23rd Mediterranean Conference on Control & Automation (MED)

MED 2015

Conference Digest

June 16-19th, 2015

Hotel Meliá Costa del Sol, Torremolinos, Spain

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http://www.med-control.org/

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Welcome

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

Welcome to the 2015 Mediterranean Conference on Control and Automation (MED'15)!

This year's MED'15 conference, in Torremolinos, Spain, is the 23rd MED conference. The very first MED took place in 1993 in Chania, Greece and since then the MED has been in Cyprus, Italy, France (Corsica), Croatia, Turkey, Israel, Portugal, Morocco, Spain and several times in Greece (for a complete list of the MED conferences, see www.med-control.org)

The objective of MED has always been to bring 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 is registered in Cyprus as a non-profit organization (see the MCA website at www.med-control.org)

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 www.med-control.org

I hope you do enjoy MED'15 and take full advantage of your stay in Malaga, taking in the sites and also relaxing at the beaches.

In 2016 the 24th MED will go to Athens, Greece and I hope to see you all there as well.

Thank you for your participation and contributions to MED'15

Panos Antsaklis, President

Mediterranean Control Association (MCA)

Message from the Conference Organizing Committee and the International Programme Committee of MED2015

On behalf of the Organizing Committee and of the International Program Committee for the 23th Mediterranean Conference on Control and Automation (MED 2015), it is a great pleasure to welcome you to the conference to be held in Torremolinos (Málaga, Spain) from June 16 to June 19, 2015.

The safety and robust performances of control and automation devices are of great significance, for the protection of human life and health, the environment, and of the vested economic value. The correct functioning of those systems has a profound impact also on production cost and product quality.

All those researcher, academic and practitioners being active in the field are invited to MED 2015 in Torremolinos (Málaga, Spain), to share recent advances in research and applications in the broad area of systems engineering, control and automation. This is an occasion to form and establish networks, to interact with scientists and invited speakers from all over the world and to attend highly qualified scientific sessions.

The conference venue will be just a step from the world-famous beaches of The Costa del Sol and a few minutes from Málaga, a vibrant and charming Mediterranean city that treasures a cultural heritage from 28 centuries and is the birthplace of Pablo Picasso.

The program for MED 2015 Conference includes more than 220 papers in five parallel sessions during three days, with 33 regular sessions and 2 invited sessions. We have selected and appointed three plenary speakers covering different areas of the conference, with the following titles:

- “The art of tuning a PID controller” by Professor Tore Hägglund of Lund University, Sweden.
- “Discrete and fluid Petri nets: dealing with individuals, dealing with populations” by Professor Manuel Silva of Zaragoza University, Spain.
- “Heterogeneous multi robot systems: smaller, smarter, specialized teams” by professor of Georgia Technology Institute, United States.

Altogether, we have proposed a technical program that we hope will cover your expectations. We look forward to your attendance at the MED 2015 events and discussions. See you in Torremolinos, Malaga, Spain.




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Past MED Conferences

22th IEEE Mediterranean Conference on Control and Automation (MED'14)
June 16-19 2014, Universitá degli Studi di Palermo, Palermo, Italy

21th IEEE Mediterranean Conference on Control and Automation (MED'13)
June 25-28 2013, Minoa Palace Resort & Spa, Platanias-Chania, Greece

20th IEEE Mediterranean Conference on Control and Automation (MED'12)
July 3-6, 2012, Catalonia Barcelona Plaza Hotel, 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 CAlos 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, Louise Maleme Beach Hotel, Chania, Crete, Greece

3th IEEE Mediterranean Symposium on Control and Automation (MED'95)
July 11-13 1995, Limassol, Cyprus

2th IEEE Mediterranean Symposium on New Directions in Control and Automation (MED'94)
June 19-21 1994, Louis Maleme Beach Hotel, Chania, Crete, Greece

1th IEEE Mediterranean Symposium on New Directions in Control Theory and Applications (MED'93)
June 21-23 1993, Handris Hotel, Maleme, Chania, Crete, Greece

Topics of Interest

Topics of interest include, but are not limited to:

Adaptive control

Aerospace control

Agent-based systems

Assistive technology

Biologically inspired systems

Bond Graph

Control

Computational intelligence

Computer controlled systems

Computing & communications

Cyber-physical systems

Decentralized control

Discrete event systems

Distributed systems

Process control

Real-time control

Fault diagnosis

Fault tolerant control

Game Theory

Genetic & evolutionary computation

Hybrid systems

Image processing

Industrial automation

Intelligent control systems

Linear systems

Manufacturing

Micro and nano-systems

Modelling & simulation

Neural networks

Networked control systems

Non-linear systems

Optimization

Petri nets

Power systems and Smart Grid

Predictive control

Education & training

Embedded control systems

Renewable energy & sustainability

Robotics

Robust control

Spectral estimation

System Biology

Unmanned systems

Virtual reality

Wireless sensor networks

Human-robot collaboration

Practical Information

Torremolinos - Costa del Sol

The Costa del Sol emerged as an international travel destination in the second half of the twentieth century, when elite tourism –an exclusive activity for a chosen few– was in search for new places. Meanwhile, the industry was broadening and reached more social layers.

