designing robust control for quasi hover conditions using Glover-McFarlane loop shaping. The model is presented symbolically as well as numerically for the specific system used in our experiments. In our control design procedure we take steps to minimize potential difficulties of MIMO loop shaping, while still producing effective linear control which is robust to a class of generic uncertainty. Finally, we present both simulation and experimental implementation results and find them in agreement.

ThC5 Imperial 4

Signal Processing (Regular Session)

Chair: Zingaretti, Primo — Univ. Pol. delle Marche

17:00-17:20 ThC5.1

Design and Test of a Precise Mobile GPS Tracker, pp. 1199-1207

Luchetti, Gioele — Univ.

Servici, Giuseppe — Univ.

Frontoni, Emanuele — Univ. Pol. delle Marche

Mancini, Adriano — Univ. Pol. delle Marche

Zingaretti, Primo — Univ. Pol. delle Marche

In the last years the widespread diffusion of smartphones with sensing capabilities paved the way to smart pervasive applications. The tracking of users activities aided by the set of sensor installed on board of smartphones represents a really interesting market for users which today demand reliable, smart and tailored services. The target group of sportsmen was of particular concern in this study. We aim at offering them a tool to record their training sessions along with a web community to share their activities with

similar users. To achieve this we have to deal with different issues concerning localization and modelling of the training session by using the GPS, as well as synchronization with the web service to upload the training data.

17:20-17:40 ThC5.2

Realizing System Poles Identification on the Unit Disc Based on Laguerre Representations and Hyperbolic Metrics, pp. 1208-1213

Soumelidis, Alexandros — Comp. and Automation Res. Inst.
Bokor, Jozsef — Hungarian Acad. of Sciences
Schipp, Ferenc — Eotvos Lorand Univ. of Budapest

In a series of paper the authors proposed a new frequency--domain approach to identify poles in discrete--time linear systems. The discrete rational transfer function is represented in a rational Laguerre--basis, where the basis elements are expressed by powers of the Blaschke--function. This function can be interpreted as a congruence transform on the Poincar'e unit disc model of the hyperbolic geometry. The identification of a pole is given as a hyperbolic transform of the limit of a quotient--sequence formed from the Laguerre--Fourier coefficients. In this paper the opportunities of reliably computing the poles are analyzed, and some algorithms are proposed for practical use.

17:40-18:00 ThC5.3

Cramer-Rao Lower Bound for Parameters of Random Processes in Navigation Data Processing, pp. 1214-1221

Stepanov, Oleg A. — Central Scientific Res. Inst. Elektropribor
Vasiliev, Vladimir — State Res. Center of the Russian Federation Concern CSRI Ele
Dolnakova, Alexandra — Concern CSRI Elektropribor

The paper considers the problem of estimating the parameters of random processes often dealt with by researchers in the processing of navigation information as a problem of optimal nonlinear filtering. An algorithm for calculating the Cramer-Rao lower bound of accuracy in this problem is suggested. The application of this algorithm is illustrated by two examples.

18:00-18:20 ThC5.4

GPS Based Attitude Determination Using Embedded Magnetometer Calibration, pp. 1222-1229

Kis, Laszlo — Budapest Univ. of Tech. and Ec.
Lantos, Béla — Budapest Univ. of Tech. and Ec.

This paper presents a method for GPS based orientation determination. The carrier phase GPS concept is used to achieve precise results. The typical problem of the integer ambiguity resolution is solved using additional magnetometer and accelerometer. For proper operation the magnetometer should be calibrated together with the moving vehicle. Two kinds of calibration methods are presented. The first can be used with aerial vehicles, the second with ground vehicles. The calibration methods are able to run online on embedded computers on the board of the vehicle. The calibration methods and the orientation determination are tested with real movements performed with a car and a sail-plane.

18:20-18:40 ThC5.5

Decision Making in Sensor Networks Observing Poisson Processes, pp. 1230-1235

Pahlajani, Chetan — Univ. of Delaware
Poulakakis, Ioannis — Univ. of Delaware
Tanner, Herbert G. — Univ. of Delaware

This paper addresses a detection problem where several spatially distributed sensors independently observe a time-inhomogeneous stochastic process. The task is to decide at the end of a fixed time interval between two hypotheses regarding the statistics of the observed process. In the proposed method, each of the sensors transmits once to a fusion center a locally processed summary of its information in the form of a likelihood ratio. The fusion center then combines these messages to arrive at an optimal decision in the Neyman-Pearson framework. The approach is motivated by applications arising in the detection of mobile radioactive sources, and it serves as a first step toward the development of novel fixed-interval detection algorithms that combine decentralized processing with optimal centralized decision making.

ThC6 Ariadne

Robotics III (Regular Session)

Chair: Batista, Pedro — Inst. Superior Técnico
Co-Chair: Moustris, George — National Tech. Univ. of Athens

17:00-17:20 ThC6.1

Towards Time-Optimal Exploration and Control by an Autonomous Robot, pp. 1236-1241

Nenchev, Vladislav — TU Berlin
Raisch, Joerg — Tech. Univ. Berlin

In this paper, we address the problem of an autonomous robotic vehicle collecting a finite but unknown number of objects with non-negligible masses and unknown locations in a restricted area and moving them to a particular spot in minimum time. An adaptive certainty-equivalent navigation and control policy is introduced based on a pick-up and an exploration/drop-off mode. While the input signal in pick-up mode is easily obtained in real time, complete exploration and drop-off corresponds to a hybrid optimal control problem (OCP) with exponential complexity in the finitely discretized space. We propose a trajectory planning algorithm by restricting the motion of the robot to a finite weighted graph. Further, we describe a discrete-time approximation of the hybrid OCP and compare both approaches with respect to computational complexity and accuracy.

17:20-17:40 ThC6.2

A Received Signal Strength Indication-Based Localization System, pp. 1242-1247

Lourenço, Pedro — Inst. for Systems and Robotics / Inst. Superior Técnico
Batista, Pedro — Inst. Superior Técnico
Oliveira, Paulo Jorge — Inst. Superior Técnico
Silvestre, Carlos — Univ. of Macau
Chen, C. L. Philip — Univ. of Macau

Localization using the received signal strength indication (RSSI) of wireless local area networks with a priori knowledge of the coordinates of the routers/access points is addressed in this paper. The proposed algorithm employs a path loss model that allows for the inclusion of the logarithmic measurements of the signal strength directly in the state of the nonlinear system that is designed. The nonlinear system is augmented in such a way that the resulting system structure may be regarded as linear time-varying for observability purposes, from which a Kalman filter follows naturally. Simulation results are included that illustrate the performance of the proposed solution.

17:40-18:00 ThC6.3

GES Source Localization Based on Discrete-Time Position and Single Range Measurements, pp. 1248-1253

Batista, Pedro — Inst. Superior Técnico
Silvestre, Carlos — Univ. of Macau
Oliveira, Paulo Jorge — Inst. Superior Técnico

This paper addresses the problem of estimating the position of a drifting source relative to an agent, in 3-D, based on discrete-time range measurements from the agent to the source, in addition to the position of the agent itself. An augmented nonlinear system is derived, in discrete-time, that can be regarded as linear for observability and observer design purposes. The analysis of the observability follows and sufficient conditions are derived, based directly on the trajectory of the agent. A Kalman filter with globally exponentially stable error dynamics is proposed and simulation results are presented that illustrate the achievable performance with the proposed solution.

18:00-18:20 ThC6.4

Enhancing Surgical Accuracy Using Virtual Fixtures and Motion Compensation in Robotic Beating Heart Surgery, pp. 1254-1260

Moustris, George	National Tech. Univ. of Athens
Mantelos, Andreas Ioannis	National Tech. Univ. of Athens
Tzafestas, Costas	National Tech. Univ. of Athens

This paper proposes a novel technique for applying virtual fixtures in a changing environment. The main targeted application is robotic beating heart surgery, which enables the surgeon to operate directly on a beating heart. Using a motion compensation framework, the motion of the heart surface is stabilized in a virtual space, which is presented to the surgeon to operate in. Consequently, the fixture is implemented in this static space, bypassing problems of dynamic fixtures such as position update, placement and force transients. Randomized experiments were performed using a trained surgeon comparing our approach to simple motion compensation and no compensation at all. The positive effect of the fixture in surgical accuracy for a tracking task is also discussed.