The designation or brand name "Costa del Sol" is said to have various origins. It is documented, however, that the name was first used for advertising purposes at the Ibero-American Exhibition held in Seville in 1929. According to some of the sources, it was coined by an Austrian consul living in Cádiz, who often went to Almería along the coast and thus usually travelled across Málaga and Granada. Taking notice of the region's good weather, he called it "Costa del Sol" (Sunny Coast). Some years later, the reference was narrowed down to Málaga Province only.

The history of the Costa del Sol proper begins in Torremolinos with the arrival of George Langworthy, locally known as "The Englishman." Langworthy and his wife settled in the Castle of Santa Clara, which they had bought in the late nineteenth century. The castle would afterwards be converted to residence for foreign citizens.

A few years later, Carlota Alessandri Tettamanzy transformed a property she owned into the Parador de Montemar. The parador was followed by Hotel La Roca. Only a few people would have imagined back then that these first three establishments, drawing guests with weird habits, would be the cornerstone of a world-class tourist hub. The opening of Hotel Pez Espada in 1959 consolidated Torremolinos as a touristy town. Celebrities –especially film stars– could be seen around and their presence attracted both more visitors and the media.

The rise of Torremolinos in the world of tourism had a domino effect. By the late 1960s or early 1970s, the neighbouring towns –Benalmádena, Fuengirola, Mijas– also experienced a travel boom, in part triggered by the Costa del Sol's transformation into a huge film set (about 250 movies were shot until 2005).

A few kilometres west of Torremolinos, a different kind of boom was under way. Alfonso de Hohenlohe, Norberto Goizueta, and José Luque were placing Marbella on the international map. In 1954, Hohenlohe opened Marbella Club, drawing aristocrats, tycoons, and film stars who could come once and again. The final turn was the development of Puerto Banús in the 1960s, whose jetties attracted big yachts and whose marina became the most popular in the Mediterranean, visited by international celebrities coming for lunch, shopping, or leisure.

The growth of the eastern part of the Costa del Sol –most of it included in Axarquía, a region with a clear al-Andalus legacy– was less spectacular but no less important. The best known town in the area, Nerja, became popular after the discovery of a stunning, unusually big cave in the nearby district of Maro in 1959.

Better connected after the development of the Mediterranean highway, the Eastern Costa del Sol is one of the most interesting places to visit in Málaga Province.

In the 50 years that have elapsed since Torremolinos coyly emerged as an international touristy town, the Costa del Sol has learnt how to adjust to the needs of the ceaseless flow of incoming tourists.

Málaga

Málaga was founded by the Phoenicians as Malaka about 770 BC, which make it one of the oldest cities in the world. After a period of Carthaginian rule, it became part of the Roman Empire showing a remarkable degree of development. After the fall of the Western Roman Empire, it was ruled first by the Visigoths and then by the Byzantine Empire (550-621).

During the 8 centuries of Muslim Arabic domination over Spain, the city became an important trade center and it was one of the Iberian cities where the Muslim rule persisted longest, having part of the Emirate of Granada. Málaga was conquered by Christian forces just five years before the fall of Granada.

In the 19th century, Málaga was one of the two most industrialized cities of Spain. In the second half of XXth century Málaga, Torremolinos, Marbella and the rest of the Costa del Sol enjoyed the highest growth of the tourism sector in Spain.

The archaeological remains and monuments from the Phoenician, Roman, Arabic and Christian eras make the historic center of the city an “open museum”, displaying its rich history of more than 3,000 years.

Nowadays the most important business sectors in Málaga are tourism, construction and technology services, but other sectors such as transportation and logistics are extended too. The Andalusia Technology Park has enjoyed a relevant growth since its inauguration in 1992.

Conference Venue

The Event will be held in Hotel Meliá Costa del Sol. This resort is located in Torremolinos where the visitors will enjoy the environment of the Costa del Sol and its beaches. In addition to this, Meliá Costa del Sol is the best option for unwinding, having fun and working in Malaga, thanks to its excellent location, its complete and comfortable facilities and its superb service.

The fantastic Convention Centre is equipped with the latest technology and has the most modern audiovisual equipment. In this way, the Convention Centre has 11 meeting and banqueting rooms all with natural light and a capacity for up to 600 people, demonstrating that Meliá Costa del Sol is the perfect place for any type of event. Regarding the facilities and other installations, the hotel provides 538 rooms and suites with stunning sea views; different dining spaces (Restaurant, Gastrobar and Lobby Bar); an outdoor pool overlooking the sea surrounded by gardens; a Thalasso Spa; mini gym open 24 hours a day; free high speed WiFi internet; Internet Corner and parking. Moreover, the hotel is just 10 minutes from the Malaga Airport and 15 min from the Ave Malaga/ Maria Zambrano train station.

How to get to the Hotel

The excellent location of Málaga Province and Costa del Sol, plus the effective road infrastructure make it esay to access them by air, by road or by rail (coordinates 36°37'15.3"N 4°29'46.2"W).

By plane

The Málaga-Costa del Sol Airport is one of the most important in Spain and has connections to major cities worldwide. Located just 8 miles from downtown and well connected with Costa del Sol. It is renowned for its modern terminals and extensive shopping areas. Málaga airport receives around 13 million passengers a year, making it the gateway to Andalusia. Currently, more than 60 airlines use its facilities. The airport website indicates flight schedules and connections.

The airport-city railway connections: The C1 line connects the airport to the city centre Torremolinos in 10 minutes. The airport stop is at Terminal 2. Frequency: every 20 minutes. First train (from Málaga) at 5.23 a.m./ Last train at 23.33 p.m. You can find all information in RENFE Cercanías.

By train

Málaga's María Zambrano Station is one of the most important Southern Spain railway communication hubs. In fact, Málaga is connected to Spain's major cities through the Spanish High Speed (AVE) network. Its central location and excellent communications with other forms of transport makes Málaga Station an important departure and arrival point when planning a visit to the city. Málaga Maria Zambrano Central Station is connected with the principal Málaga

towns and all its services are managed by the company RENFE (National Railway Service). In this way, the C1 line connects the Málaga Maria Zambrano Station to the city centre Torremolinos in 19 minutes. Frequency: every 20 minutes. Information: +34 902 24 02 02

By road

Access from the north is along the A-45 motorway (Antequera-Málaga), which links up with the A-92 motorway that crosses the Andalusian Region. The highways from the north of Spain join this motorway.

Torremolinos is located on the route of national road N-340 (Highway of the Mediterranean), the A-7 (Mediterranean Motorway) and the AP-7 motorway. You can get from Cadiz (west) or Malaga (east). In both cases, to get to the city, take exits marked as Torremolinos center or Torremolinos convention center.

Taxi information

Airport taxi ranks: Terminal 3 Floor 0. Arrivals

Radiotaxi tel. no.: +34 952 04 08 04

Unitaxi tel. no.: +34 952 33 33 33

The taxi fare from the airport to the hotel Meliá Costa del Sol is approximately 18€

Reception & Registration Desk

The reception desk will be located at the Congress and Convention Centre of Hotel Meliá Costa del Sol, Paseo Marítimo, 11. 29620 Torremolinos (see Site Map).

The opening hours will be the following:

- Tuesday 16th June from 08:30 to 20:30
- Wednesday 17th June from 08:30 to 19:00
- Thursday 18th June from 09:30 to 19:00
- Friday 19th July from 09:30 to 13:00

Oral Session Room Facilities

Every room will be provided with a multi-media LCD projector and a desktop computer with MS Office. Electricity will be supplied at 220 V, 50 Hz AC through standard European sockets.