18:20-18:40 ThC6.5

Closed-Form Solution for Absolute Scale Velocity Estimation Using Visual and Inertial Data with a Sliding Least-Squares Estimation, pp. 1261-1266

Lippiello, Vincenzo	Univ. di Napoli Federico II
Rafik, Mebarki	Univ. di Napoli Federico II

In this paper a method for the on-line absolute-scale velocity estimation of a system composed of a single camera and of an inertial measurement unit is presented. The proposed formulation makes use of spherical image measurements acquired from at least three camera positions and inertial measurements to estimate the system velocity by solving also the absolute scale problem. A new multi-rate formulation based on a sliding least-squares estimation formulation is proposed, which is capable of providing the velocity estimation also in cases of constant and zero velocity. The effectiveness of the proposed approach is shown through extensive simulations.

FrA1 IMPERIAL

Autonomous Marine Vehicles (Invited Session)

Chair: Vukic, Zoran	Univ. of Zagreb, FER
Co-Chair: Zereik, Enrica	National Res. Council
Organizer: Bibuli, Marco	CNR – ISSIA
Organizer: Zereik, Enrica	National Res. Council
Organizer: Miskovic, Nikola	Lab. for Underwater Systems and Tech. Facultyof Electrical Engin

10:30-10:50 FrA1.1

A Real-Time Mosaicking Algorithm Using Binary Features for ROVs (I), pp. 1267-1273

Ferreira, Fausto	CNR – IEIIT
Veruggio, Gianmarco	CNR
Caccia, Massimo	CNR – ISSIA
Zereik, Enrica	National Res. Council
Bruzzone, Gabriele	CNR – ISSIA

This article presents a real-time mosaicking algorithm based on a SLAM framework. The mosaic of the seafloor can be useful in real time for a ROV operator that is piloting the ROV. Two important aspects arise in this kind of work: data association and computational time. In order to solve the first one, a combination of SURF features and template correlation methods is used. To minimize the computational time, a very recent approach in the domain of feature description is used: BRIEF binary features. Finally, to be able to update the whole mosaicking in a fast and easy way, local mosaics are used instead of a global one. The algorithm was tested using data collected in a typical experiment and the results show the improvement with respect to previous versions of a similar algorithm.

10:50-11:10 FrA1.2

Cooperative Path-Following in a Moving Path Reference Framework for Autonomous Marine Vehicles (I), pp. 1274-1279

Zereik, Enrica	National Res. Council
Bibuli, Marco	CNR – ISSIA
Caccia, Massimo	CNR – ISSIA
Bruzzone, Gabriele	CNR – ISSIA

This paper focuses on the improvement of a virtual target based path-following guidance system for the execution of coordinated manoeuvres within a multi-vehicle framework, with the chance of defining moving reference paths. The analysis of a Lyapunov-based guidance algorithm is carried out keeping into account the presence of a reference path's velocity vector, proving the convergence of the control system. Furthermore the overall architecture to achieve the motion coordination of a set of robotic platform is reported. Experimental results, obtained from a development and test campaign, are also reported in order to validate the proposed approaches.

11:10-11:30 FrA1.3

Guidance and Control of an Overactuated Autonomous Surface Platform for Diver Tracking (I), pp. 1280-1285

Miskovic, Nikola	Lab. for Underwater Systems and Tech. FER, Univ. of Zagreb
Nađ, Đula	FER, Univ.of Zagreb
Stilinović, Nikola	FER, Univ. of Zagreb
Vukic, Zoran	Faculty of Electrical Engineering and Computing, Univ. of Zagreb

The high-risk nature of SCUBA diving activities is usually dealt with by pairing up divers and adopting well defined rules for diving operations to reduce the chance of accidents. However, during more challenging dives (such as technical dives) these procedures may not be sufficient to ensure almost accident-free operations, for the divers must manoeuvre in complex 3D environments, carry cumbersome equipment, and focus attention on operational details. Technological advancement and research related to diver safety, navigation and monitoring has been identified as crucial for advancing diving activities. This paper reports current state of research performed at UNIZG–FER related to an autonomous overactuated surface platform used for following divers and transmitting GPS signal to the underwater. The implemented guidance and control algorithms are described and simulations obtained on realistic models developed in the ROS environment are provided. Special attention is given to algorithms for diver tracking by using measurements from a USBL. Diver motion estimators are used to improve the performance of the sparse and noisy USBL measurements. The results presented in this paper are a starting point for in-the-field experiments expected to take place in the real-world environment.

11:30-11:50 FrA1.4

GAS Decentralized Navigation Filters in a Continuous-Discrete Fixed Topology Framework, pp. 1286-1291

Viegas, Daniel	Inst. Superior Técnico
Batista, Pedro	Inst. Superior Técnico
Oliveira, Paulo Jorge	Inst. Superior Técnico
Silvestre, Carlos	Univ. of Macau

This paper addresses the problem of state estimation in formations of autonomous vehicles. The approach considered here consists in the implementation of a local state observer in each vehicle relying only on locally available measurements and data communicated by neighboring agents, resulting in a decentralized state observer which features lower computational and communication loads than comparable centralized solutions. A method for computing observer gains which yield globally asymptotically stable error dynamics is presented for fixed topology formations, as well as an iterative algorithm for improving the decentralized estimator's performance when the measurements are corrupted by noise. The proposed framework is particularized to the practical case of a formation of Autonomous Underwater Vehicles (AUVs), and a continuous-discrete formulation is achieved for the local state observers, to take into account the difference in sampling rates between on-board instrumentation and positioning systems. To assess the performance of the solution, simulation results are presented and discussed for different formation topologies.

11:50-12:10 FrA1.5

Comparative Assessment of Human Machine Interfaces for ROV Guidance with Different Levels of Secondary Visual Workload (I), pp. 1292-1297

Vasilijevic, Antonio	Lab. for Underwater Systems and Tech, FER, Univ. of Zagreb
Miskovic, Nikola	Lab. for Underwater Systems and Tech, FER, Univ. of Zagreb
Vukic, Zoran	Lab. for Underwater Systems and Tech, FER, Univ. of Zagreb

Majority of ROVs are underwater vehicles with relatively slow dynamics virtually providing a ROV pilot extra time to perform other tasks, such as inspections and arm operation. However, with many tasks performed simultaneously with flying the relevant information is typically dispersed on a number of screens overloading the pilot's visual channel. Surprisingly, there is very little research examining the unique human-factors problems associated with unmanned underwater vehicles. Use of audio display has been suggested as a means to reduce visual workload, to enhance situation awareness, and mitigate the visual and cognitive demands of contemporary ROV operations. Our research is focusing to investigating the effects of secondary visual tasks on operators workload and performance using standard visual navigation interface, augmented reality visual interface and audio interface. All experiments were performed on the state-of-the-art, real-time ROV simulator developed by Mobile & Marine Robotics Research Centre, University of Limerick and augmented reality system developed by Laboratory for Underwater Systems and Technologies, University of Zagreb. As expected, the results show that in no-load conditions visual guidance is better than the guidance-by-sound. By contrast, the effects of secondary visual load affect operators' performance.

The use of augmented reality paradigm and especially hearing, in the form of the auditory display, emerges as an important advantage. Improvement depends on a level of experience in using auditory guidance system. Practice has a major effect on performance, bringing us to the conclusion that there is a more room for improvement in using auditory interface.

FrA2 Imperial 1

Renewable Energy and Sustainability (Regular Session)

Chair: Aitouche, Abdel LAGIS/HEI

10:30-10:50 FrA2.1

Stability Analysis of Photovoltaic Systems Driven by Advanced MPPT Controllers, pp. 1298-1303

Krommydas, Konstantinos Univ. of Patras

Alexandridis, Antonios Univ. of Patras

An advanced maximum power point tracking (MPPT) control method, namely the ripple correlation control (RCC) MPPT method, is applied on a dc/dc boost converter used to interface a photovoltaic (PV) system with the electrical grid. An extensive nonlinear stability analysis is conducted in which the nonlinear model of both the PV source and the dc/dc boost converter dynamics are taken into account. Using this accurate nonlinear model and exploiting the singular perturbation theory and Lyapunov techniques, it is proven in the paper that for appropriate gain values of the RCC-MPPT controller, asymptotic stability to the desired equilibrium is guaranteed. The RCC-MPPT controller performance is finally evaluated by simulating an extreme case of rapid irradiance changes on a complete PV system.