Internet Facilities

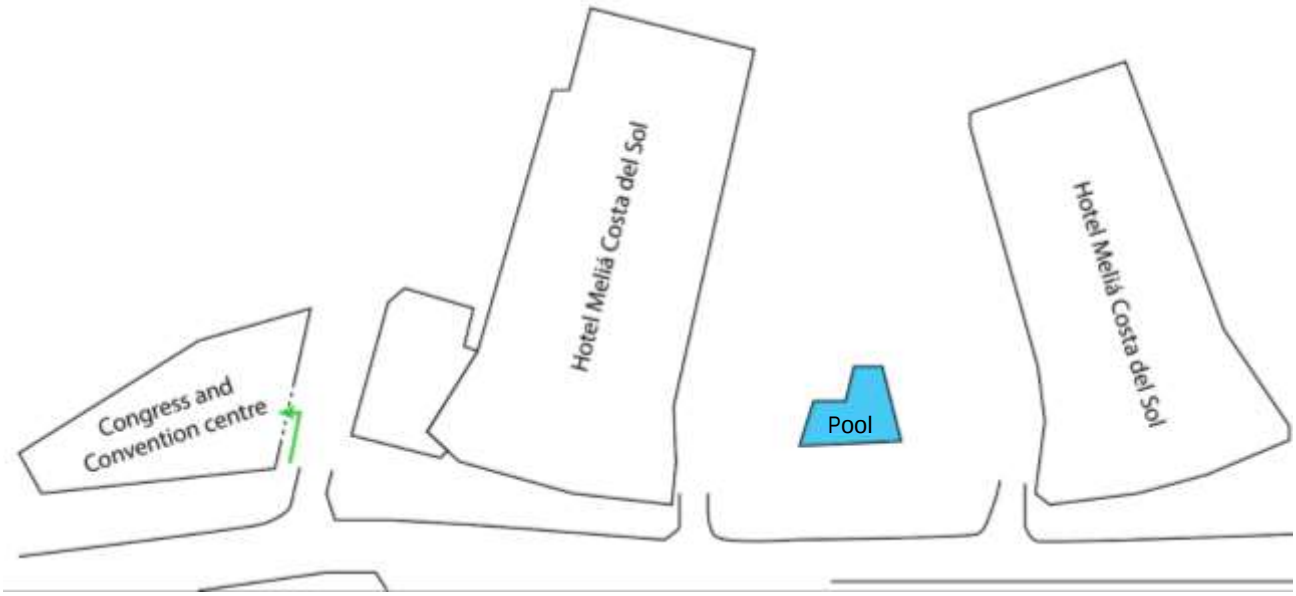
Free wireless connection will be available in the Congress and Convention Centre for participants during the days of the Conference. Wi-fi name:CONVENTION CENTER and password: MELIACENTER

Lunch Facilities

The registration fee includes light lunches for the three days of the Conference (17th, 18th and 19th of June). Lunches, as well as coffee breaks, will be served at the Salón Mediterraneo, located in Congress and Convention Centre (floor 1).