10:50-11:10 FrA2.2

Robust Fuzzy Controller for Photovoltaic Maximum Power Point Tracking, pp. 1304-1309

Kamal, Elkhatib LAGIS FRE CNRS 3033, Lille, France

Aitouche, Abdel LAGIS/HEI

Kuzmych, Olena Volyn National Univ.

In this paper, the stability and robustness analyses of uncertain multivariable nonlinear control systems based on fuzzy logic approaches are presented. A system that comprises a Takagi-Sugeno (TS) fuzzy plant model and a fuzzy controller connected in closed-loop is first considered and second establishing fuzzy state observers. The TS fuzzy plant model represents an uncertain multivariable nonlinear system as a weighted sum of a number of sub-systems. Similarly, the fuzzy controller is a weighted sum of a number of sub-controllers. The concept of Parallel Design Compensation (PDC) is employed to design Grid-Point Fuzzy Controller (GPFC) from the TS fuzzy models. The sufficient conditions are formulated in the format of Linear Matrix Inequalities (LMIs). The effectiveness of the proposed controller design methodology is finally demonstrated through a photovoltaic panel array to maximize the PV power. In detail, we consider a dc/dc buck converter to regulate the output power of the photovoltaic panel array. Therefore, the proposed method provides an easier implementation form under strict stability analysis. Finally, the control performance is shown from the numerical simulation results.

11:10-11:30 FrA2.3

Influence of the Transition from Part Load to Full Load Operation on the Mechanical Subsystem of the Drive Train of a Wind Energy Converter, pp. 1310-1315

Broy, Alexander Ruhr-Univ. Bochum

Sourkounis, Constantinos Ruhr-Univ. Bochum

Considering control theory aspects, the operation of wind energy converters can basically be distinguished between part load and full load operation. At part load operation, the system is operated below nominal wind speed and control methods are generally designed to gain as much power as possible by the wind.For this purpose, generally MPPT tracking methods with underlying torque or speed control are used. At full load operation, the system is operated at nominal wind speed and beyond before it is disconnected when the wind speed becomes too strong.Full load operation is characterized by the fact that the power withdrawn from the wind must be limited to the nominal power of the system. For this purpose, a pitch system is used. The speed remains almost constant at this operating range, and the torque introduced from the rotor side is limited by an adjustment of the rotor blades. Due to the fact, that both of the control systems access the same mechanical system and are therefore coupled, interactions arise at the transition point around the nominal wind speed which involves extensive mechanical loads when both control methods are not adjusted to each other. The transition between the two operating ranges may lead to significant increases of the load spectrum of the drive train and to a mechanical loading of the wind power system. The special straining of the drive train is particularly emphasized within the scope of this paper. Of considerable influence are control methods of the respective operating ranges (MPPT and pitch control methods). The relatively “hard” transition between the operating ranges, may lead to stimulations of the eigen-frequencies of the drive train, particularly when the transition is crossed several times. In this case it is important to adjust th

11:30-11:50 FrA2.4

Regulation of Angular Speed and Reactive Power for a Wind Turbine Applying Robust Feedback Linearization and H-Infinity Control, pp. 1316-1321

Di Giorgio, Alessandro Univ. of Rome "La Sapienza"

Mercurio, Andrea Univ. of Rome "La Sapienza"

Liberati, Francesco Univ. of Rome "La Sapienza"

This paper deals with the robust regulation of reactive power and rotor angular speed in a wind turbine driven Doubly Fed Induction Generator, which constitutes one of the key functionalities for the implementation of the future Smart Grids. The focus of the work is the application of a recent development in the theory of robust control of nonlinear systems, which combines robust feedback linearization and H-infinity linear control. The derived robust control system is compared to a traditional one making use of classical feedback linearization and PI controllers. Simulations show the effectiveness of the new approach in extending the performances of the classical feedback linearization based regulator from nominal parameters condition to the perturbed one.

11:50-12:10 FrA2.5

Minimization of Water Losses for Optimal Hydroelectric Power Generation, pp. 1322-1328

Rosero, Nadia Univ. del Valle

Ramirez, Jose Miguel Univ. del Valle

Martinez, John-Jairo Gipsa-Lab. INP-Grenoble

This paper deals with the problem of reducing water losses during power generation in hydro-power valleys. Because the main resources is water, it is important to guarantee that the demanded power per hour is generated in such a way that water is used as much as possible along the valleys. That is achieved by minimizing the spilling flows. The natural interactions between power units and the fact that these units have to respect different real-time constraints (the demanded power generation, for instance) suggest the use of more advanced techniques for optimal coordination. In this work, an explicit Model Predicted Control is proposed for tackle the problem of system constraints together with the problem of water losses minimization. Firstly, a model of the system including a model of the exogenous disturbances is proposed. Here an extended observer is designed and used to solve the control problem. Then, the original control problem is established and rewritten in terms of a Quadratic Program problem. After that, a very simple explicit solution of the Quadratic Program problem is proposed by using a geometrical approach. This allows its implementation in real-time applications and it could be more intuitive for engineers piloting hydropower plants. The paper includes a realistic simulation that is intended for illustrating the behavior of the controlled system for reducing the spilling flows.

12:10-12:30 FrA2.6

IEC 61851 Compliant Electric Vehicle Charging Control in

Smartgrids, pp. 1329-1335

Di Giorgio, Alessandro — Univ. of Rome "La Sapienza"
Liberati, Francesco — Univ. of Rome "La Sapienza"
Canale, Silvia — Univ. of Rome "Sapienza"

This paper deals with the problem of controlling electric vehicles charging in a smart grid. We present an event driven model predictive control (MPC) approach, which aims to find a proper trade-off between the needs of minimizing both the cost of energy withdrawal and the error while tracking a reference aggregated charging power profile. All in respect of drivers' preferences, technical bounds on the control action (in compliance with the IEC 61851 standard) and grid constraints. The proposed control approach allows "flexible" EV users to participate in demand side management programs, which will play a crucial role for stability and efficiency of the future smart grids. Simulation results are provided and discussed in details, showing the relevance of our contribution.

FrA3 — Imperial 2

Biologically Inspired Systems (Regular Session)

Chair: Tsakiris, Dimitris — FORTH

10:30-10:50 — FrA3.1

Stabilizing a Quadruped Robot Locomotion Using a Two Degree of Freedom Tail, pp. 1336-1342

Mutka, Alan — FER, Univ. of Zagreb
Orsag, Matko — Univ. of Zagreb
Kovacic, Zdenko — Univ. of Zagreb

This paper investigates how to improve locomotion stability of a dynamical system composed of four spring-mass subsystems by using a tail-like inertial appendage. The paper presents a Denavit-Hartenberg parameterization based kinematic model combined with a Newton-Euler based dynamic model of a two degree of freedom tail. Impedance based leg control simplifies the leg motion so that it can be modeled as a damped spring-mass system. The tail presented in the paper is used as a counterweight, capable of shifting its center of mass so as to balance the body of the robot. To that end, a recursive algorithm that moves the tail in order to balance the robot is proposed. A realistic robot model is built in the Open Dynamic Engine environment and is used to conduct a series of tests proving the effectiveness of the proposed algorithm.

10:50-11:10 — FrA3.2

Turning Maneuvers of an Octopus-Inspired Multi-Arm Robotic Swimmer, pp. 1343-1349

Sfakiotakis, Michael — Foundation for Res. and Tech. - Hellas (FORTH)
Kazakidi, Asimina — Foundation for Res. & Tech. - Hellas (FORTH)
Tsakiris, Dimitris — FORTH

Inspired by the agile underwater maneuvering of the octopus, an eight-arm robotic swimmer was developed. Associated dynamical models are used here to design turning maneuvers, an important ability for underwater navigation. The performance of several turning gaits, based on sculling arm movements, of this robotic system was investigated in simulation, with respect to their various kinematic parameters. Experiments with a prototype robotic swimmer confirmed the computational results and verified the multi-arm maneuverability of such systems.

11:10-11:30 — FrA3.3

Automated Detection of Scallops in Their Natural Environment, pp. 1350-1355

Kannappan, Prasanna — Univ. of Delaware
Tanner, Herbert G. — Univ. of Delaware

Automating the counting of marine animals like scallops benefits marine population survey efforts. These sur- veys are tools for policy makers to regulate fishing activities, and sources of information for biologists and marine ecologists interested in population statistics of marine species. In this paper we discuss some practical difficulties that arise in the scallop detection problem from visual data, and propose a solution based on top-down visual attention. We assess the performance of the proposed method against a comparable and related method which has recently been employed in literature, using a significant amount of ground truth data.

11:30-11:50 — FrA3.4

A Comparative Study on Differential Evolution with Other Heuristic Methods for Continuous Optimization, pp. 1356-1361

Maione, Guido — Pol. di Bari
Punzi, Antonio — ISS Innovative Software Services GmbH, Stuttgart
Li, Kang — Queen's Univ. Belfast

In this paper, we describe an optimization method based on differential evolution (DE). It shows good convergence properties with few parameters. However, the appropriate selection of the parameters is a difficult task. Hence, we here analyze the performance indexes of the DE algorithm to set the control parameters. Moreover, to identify the best parameter intervals, the DE approach is first compared to two different Particle Swarm Optimization (PSO) algorithms and then to a recent adaptive genetic algorithm (DABGA). The optimization of benchmark functions shows that the DE algorithm performs better than PSO and DABGA methods.

11:50-12:10 — FrA3.5

Gravity and Inclination Effects on the Design of Quadruped Robots for Space Exploration, pp. 1362-1367

Kontolatis, Ioannis — National Tech. Univ. of Athens
Papadopoulos, Evangelos — National Tech. Univ. of Athens

Leg uncompressed length and compliance have significant impact on the performance of quadruped robots. Also, gravity has a direct effect on robot motion characteristics. This paper presents results obtained using a planar lumped parameter model of a quadruped robot and an extensive research scheme to determine the optimum design parameters for quadrupeds moving in various gravity environments. An optimum region of leg spring constant and uncompressed length emerges for level terrain traversal. The maximum values for negative and positive slopes according to forward velocity in three gravity environments are also determined. Experiments with the NTUA Quadruped are conducted to validate the simulation environment. Experimental results obtained using internal sensors show that the quadruped robot performs gaits with the desired characteristics and in accordance to simulations.

FrA4 — Imperial 3

Predictive Control I (Regular Session)

Chair: Ioannidis, Stratos — Tech. Univ. of Crete

10:30-10:50 — FrA4.1

Model Predictive Tracking Control for a Head-Positioning in a Hard-Disk-Drive, pp. 1368-1373

Taktak, Manel — ENIS
Chemori, Ahmed — LIRMM, Montpellier
Ghommam, Jawhar — ENIS
Derbel, Nabil — ENIS

This paper deals with the track-following problem of a Read/Write (R/W) head of a Hard-Disk-Drive (HDD) servo-system, which is resolved through two control algorithms generated from Model Predictive Control (MPC). The first approach consists of a classical linear MPC without constraints. The second method is inspired from the MPC technique but uses a reference trajectory to steer the actuator as close as possible to the set-point trajectory. Numerical simulation results of the proposed controllers are presented and compared with those of a classical Proportional Integral Derivative

Controller (PID). Different simulation scenarios are presented including nominal case, external disturbance rejection, and robustness towards parameters' uncertainties.

10:50-11:10 FrA4.2

On the Computation of Kalman Gain in Large Adaptive Optics Systems, pp. 1374-1379

Beghi, Alessandro — Univ. of Padova
Cenedese, Angelo — Univ. of Padova
Masiero, Andrea — Univ. of Padova

In large ground telescopes the Adaptive Optics (AO) system aims at compensating the atmosphere effect on telescope measurements, and, the use of optimal filtering is fundamental for such task. This work is motivated by two important characteristics of new AO systems: on one hand, because of the request of very high measurement resolutions, the size of new telescopes, and of their sensors, is quickly increasing in the last decades, thus imposing to the AO systems the analysis of larger amount of data. On the other hand, the optimal filter has to be periodically updated according to temporal changes in atmosphere characteristics. Hence, it is of fundamental importance the use of computationally efficient algorithms for the update of the optimal filter gain. This paper proposes some changes to a recently presented method for the efficient computation, in the frequency domain, of the Kalman gain for large AO systems [15]. The proposed changes, which mainly aim at correcting some issues due to the conversion spatial--frequency domain, and viceversa, allow to compute a better approximation of the optimal Kalman gain, and, consequently, significantly improve the performance of the AO system.

11:10-11:30 FrA4.3

Stability Analysis of a Predictive PI Controller, pp. 1380-1385

Airikka, Pasi — Metso Automation

Industrial processes are typically regulated by PID controllers. However, for dead time dominating systems, the PID controller is not very applicable. More than two decades ago, a predictive PI controller was introduced for improving control performance of processes having dominating dead times. The predictive PI controller is rather simple to use and implement, intuitively appealing and applicable to delay dominating systems. Yet, its stability analysis has not received attention that it should have, nor its tuning which has been given only one guideline that was presented in the original paper. In this paper, the stability of the predictive PI control loop is analysed in details not only for accurate process models having no model mismatch but also processes having modelling errors and uncertainties. Consequently, some preliminary guidelines for tuning are given.

11:30-11:50 FrA4.4

Stabilizing Predictive Controller for Singular Linear Systems, pp. 1386-1392

Sredojev, Sonja — The Univ. of New South Wales
Eaton, Ray — The Univ. of New South Wales

Developing the model predictive controllers (MPC) for singularly perturbed systems is an important and challenging problem. In this paper we derive sufficient conditions for exponentially stabilizing MPC for a family of singularly perturbed liner time-varying (LTV) systems. A min-max MPC approach is employed to compute the optimal time-varying input vector subject to constraints and uncertainties. More specifically, the set of admissible control signals is calculated by minimizing the upper bound of a cost function along the finite horizon for the worst case scenario with respect to the input uncertainties. The optimality itself does not necessarily imply stability. Therefore, the purpose of this paper is twofold. First we derive the conditions that would guarantee the stability of the multi-scales dynamics. Second, the stability conditions are introduced into the optimization problem to compute the input signal in optimization performed over the defined set of constraints.

11:50-12:10 FrA4.5

A New Dual-Mode Model Predictive Control for Constrained Linear Systems, pp. 1393-1397

Nguyen, Hoai-Nam — Tech.
Gutman, Per-Olof — Tech.

An efficient dual mode model predictive control algorithm is proposed for time-invariant linear discrete-time systems with state and input constraints. The approach significantly enlarges the feasibility regions compared to dual mode approach. In addition, the unconstrained optimal performance for states near the origin is guaranteed. The efficacy of the approach is demonstrated via numerical example.

FrA5 Imperial 4

Robust Control II (Regular Session)

Chair: Herman, Przemyslaw — Poznan Univ. of Tech.

10:30-10:50 FrA5.1

An Indirect Adaptive Feedback Attenuation Strategy for Active Vibration Control, pp. 1398-1403

Landau, Ioan Dore — CNRS
Airimitoaie, Tudor-Bogdan — IRISA / Inria Rennes Bretagne Atlantique

From a control point of view, active vibration control requires attenuation of unknown and/or time varying multiple narrow band disturbances. Internal Model Principle (IMP) is currently used for building adaptive active vibration control systems. IMP leads to asymptotic suppression of the disturbances but often introduces in the case of multiple narrow band disturbances a strong "water bed" effect on the output sensitivity function (unwanted amplification). In this paper, an indirect adaptive control methodology for attenuation of multiple unknown time varying narrow-band disturbances is proposed. The method is based on the real time estimation of the frequency of narrow-band disturbances using adaptive notch filters (ANF) followed by the design of a controller using adjustable band-stop filters (BSF) for the appropriate shaping of the output sensitivity function. A Youla-Kucera parametrization of the controller is used for reducing the computation load. This approach is compared on an active vibration control (AVC) system with a direct adaptive control scheme based on the internal model principle (IMP). Real time experimental results are provided.