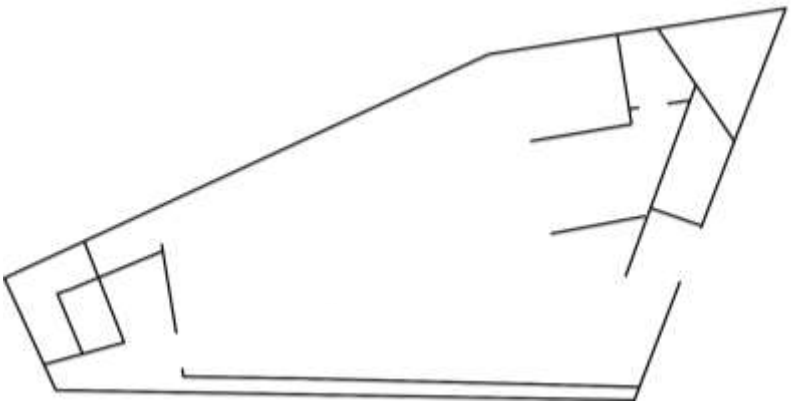
Site Map

Hotel Meliá Costa del Sol and Congress and Convention Centre

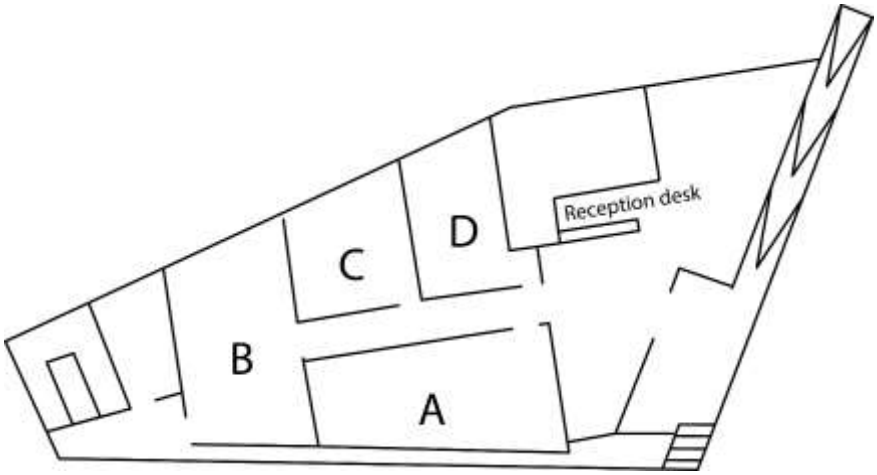


Congress and Convention Centre

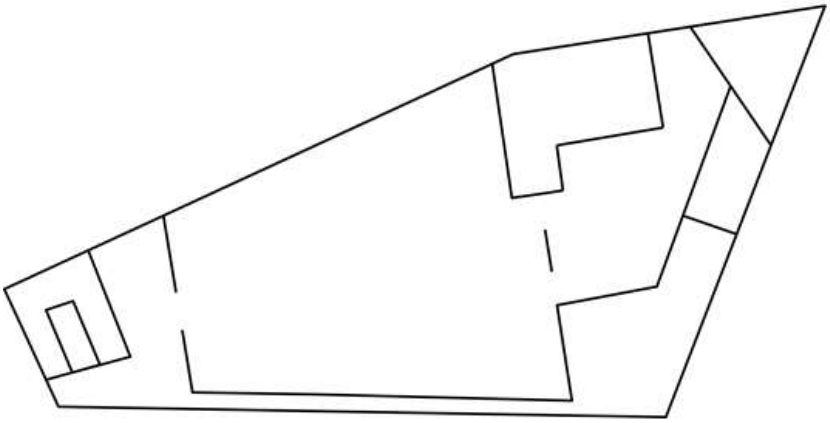
Floor -1: Salón Málaga



Floor 0: Salón Torremolinos and Reception Desk



Floor 1: Salón Mediterraneo



Welcome Reception: Outdoor pool of the Hotel Meliá Costa del Sol.

Opening Ceremony, Plenary Sessions: Salón Málaga.

Regular and Invited Sessions: Salón Torremolinos A, B, C, D and Salón Málaga

Workshop and Tutorial: Salón Torremolinos A

Registration Desk: Salón Torremolinos hall

Coffee breaks and lunches: Salón Mediterráneo

Social Programme

Welcome Reception

There will be a welcome cocktail in the outdoor pool of the Hotel Meliá Costa del Sol on Tuesday 16th June from 20:30 to 21:30.

Conference Banquet

There will be a bus for the Conference Banquet on Thursday evening 18th June. Buses will depart from the main entrance of the Hotel Meliá Costa del Sol at 20.00. It will start at about 21:00. After the banquet, at around 23:30, buses will depart back to the Hotel Meliá Costa del Sol.

The Conference Banquet is included in the full registration fee. Extra tickets will be available on sale in the registration desk (75€/person).

The Conference Banquet will be held at the Automobile Museum of Malaga. It is located in an emblematic building, the Old Tobacco Factory called “La Tabacalera”.

The construction began in 1923 and finished in the 1927. The manufacture of tobacco in these facilities stopped in 2002, and in 2004 Málaga Town Hall took over the building and renovated it to become a cultural complex.

The museum consists of 6,000 square meters that show the history of the automobile and all its evolution from the late nineteenth through the twentieth century and the beginning of XXI but approaching a new concept: the automobile as a work of art. It is the only museum in the world with the following characteristics: a permanent collection of vehicles, more than 300 vintage hats and art works conceived from motor pieces, as the customized engine room, created exclusively for this collection and the new fashion exposition Maga Sublime Collection.

The exposition belongs to Joao Magalhaes, a Portuguese businessman, so it is a private exhibition with a single owner. The museum is divided into thirteen thematic areas: Belle Epoque, 20s, Popular Cars, 30s, Design Cars, The Fashion Corner, Dream Cars, Alternatives Energies, English Tradition, the Engine Room, 50s, Tuning and Maga Sublime Collection. And very important: most of the cars in the collection work. Fashion, art and design in all its splendor!

Address: Edificio Tabacalera.
Avenida Sor Teresa Prat, 15.
29003, Málaga.

***Phone*:** +34 951 13 70 01
Free Parking

GPS coordinates: 36’699666,-4’439643
Web: www.museoautomovilmalaga.com

Technical Programme

Workshops - Tutorials

One workshop and one tutorial have been programmed on Tuesday 16th.

Workshop title: *Interactive Aerial Robots*

Proposed by: *Dr. Guillermo Herdia* and *Dr. J. Ramiro Martínez-de Dios* (University of Seville, Spaing).