10:50-11:10 FrA5.2

Adherence Control for Electric Vehicles on Varying Road Conditions, pp. 1404-1410

Geamanu, Marcel-Stefan — Lab. des Signaux et Systèmes, Supélec/ IFPEN
Cela, Arben — Groupe ESIEE
Mounier, Hugues — Univ. Paris Sud 11
Niculescu, Silviu-Iulian — UMR CNRS 8506, CNRS-SUPELEC
Le-Solliec, Guenael — IFP

The present paper describes a torque saturation control technique applied on vehicular control, operating on time-varying tire-road adherence conditions. The method is based on an instantaneous estimation of the maximum available friction using the Dugoff tire model [3]. The novelty lies in the modelling of the road conditions, which are regarded as continuous variables. A ”dynamic” Pacejka model is built around the classical Pacejka model, giving a more realistic approach of the tire-road interaction. The implemented estimation method has to adapt to all the parameter changes, to produce a reliable maximum friction on which the control will be applied. The complex modelling of the road conditions will be enlarged with a noise perturbation, to test our method's robustness. At the same time, the vehicle is considered to be equipped with ”inwheel” electrical motors, which provide a quick transmission of the torque directly at the wheel.

11:10-11:30 FrA5.3

High-Gain Disturbance Observer Tuning Seen As a Multicriteria Optimization Problem, pp. 1411-1416

Madonski, Rafal — Poznan Univ. of Tech.
Piosik, Adam — Poznan Univ. of Tech.

Herman, Przemyslaw — Poznan Univ. of Tech.

The paper analyses the potential use of a Nondominated Sorting Genetic Algorithm (NSGA-II) in finding the parameters of an Extended State Observer (ESO). The ESO in the proposed framework is used as a part of a disturbance-rejection controller, which governs the horizontal position of a nonlinear cart-like system. The considered multicriteria optimization NSGA-II algorithm is introduced to automatically find a set of the observer design parameters that guarantee a desired (and predefined) behavior of the plant. The validity of the considered approach is verified with real experiments conducted on a laboratory testbed.

11:30-11:50 FrA5.4

Fuzzy Robust Tracking Control with Pole Placement for a Turbocharged Diesel Engine, pp. 1417-1422

Abidi, Ines — Univ. of Picardie JulesVerne,Lab.
Bosche, Jérôme — Univ. of Picardie Jules Verne of Amiens
El Hajjaji, Ahmed — Univ. de Picardie-Jules Verne
Aguilera-González, Adriana — Univ. de Picardie Jules Verne

This paper addresses the modeling and control of the air path system of diesel engines. We propose a robust control for the diesel engine equipped with Exhaust Gas Recirculation (EGR) and Variable Geometry Turbocharger (VGT) systems. The goal is to control carefully the air flow for a diesel engine to reduce emissions of pollutant particles and fuel consumption. A mean value model of the air loop is considered and rewritten using a fuzzy Takagi-Sugeno (TS) approach. A control strategy based in Lyapunov function and pole placement in LMI regions (Linear Matrix Inequalities) is developed. It takes into account the variation of the engine speed. The goal is to design a robust control law that tracks some reference signals. The effectiveness of the proposed fuzzy tracking controllers in the system diesel engine is demonstrated through numerical simulations.

11:50-12:10 FrA5.5

Control of Air Flow in Air Heating Set, pp. 1423-1427

Dlapa, Marek — Tomas Bata Univ. in Zlin

The paper deals with the robust control of air-flow in air heating set. The identification is performed using step responses and approximation via second order system. The controller is designed using the structured singular value (SSV or μ) and algebraic approach. Since the cost function is nonconvex the optimization cannot be done using standard tools. Hence an evolutionary algorithm - Differential Migration (DM) is employed yielding good results in this case. The functionality of the controller is verified through experiments on the real plant.

FrA6 — Ariadne

Control Systems (Regular Session)

Chair: Ntogramatzidis, Lorenzo — Curtin Univ.

10:30-10:50 FrA6.1

A Lexicographic Approach to Constrained MDP Admission Control, pp. 1428-1433

Panfili, Martina — "Sapienza" Univ. di Roma,
Pietrabissa, Antonio — Consorzio per la Ricerca nell'Automatica e nelle Telecomunicazio

This paper proposes a Reinforcement Learning-based lexicographic approach to the Call Admission Control (CAC) problem in communication networks. The CAC problem is modeled as a multi-constrained Markov Decision Problem (MDP). To overcome the problems of the standard approaches to the solution of constrained MDP, a multi-constraint lexicographic approach is defined, and an on-line implementation based on Reinforcement Learning techniques is proposed. Simulations validate the proposed approach.

10:50-11:10 FrA6.2

Arbitrary Pole Placement by State Feedback with Minimum Gain, pp. 1434-1438

Schmid, Robert — Univ. of Melbourne
Ntogramatzidis, Lorenzo — Curtin Univ.
Nguyen, Thang — Univ. of Exeter
Pandey, Amit — Department of Electrical and Electronic Engineering

We consider the classic problem of pole placement by state feedback. We offer an eigenstructure assignment algorithm to obtain a novel parametric form for the pole-placing gain matrix that can deliver any set of desired closed-loop eigenvalues, with any desired multiplicities. This parametric formula is then exploited to introduce an unconstrained nonlin- ear optimisation algorithm to obtain a gain matrix that delivers the desired pole placement with minimum gain.

11:10-11:30 FrA6.3

Control Performance Index Minimal Tuning of Set-Point Weighted PID-Controllers for LTI Plants Based on Convex Optimisation, pp. 1439-1444

Esch, Jonas — Univ. of Duisburg Essen
Ding, Steven X. — Univ. of Duisburg-Essen
Weinhold, Nick — IAV GmbH
Schultalbers, Matthias — IAV GmbH

This paper addresses the problem of control performance index (CPI) minimal tuning of proportional integral differential (PID) feed-back-controllers with set-point weighting. Common CPIs, such as the integrated absolute error (IAE), are considered as objective functions to be minimised by parameter tuning. Many CPIs are convex functions, if their domain is convex and thus their only minimum is the global minimum. In order to exploit this for optimal tuning, we formulate parameter tuning as an optimisation problem with controller parameters as variables. Convexity of the IAE as CPI is shown exemplarily, since it can be used for PID-parameter and set-point weight tuning. Furthermore, we show the necessary convexity of the CPI's domain for the fixed structure set-point weight and PID-parameter tuning. For set-point weight tuning, convexity of the domain is shown straight forward from the standard definition of a convex set. For PID-parameter tuning, a convex representation of the domain is found that can be used equivalently to the original domain. To this end, we utilise the fact that CPIs merely quantify input-output behaviour which allows to relax structural constraints. Furthermore, it is shown how readily available iterative algorithms can be used to automate tuning and find the global optimal controller parameters. In a simulation example, the proposed techniques are applied to tune a set-point weighted PI-controller for a first order lag plus delay plant.

11:30-11:50 FrA6.4

Microcontroller Implementation of Digital Fractional Order Controllers for Time Delay Processes, pp. 1445-1450

Both, Roxana — Tech. Univ. of Cluj-Napoca
Muresan, Cristina Ioana — Tech. Univ. of Cluj Napoca
Dulf, Eva Henrietta — Tech. Univ. of Cluj Napoca
Dulf, Francisc-Vasile — Univ. of Agricultural Sciences and Veterinary Medicine

The present work deals with the control of the liquid carbon monoxide level in a cryogenic carbon isotopes separation column. Due to the fact that the cryogenic carbon isotope separation column is a time and cost consuming process, the authors propose a hardware in the loop (HIL) simulation of the closed loop system prior to the actual implementation with, the controller being implemented on a NI PXI-8183 embedded controller from National Instruments and also on a MSP 430 Ultra-Low-Power microcontroller from Texas Instruments while the process is simulated using a personal computer. The designed controller is a PI fractional order controller and is implemented in a Smith-predictor structure, due to the process large time delays. The real time simulation results prove the efficiency of the controller,

suggesting the possibility to use the implemented control structure on the real plant.

11:50-12:10 FrA6.5

Differential Evolution Based Intelligent Control for Speed Regulation of a PMDC Motor, pp. 1451-1456

Hussain, Syed Asim — King Fahd Univ. of Petroleum & Minerals

Abido, Mohammad Ali — King Fahd Univ. of Petroleum & Minerals

Differential Evolution (DE) is an evolutionary algorithm (EA) known for its simplicity, robustness and performance. Compared to other EAs, DE has shown better performance according to recent research. In this paper a DE algorithm is designed for controller optimization of a PMDC motor speed regulation system. Presenting a comprehensive description of the plant, architecture is designed for automatic speed regulation. Then the DE algorithm is applied on the system to optimize the controller parameters. Performance of the optimal controller is studied with simulations and performance and robustness of the DE algorithm has been analyzed.

FrB1 IMPERIAL

Nonlinear Control III (Regular Session)

Chair: Fadel, Maurice — LAPLACE

Co-Chair: Grøtli, Esten Ingar — Norwegian Univ. of Science and Tech.

14:00-14:20 FrB1.1

Nonlinear Observer Design for a Greitzer Compressor Model, pp. 1457-1463

Backi, Christoph Josef — Norwegian Univ. of Science and Tech.

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

Grøtli, Esten Ingar — Norwegian Univ. of Science and Tech.

In this paper two different observers for a nonlinear compressor model have been developed and compared: A nonlinear observer based on a circle criterion design and an Extended Kalman Filter. Both of these observers were implemented together with linear control strategies in order to (surge-)control the nonlinear Greitzer compressor model. The newly developed nonlinear observer is a full state observer providing local asymptotic stability results. Compared to the Extended Kalman Filter, the nonlinear observer showed itself at least equivalent, even superior for open-loop estimation.

14:20-14:40 FrB1.2

Nonlinear Control of a Novel Active Magnetic Bearings Technology Based High-Precision Positioning Stage, pp. 1464-1469

Basovich, Sergei — Ben Gurion Univ.

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

Brand, Ziv — Ben Gurion Univ.

Levi, Nisim — Ben Gurion Univ.

This paper presents modelling and control of a novel positioning stage based on Active Magnetic Bearings (AMB) technology. The stage includes a single moving part levitated and controlled with 6 degrees of freedom by 6 couples of reluctance electromagnetic actuators. The position control of the stage is achieved by simultaneous stabilization of each one of its 6 actuators. The proposed control law is an output feedback nonlinear controller combined with a velocity observer. This observer is based on the concept of approximate differentiation. The main feature of the presented positioning stage is that all 6-DOF are controlled by electromagnetic forces generated by AMB actuators. No other means, such as permanent magnets or mechanical support, are present in order to counteract the payload's weight against gravity.

14:40-15:00 FrB1.3

Compositional Stability of Approximately Symmetric Systems: Initial Results, pp. 1470-1476

Goodwine, Bill — Univ. of Notre Dame

This paper considers nonlinear control systems that are approximately symmetric, and extends some prior work of the author related to stability of symmetric systems to the case where the system is not exactly symmetric. Many engineering systems are composed of components that are nominally identical, but due inherent variability in physical systems, can not be exactly symmetric. By exploiting the baseline symmetric structure of the system and constraining the deviations from exact symmetry, stability results are derived that are independent of the number of components in the system. This paper specifically focuses on the application of LaSalle's Invariance Principle to approximately symmetric systems, which has broad applicability. The main utility of the stability result is one of scalability or compositionality because the main result shows that if the system is stable for a given number of components, under appropriate conditions, stability is then guaranteed for a larger system composed of the same type of components which are interconnected in a manner consistent with the smaller system.

15:00-15:20 FrB1.4

Direct Torque Control – a Solution for Mono Inverter-Dual Parallel PMSM System, pp. 1477-1483

Fadel, Maurice — LAPLACE

Nguyen, Linh — LAPLACE/CNRS/INPT

Ana, Llor — LAPLACE/ENSEEIHT/CNRS

The objective of this paper is to present a Direct Torque Control (DTC) algorithm for controlling system composed by two Permanent Magnet Synchronous Motors (PMSM) operating in parallel, fed by a single power inverter. In this system, it is expected that both motors will get the same speed even if they have different conditions of load torque. The principle of DTC algorithm is considered as follows: The space vector plane is divided into 12 sectors of 30 ° each and four input information are considered, two related to the flux of each machine and two related to the torque. Based on these 16 combinations in 12 different sectors a switching table is proposed to determine the best vector of voltage to be applied by the inverter. Simulation results in Matlab/Simulink indicated that the algorithm (DTC) is well adapted for the synchronism of this system over a wide range of operations.

15:20-15:40 FrB1.5

CLF-Based Nonlinear Control Design for Turbocharged Diesel Engine, pp. 1484-1489

Kuzmych, Olena — Hautes Etudes d'Ingenieur and LAGIS CNRS

Aitouche, Abdel — LAGIS/HEI

In this paper, we propose a Control Lyapunov Function based nonlinear robust controller for turbocharged Diesel engine. The basic idea is to develop inverse optimal control and utilize more general Lyapunov function which provides additional degree of freedom in order to achieve better performance. The obtained controller gain guarantees the global convergence of the Diesel engine system and regulates the flows for the Variable Geometry Turbocharger and Exhaust Gas Recirculation systems in order to optimize oxygen-fuel ratio and intake manifold EGR fraction. Simulation of the control performance based on professional simulator AMESim (LMS) shows the effectiveness of this approach.

FrB2 Imperial 1

Distributed Systems II (Regular Session)

Chair: Barão, Miguel — Inesc-id

14:00-14:20 FrB2.1

Optimizing Mixtures of Dependency Trees with Application to Distributed Probabilistic Control, pp. 1490-1494

Barão, Miguel — Inesc-id

One of the problems in distributed control is that of establishing a communication network topology between the intervening controllers that best suits the closed loop performance of the whole system. In this paper, a particular view of this problem is analysed where the optimal actuation is described probabilistically and assumed to be jointly specified. The main problem is that of finding a topology having pairwise communication links that best approaches a joint distribution of actions at each time instant. The proposed algorithm uses properties of the natural gradient in the manifold of categorical distributions to find a mixture of dependency trees under certain network topology constraints.

14:20-14:40 FrB2.2

LTI Continuous Time Consensus Dynamics with Multiple and Distributed Delays, pp. 1495-1501

Somarakis, Christoforos — Univ. of Maryland, Coll. Park
Baras, John S. — Univ. of Maryland

We study linear time invariant (LTI) continuous time consensus dynamics in the presence of bounded communication delays. Contrary to traditional Lyapunov based methods, we approach the problem using Fixed Point Theory. This method allows us to create an appropriate complete functional metric space and through contraction mappings to establish the existence and uniqueness of a solution of this model. We explore the case of constant as well as distributed delays.

14:40-15:00 FrB2.3

Strict LMI Approach to the Robust Stabilization of Takagi-Sugeno Fuzzy Descriptor Systems, pp. 1502-1506

Bahloul, Mohamed — Univ. of Picardie Jules Verne
El Hajjaji, Ahmed — Univ. de Picardie-Jules Verne
Chaabane, Mohamed — National Engineering school of Sfax, Tunisia
Souissi, Mansour — Engineering school of Sfax, Tunisia

This paper deals with the stability and stabilization problems of uncertain descriptor fuzzy systems described by Takagi-Sugeno (TS) fuzzy models. Sufficient conditions are developed to synthesize the feedback controller based on the so-called Parallel Distributed Compensation (PDC) for nominal and uncertain fuzzy descriptor systems. New design conditions are formulated on strict LMIs terms (Linear Matrix Inequalities) which can be solved easily using Matlab tools. A numerical example is provided to show the effectiveness of the proposed results.

15:00-15:20 FrB2.4

Circular Formation Control Protocols for Dynamic Unicycles Via Hybrid Stabilization of Sets, pp. 1507-1513

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

In this paper, we develop a hybrid control framework for addressing circular formation control protocols for dynamic unicycles using stabilization of sets. The proposed framework develops a novel class of fixed-order, energy-based hybrid controllers as a means for achieving cooperative control formations. These dynamic controllers combine a logical switching architecture with the continuous system dynamics to guarantee that a system generalized energy function whose zero level set characterizes a specified system formation is strictly decreasing across switchings.

15:20-15:40 FrB2.5

Adaptive Rule-Base Fuzzy Logic Power System Stabilizer for a Multimachine System, pp. 1514-1519

Hussein Mohammed, Tawfiq — Univ. of Benghazi
Shamekh, Awad — Univ. of Benghazi

A new type of power system stabilizer based on fuzzy set theory is proposed to improve the dynamic performance of a multi-machine power system. To have good damping characteristics over a wide range of operating conditions, speed deviation and it is derivative of a machine are chosen as the input signals to the fuzzy stabilizer on that particular machine. The paper proposes Adaptation to Rule bases of the designed Fuzzy logic Power System Stabilizer (ARFPSS) to damp inter-area modes of oscillation. The proposed technique is derived as a direct fuzzy logic power system stabilizer. However, the integration steps are restricted to be in the linear area to avoid the problems that may result when the solution has become saturated. The article shows that ARFPSS is more efficient than the Conventional Power System stabilizers (CPSS's) due to its ability to cope with oscillations at different operating points and different fault locations. A bench mark simulation problem of a 4-machine 2-area power system is exploited to demonstrate the performance of the proposed controller compared with standard techniques.