Organised by: *SEIDROB* (www.sedirob.es)

Room: Salón Torremolinos A

Abstract: Aerial robotics has experienced a significant development in the last years. Many application functionalities such as surveillance, mapping, and target tracking have been developed. Aerial robots have been integrated as component in more complex systems which requires enhancing their capability for interaction.

In the last decade aerial robots have been integrated for cooperation with sensor networks or other aerial, ground or marine robots for tasks such as detection, monitoring, tracking in applications such as environmental analysis, search and rescue or frontier surveillance, among many others. Recently, new applications that involve physical interaction with objects in the environment have been developed including load transportation and deployment by means of one or several robots, remote inspection by contact, structure construction, and cooperative assembly and manipulation by several aerial robots. However, several problems remain opened and require further scientific and technological efforts to allow the adoption of these robotic systems in real industrial applications.

This workshop is devoted to aerial robots interacting with other robots, sensor networks or with objects in the environment. The workshop will present scientific and technological results and facilitate discussion on technology gaps and research directions.

Schedule:

09:00-09:10	**Welcome and Presentation**
09:10-09:50	**"Aerial robots: From physical interactions to aerial robotic manipulation"** **Anibal Ollero, Universidad de Sevilla and Scientific Advisor of FADA-CATEC (Spain)**
09:50-10:30	**"Cooperation between aerial robots and unmanned underwater vehicles"** **Joao Soussa, University of Porto (Portugal)**
10:30-11:00	**Pause**
11:00-11:40	**"Cooperative multi robot aerial systems: applications and control" Tin Muskardin, DLR (Germany)**

11:40-12:20	**"Visual servoing for aerial manipulation" Vincenzo Lippiello, Università di Napoli (Italy)**
12:20-13:00	**"UAS-WSN cooperation for data collection in large environments" J. Ramiro Martinez-de Dios, Universidad de Sevilla (Spain)**
13:00-13:25	**Discussion with short presentations by attendants**
13:25-13:30	**Conclusions and Closing**

Targeted Audience: The Workshop is suitable for researchers and practitioners from academia, government, and industry interested in the research topics related to the free flying robots interacting with the environment, other robots or sensor networks and their potential technology transfer and applications to inspection, assembly, structure construction, and space.

Tutorial title*: Quantitative Feedback Control and Reset Control: Fundamentals and Applications*

Proposed by: *Prof. Alfonso Baños* (University of Murcia, Spain).

Room: Salón Torremolinos A

Abstract: *Quantitative Feedback Theory* (QFT) is a well-established robust control design framework that has been developed by a number of researchers around the seminal works of Isaac M. Horowitz (1920-2005). After pioneering frequency domain control design for uncertain systems in the 1960s, the first stone of QFT appears in 1972 as the result of a fruitful collaboration with Marcel Sidi. In this work, mainly focused on single input-single output, linear, and time invariant uncertain systems, Nichols chart (NC) first appears to be instrumental in the uncertainty representation (templates), as well as in the modeling of stability and performance specifications (boundaries). As a result, the robust control design problem is stated as a nominal loop gain shaping problem: minimization of the high frequency gain restricted to the frequency response to avoid forbidden regions of NC as defined by boundaries. A large number of works by researchers over the world, and mainly led by Isaac M. Horowitz that kept active for all his life, has extended QFT to cope with a variety of robust control design problems, including multiple-inputs multiple-outputs systems, nonlinear and time-varying systems, systems with hard nonlinearities (amplitude and rate saturation), multi-loop systems, etc. In addition, since its origins QFT has been successfully applied in control practice, solving hard control problems in which the robustness/performance interplay is especially relevant. Experimental applications can be found in many engineering areas including aerospace, naval, chemical, automotive, civil, energy, etc.

Reset control systems trace back to the seminal work of Clegg in 1958, that introduced a nonlinear integrator that sets its output to zero whenever its input is zero. Almost two decades later, two works led by Horowitz propose design methods to incorporate a Clegg integrator (CI), and also a first order reset element (FORE), into a control loop. In the late 90s, the term reset controller is first coined in the works led by Hollot and Chait to describe a linear and time invariant system with mechanisms and laws to reset their states to zero, being the main motivation its use for overcoming fundamental limitations of linear and time invariant (LTI) control systems. Since reset controller dynamics is a combination of time and event based dynamics, it is not surprising that in the last decade different impulsive/hybrid dynamical system formulations were used for modeling and analysis of reset control systems. There are two main frameworks that have been successfully used for modeling reset control systems: the framework of impulsive dynamical systems (IDS), and the framework of hybrid inclusions (HI).