FrB3 — Imperial 2

Computational Intelligence (Regular Session)

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

14:00-14:20 FrB3.1

Observer Based Dissipative Reliable Control for Takagi-Sugeno Fuzzy Systems with Time Delay, pp. 1520-1525

Gassara, Hamdi — Univ. of Picardie Jules Verne
Siala, Fatma — Sfax Univ.
El Hajjaji, Ahmed — Univ. de Picardie-Jules Verne
Chaabane, Mohamed — National Engineering school of Sfax, Tunisia

Abstract—This paper is concerned with the design of −dissipative reliable control for continuous Takagi-Sugeno (TS) fuzzy systems with unavailable states and time-varying delay. The sufficient conditions for the existence of fuzzy observer and the −dissipative reliable fuzzy controller are given in terms of Linear Matrix Inequalities (LMI) which can be solved efficiently by using the LMI optimization techniques. The conditions are obtained by using a free weighting matrix technique (Newton Leibniz formula) without imposing model transformation which reduce the conservatism. The obtained LMI are dependent, not only upon upper bound of time delay, but also on the dissipative margin and on the actuator failure parameter. Furthermore, a more general actuator failure model is adopted in this paper, which covers the typical work status of actuator, i.e. normal operation, partial degradation and outage. The results of Hinfty performance, positive realness and mixed of H1 and positive real performance are easy corollaries of the dissipative result. A numerical example is given in order to demonstrate the effectiveness of our result.

14:20-14:40 FrB3.2

A Supervised Learning Method of Neural Networks in a Non-Linear and Time Depended Control Process, pp. 1526-1531

Papoutsidakis, Michail — Tech. Inst. of Piraeus
Pipe, Tony — Univ. of the West ofEngland, Bristol
Chamilothoris, George — Piraeus Inst. of Tech.

The task of controlling the performance of a pneumatic positioning system has always be and still remains, a challenge for researchers in the area of control. The unpredictable system behavior arises not only from the non linear nature of the system dynamics but also from the existence of energy loses after long term operations. Therefore a huge effort is spent throughout multiple control approaches in order to minimize the position error of a pneumatic piston. In this paper an attempt to achieve highly piston position accuracy is implemented based on a modified artificial neural network technique. The so-called “radial basis function” was applied, improved the response of a real pneumatic rig whilst all experimentation results are recorded in this paper.

14:40-15:00 FrB3.3

Learning Structural Uncertainties of Nonlinear Systems with RBF Neural Networks Via Persistently Exciting Control, pp. 1532-1537

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

This work presents a scheme for learning, on-line, the actual nonlinearities of systems in canonical form. The proposed architecture comprises of an on-line Radial Basis Function (RBF) neural network identifier and a controller, with the signals issued by the latter guaranteeing the satisfaction of a Persistency of Excitation (PE) condition for the RBF regressors employed. As a consequence, the neural network weight estimates are proven to converge to small neighborhoods of their true values; thus succeeding learning the actual system nonlinearities with quality guarantees. Key characteristic is the isolation between identifier and controller design, increasing the robustness level of the proposed on-line learning scheme. Finally, a simulation study is provided to demonstrate its effectiveness.

15:00-15:20 FrB3.4

H1 Fuzzy Networked Control for Vehicle Lateral Dynamics, pp. 1538-1543

Latrach, Chedia — Univ. of Picardie Jules Verne
Kchaou, Mourad — National School of Engineers of Sfax Tunisia
El Hajjaji, Ahmed — Univ. de Picardie-Jules Verne
Rabhi, Abdelhamid — MIS

Abstract—A vehicle dynamics control system (NCS) has been developed in this study for improving vehicle yaw rate dynamics under unreliable communication links with packet dropouts, and network-induced delay which are two typical network constraints of unreliable transmission. The NCS system consists of a fuzzy H1 static output feedback controller. After giving the nonlinear model of the vehicle, a Takagi- Sugeno (T-S) fuzzy model representation is first discussed. Next, based on the Lyapunov krasovskii functional approach and a parallel distributed compensation scheme, the gains of the fuzzy controller are determined in terms of Linear Matrix Inequality (LMI). Simulations have been conducted to evaluate performance of the closed loop system under limitation of the network resources caused by data transmission.

15:20-15:40 FrB3.5

Feedback Design Air-Path Control on a Diesel Engine Based on Takagi-Sugeno Fuzzy Descriptor Systems, pp. 1544-1549

Aguilera-González, Adriana — Univ. of Picardie Jules Verne
Bosche, Jérôme — Univ. of Picardie Jules Verne
El Hajjaji, Ahmed — Univ. of Picardie-Jules Verne
Abidi, Ines — Univ. of Picardie JulesVerne

In this work a Parallel Distributed Compensation (PDC) Fuzzy controller is applied to regulate the intake and exhaust manifold pressures in a four-cylinder diesel engine with Exhaust Gas Recirculation (EGR). The control strategy implements a feedback controller that generates commands to regulate the mass flow rates and to force two internal variables (pressures) to follow the reference. The PDC-Fuzzy controller is based on a structure of the Takagi-Sugeno (TS) Fuzzy descriptor model, which permits to represent adequately the nonlinear multivariable structure of the process taking into account the constraints on inputs and states. The proposed model is based on a transformation of scalar functions that circumvents the difficulties inherent in the nonlinearity. The PDC-Fuzzy controller is designed using new conditions on Linear Matrix Inequalities (LMI) constraints without invertibility of the Lyapunov matrix to guarantee a robust stability of the diesel engine. The performance of the tracking control strategy is tested in simulations on a four-cylinder diesel engine.

FrB4 — Imperial 3

Predictive Control II (Regular Session)

Chair: Peyrl, Helfried — ABB Corp. Res.

14:00-14:20 FrB4.1

Linear Model Predictive Control for the Encirclement of a Target Using a Quadrotor Aircraft, pp. 1550-1556

Iskandarani, Mohamad — Royal Military Coll. of Canada
Givigi, Sidney — Royal Military Coll. of Canada
Rabbath, Camille Alain — Defence Res. & Dev Canada
Beaulieu, Alain — Royal Military Coll. of Canada

Encirclement is a task accomplished by an Unmanned Aerial Vehicle (UAV) in order to maintain awareness and containment of a given target. The aim of the UAV encircling this target is to maintain close proximity at all times. In this paper, the problem of maintaining a circular path around a target is considered and a Linear Model Predictive Control (LMPC) strategy is implemented on a Qball-X4 quadrotor aircraft in order to follow the circular path. A linear model for the two-dimensional movement of the UAV and its respective MP controller has been designed in MATLAB Simulink, simulated in a X-Plane/MATLAB interface and implemented on the actual vehicle in real-time. The results of the LMPC in simulation are compared to those found while implementing the algorithm on a physical platform. The contributions of this paper lay in the implementation of an autonomous Linear MP controller for the encirclement of a stationary target by a Qball-X4 quadrotor.

14:20-14:40 FrB4.2

An Architecture for Solving Quadratic Programs with the Fast Gradient Method on a Field Programmable Gate Array, pp. 1557-1562

Boechat, Marc-Alexandre — ABB Corp. Res.
Liu, Junyi — École Pol. Fédérale de Lausanne
Peyrl, Helfried — ABB Corp. Res.
Zanarini, Alessandro — ABB Schweiz AG - Corp. Res. Center, Segelhofstrasse 1K,
Besselmann, Thomas — ABB Corp. Res.

In this paper, an architecture for the implementation of gradient-based optimisation methods on a Field Programmable Gate Array (FPGA) is proposed. Combining the algorithmic advantages of gradient-based algorithms with the computational strengths of a tailored FPGA implementation allows to solve the quadratic programs occurring e.g. in Model Predictive Control (MPC) applications in the microsecond range. The experimental comparisons show a computational advantage of the proposed FPGA implementation against parallel software versions ranging between one and two orders of magnitude. The proposed FPGA-based solution can broaden the applicability of MPC to problems that were considered out-of-reach till recent years.