Tutorial scope: The tutorial will be focused on single-input single-output systems, and will introduce basic concepts as well as control systems analysis and design methods, with emphasis in control practice but showing solid mathematical basis. The tu- torial will be developed (tentatively) in two 50 min. sessions, with the following schedule:

QFT for LTI systems.

- Uncertainty representation (templates)

- Design specifications: robust stability and performance (boundaries)
- Two-degrees of freedom feedback control systems
- Loop gain shaping: from manual to automatic procedures
- Precompensator design
- CADCS Tools and Applications

QFT for nonlinear and time-varying systems.

- ”Equivalent” LTI systems and disturbances sets
- Design validation through Schauder fi point theorem
- Stability and Performance analysis
- Case study

Reset control systems: an IDS approach.

- Overcoming LTI fundamental limitations
- Resetting law: zero-crossing, sector-based, reset band, and more.
- Well-posedness, Zeno solutions and time regularization
- Stability Analysis with stable and unstable base system
- A QFT approach to reset control design
- The PI+CI compensator
- Case study

Schedule:

16:00-16:50	**Part I. QFT and Reset Control**
16:50-17:00	Pause
17:00-17:50	**Part II. QFT and Reset Control**

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Program at a Glance

MED 2015 Technical Program Wednesday June 17, 2015

Track T1	Track T2	Track T3	Track T4	Track T5
09:00-09:30 WeOpO Salón Málaga Opening Ceremony				
09:30-10:30 WePL Salón Málaga Prof. Tore Hägglund. the Art of Tuning a PID Controller				
10:30-11:00 WeAMCoffee_Break Salón Mediterráneo				
11:00-13:00 WeAT1 Salón Málaga Uav Guidance and Control Applications	11:00-13:00 WeAT2 Salón Torremolinos A Adaptive Control	11:00-13:00 WeAT3 Salón Torremolinos B Automative Control	11:00-13:00 WeAT4 Salón Torremolinos C Biomedical Engineering	11:00-13:00 WeAT5 Salón Torremolinos D Fault Diagnosis I
13:00-14:30 WeLunch_Break Salón Mediterráneo				
14:30-16:30 WeBT1 Salón Málaga On Robust and Fault Tolerant Control of Nonlinear Systems	14:30-16:30 WeBT2 Salón Torremolinos A Process Control I	14:30-16:30 WeBT3 Salón Torremolinos B Robotics I	14:30-16:30 WeBT4 Salón Torremolinos C Power Systems and Smart Grid I	14:30-16:30 WeBT5 Salón Torremolinos D Fault Diagnosis Ii
16:30-17:00 WePMCoffee_Break Salón Mediterráneo				
17:00-19:00 WeCT1 Salón Málaga Predictive Control	17:00-19:00 WeCT2 Salón Torremolinos A Linear Systems	17:00-19:00 WeCT3 Salón Torremolinos B Modelling and Simulation	17:00-19:00 WeCT4 Salón Torremolinos C Power Systems and Smart Grid Ii	17:00-19:00 WeCT5 Salón Torremolinos D Nonlinear Control

MED 2015 Technical Program Thursday June 18, 2015

Track T1	Track T2	Track T3	Track T4	Track T5
09:30-10:30 ThPL Salón Málaga Prof. Manuel Silva. Discrete and Fluid Petri Nets: Dealing with Individuals, Dealing with Populations				
10:30-11:00 ThAMCoffee_Break Salón Mediterráneo				
11:00-13:00 ThAT1 Salón Málaga Process Control Ii	11:00-13:00 ThAT2 Salón Torremolinos A Nonlinear Systems	11:00-13:00 ThAT3 Salón Torremolinos B Aerospace Control	11:00-13:00 ThAT4 Salón Torremolinos C Robust Control I	11:00-13:00 ThAT5 Salón Torremolinos D Unmanned Systems I
13:00-14:30 ThLunch_Break Salón Mediterráneo				
14:30-16:30 ThBT1 Salón Málaga OPTIMIZATION	14:30-16:30 ThBT2 Salón Torremolinos A Image Processing	14:30-16:30 ThBT3 Salón Torremolinos B Renewable Energy and Sustainability	14:30-16:30 ThBT4 Salón Torremolinos C IDENTIFICATION	14:30-16:30 ThBT5 Salón Torremolinos D Unmanned Systems Ii
16:30-17:00 ThPMCoffee_Break Salón Mediterráneo				
17:00-19:00 ThCT1 Salón Málaga Discrete Events and Automation	17:00-19:00 ThCT2 Salón Torremolinos A Real-Time Control	17:00-19:00 ThCT3 Salón Torremolinos B Wireless Networks and Communications	17:00-19:00 ThCT4 Salón Torremolinos C Intelligent Control	17:00-19:00 ThCT5 Salón Torremolinos D Agent-Based Systems