14:40-15:00 FrB4.3

Control of Autonomous Underactuated Surface Vehicle in the Presence of Environmental Disturbances, pp. 1563-1568

Przybyla, Mateusz — Poznań Univ. of Tech.
Lakomy, Krzysztof — Poznań Univ. of Tech.
Herman, Przemyslaw — Poznan Univ. of Tech.

This paper presents an output feedback design for a class of underactuated surface vehicles. Besides a standard controller, based on VFO (Vector Field Orientation) method, it consists of ESO (Extended State Observer) which estimates disturbances affecting the system and a partial dynamics decoupling. The estimates are used in a control loop to prevent the impact of environmental forces. The effectiveness of this method is verified with simulation tests.

15:00-15:20 FrB4.4

Freeway Shockwave Control Using Ramp Metering and Variable Speed Limits, pp. 1569-1574

Csikós, Alfréd — Computer and Automation Res. Inst.
Varga, István — Budapest Univ. of Tech. and Ec.
Hangos, Katalin M. — Computer & Automation Rsrch. Inst. of the HungarianAcademyof Science

In this work a novel controller design method is suggested for motorway shockwave management using ramp metering and variable speed limit (VSL) control. The proposed controller has a

feedforward-feedback control structure that is designed for a motorway arterial model. For the feedback design the nonlinear model predictive control is used. The feedforward control is utilized to enhance the operability of the control system to high disturbances. Two different controllers are designed: while controller A uses continuous VSL signs, VSL input values of controller B is chosen from a discrete set. For the latter, a two-step optimization is used to decrease oscillations. The designed controllers are tested in a case study, in which a total traffic breakdown situation is modeled. In the uncontrolled case, the initial perturbation leads to a traffic jam with zero traffic speed, whereas the proposed control design is capable of preventing the congestion.

15:20-15:40 FrB4.5

An Obstacle Avoidance Model Predictive Control Scheme: A Sum-Of-Squares Approach, pp. 1575-1582

Lucia, Walter — Univ. della Calabria
Franze', Giuseppe' — Univ. Degli Studi della Calabria
Muraca, Pietro — Univ. della Calabria

The paper addresses the obstacle avoidance motion planning problem for ground vehicles operating in uncertain environments, i.e. time-varying obstacle scenarios are taken into consideration. By resorting to set-theoretic ideas and sum of squares (SOS) decomposition techniques, a receding horizon control algorithm is proposed for robots modelled by polynomial systems subject to input/state constraints. Sequences of inner ellipsoidal approximations of the exact onestep controllable sets are pre-computed for all the possible obstacle scenarios and then on-line exploited to determine the more adequate control action to be applied to the robot in a receding horizon fashion. The results here proposed are a significant generalization of existing algorithms which are tailored only for linear time invariant plant descriptions. The resulting framework guarantees Uniformly Ultimate Boundedness and constraints fulfilment regardless of any obstacle scenario occurrence.

FrB5 Imperial 4

Image Processing (Regular Session)

Chair: Zingaretti, Primo — Univ. Pol. delle Marche
Co-Chair: Papanikolopoulos, Nikos — Univ. of Minnesota

14:00-14:20 FrB5.1

A Genetic Algorithm for the Construction of Optimized Covariance Descriptors, pp. 1583-1588

Bruyas, Arnaud — CSE, UMN
Papanikolopoulos, Nikos — Univ. of Minnesota

The problem of real-time tracking has been studied widely and many methods in very different fields of application have been developed manipulating image based elements. While all use features as a way to represent a tracked object in the image, naturally, depending on the method and the objects, some features are better than others. As part of the project presented in [1], the goal of this paper is to provide efficient descriptors to perform real-time tracking of children. Covariance descriptors are a common and convenient way to describe an object, since they compile in a single matrix several features and also their statistical interrelationships. This paper introduces a Genetic Algorithm as a way to seek the best combination among a list of features for describing a selected object in a video sequence. The implemented Genetic Algorithm is a Niched Pareto Genetic Algorithm (NPGA), and two different methods of selection/reproduction have been compared; a regular method and one based on a High Elitism process. Reliable results are obtained, since the features combined seem to match the tracked object characteristics, but dissimilarities between the two methods are also highlighted.

14:20-14:40 FrB5.2

Road Pavement Crack Automatic Detection by MMS Images, pp. 1589-1596

Mancini, Adriano — Univ. Pol. delle Marche
Malinverni, Eva Savina — Univ. Pol. delle Marche
Frontoni, Emanuele — Univ. Pol. delle Marche
Zingaretti, Primo — Univ. Pol. delle Marche

The research topic was to test different feature extraction methods to localize road pavement cracks useful to construct a spatial database for the pavement distress monitoring. Several images were acquired by means of a line scan camera that assembled in a Mobile Mapping System (MMS) allows tracking directly the position of the images by a GPS-INS system. Following an automatic digital image processing was performed by means of several algorithms based on different approaches (edge detection and fuzzy set theory). The detected cracks were described with some parameters in relation to some shape characteristics (dimension, typology, direction), which are necessary to recognize the gravity of the road pavement conditions. The edge detection techniques tested in this research allowed identifying fatigue cracking or alligator cracking and also thin linear cracks in images with strong radiometric jumps by applying filters, gradient functions and morphological operators. The snake approach was one of them, in particular the type called Gradient Vector Flow (GVF). Another approach was based on the fuzzy theory. The advantage of this method is that the pixels, necessary to identify the cracks in road pavement, are darker than their surroundings in an image. The last stage was the pavement distress spatial database collection. The Mobile Mapping System (MMS) has allowed localizing the raster data and consequently the vector features of the detected cracks, associating into the table their attributes too. The proposed approaches allow to automatically localize and classify the kind of road pavement crack.

14:40-15:00 FrB5.3

Virtual Simulator for Testing a Vision Based Pose Estimation System for Autonomous Capture of Satellites with Interface Rings, pp. 1597-1602

Velasquez, Andres Felipe — West Virginia Univ.
Marani, Giacomo — West Virginia Univ.
Evans, Thomas — West Virginia Univ.
Napolitano, Marcello — West Virginia Univ.
Christian, John — West Virginia Univ.
Doretto, Gianfranco — West Virginia Univ.

This paper describes the design and the performance of a virtual simulation to evaluate a machine vision based pose estimation system used for the general problem of satellite servicing. The vision system features a wide angle monocular camera to track the interface ring of a non-cooperative satellite using ellipse extraction. The effects of the camera parameters and of the relative camera-satellite position on the system accuracy are evaluated. Different parameters such as resolution, field of view angle, distortion, occlusions and errors in the intrinsic parameters are considered. The study reveals the importance of the availability of such a visual simulation environment for the purpose of mission planning.

15:00-15:20 FrB5.4

A Velocity Field Approach to the Detection of Pedestrian Interactions, pp. 1603-1608

Portelo, Ana I. — INESC-ID
Ricardo, Ribeiro — IST/ISR
Figueiredo, Mario — IT/IST
Lemos, Joao M. — Inesc-id
Marques, Jorge S. — Inst. Superior Técnico

The problem of detecting pedestrian interactions in image sequences is addressed. An extension of the motion field model to account for pedestrian interactions is presented. Pedestrian movements are modelled by a non-linear state model in discrete time, in which the trajectories follow a known field, in the absence of interactions, and include an extra term otherwise. The detection of interactions between pedestrians is reduced to a time varying parameter estimation problem, for which algorithms based on moving horizon estimation with a variable forgetting factor and on a

Kalman filter are compared.

15:20-15:40 FrB5.5

Conversion of Color Documents to Grayscale, pp. 1609-1614

Papamarkou, Iliana Aristotle Univ.
Papamarkos, Nikos Democritus Univ. of Thrace

In this paper, a novel method to convert color documents to grayscale is proposed. This approach takes as criteria that a suitable form of a grayscale document must have locally uniform background, well separated characters from the background and reduced noise. The main stages of the proposed technique are color reduction to a limited number of dominant colors and transformation of the gray classes obtained to a more compact form. The resultant grayscale document gives better OCR results and better compression ratio.

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