MED 2015 Technical Program Friday June 19, 2015

Track T1	Track T2	Track T3	Track T4	Track T5
09:30-10:30 FrPL Salón Málaga Prof. Magnus Egerstedt. Heterogenous Multi Robot Systems: Smaller, Smarter, Specialized Teams				
10:30-11:00 FrAMCoffee_Break Salón Mediterráneo				
11:00-13:00 FrAT1 Salón Málaga Distributed Systems	11:00-13:00 FrAT2 Salón Torremolinos A Robotics Ii	11:00-13:00 FrAT3 Salón Torremolinos B Bio-Inspired Systems	11:00-13:00 FrAT4 Salón Torremolinos C Robust Control Ii	11:00-13:00 FrAT5 Salón Torremolinos D Education and Training
13:00-14:30 FrLunch_Break Salón Mediterráneo				

Plenary Sessions

Plenary Session title: The Art of Tuning a PID Controller

by Tore Hägglund (Lund University, Sweden)

Date: Wednesday 17th June 2015
Time: 9:30-10:30
Room: Salón Málaga

In industry, PID controller tuning is often viewed as an art that only few engineers master. Except for the on/off controller, the PID controller is the simplest controller one can imagine. It is also by far the most common controller in industry. There are numerous methods to tune the parameters of the controller proposed and published in the literature. In spite of this, many PID controllers are badly tuned or even not tuned at all. Why is it so? This question is the topic of the presentation that also will propose remedies to improve the situation.

A major reason for the situation is that there simply are so many controllers to tune in a process control plant. The instrument engineers have just not enough time to keep all controllers well-tuned. This fact has become even more evident in recent years due to the trend of reducing the personnel in process control plants. There are, however, many other reasons. There are several aspects that should be taken into account when tuning a PID controller. The closed-loop system should behave well with respect to set point changes, load disturbances, and measurement noise. It must also be robust to process variations, since most processes are nonlinear. Very few design methods take all these aspects into account, especially not simple ones. The many aspects and the fact that the specifications vary from case to case make the PID controller tuning a trade-off problem, where the trade-off has to be made by the engineers.

Set point changes can be treated using feed forward or set point weighting. Therefore, it is suggested that set point changes are excluded from the trade off and not considered in the first phase of the design. If load disturbances are measurable, feed forward can be used also in these cases, but there are often additional load disturbances that are not measurable. Therefore, it is suggested that the controllers are tuned with the goal to optimize the performance at load disturbances, and that requirements on robustness are introduced as constraints in this optimization. The constraints may act as tuning knobs that give the engineer the possibility to influence the tradeoff between performance and robustness.

Measurement noise has only recently been taken into account in PID controller tuning. This may be one reason why the derivative part is so seldom used in practice. It is difficult to take the noise into account without knowledge of the noise characteristics, but it is suggested that the filter in the PID controller is tuned so that it is as effective as possible in reducing the control signal variations due to noise, but with a limited reduction of the control performance at load disturbances.

Finally, it should be remarked that even a good design method will not solve the problem that the engineers have very limited time to spend on the controller tuning. Therefore, the presentation ends with a discussion about automatic tuning procedures, and how these should be developed to meet the demands and be accepted and used more extensively in industry.

Tore Hägglund received his M.Sc. in engineering physics in 1978 and his Ph.D. in automatic control in 1984, both from Lund Institute of Technology, Sweden, where he is currently a professor. During the PhD studies he also developed the relay auto-tuner for automatic tuning of PID controllers together with Professor Karl Johan Åström. The method got patented and is now implemented in many industrial products. Between 1985 and 1989 he worked for Alfa Laval Automation (now ABB) on the development of industrial adaptive controllers. He is a coauthor of Advanced PID Control and Process Control in Practice.

He is author or coauthor of 10 books, 6 book contributions, and more than 115 journal and conference papers. He holds 6 patents and has received along his research career several distinctions and awards, such as the awards from "Innovation Cup" in 1985 (Automatic tuning), 1989 (Deadtime compensator), 1993 (Oscillation detection), 1997 (Detection of conservative tuning), and 1999 (Ratio controller). Furthermore, he has received also the Raymond D. Molloy Award from ISA for being a best-selling author in 2007.

His current research interests are in the areas of process control, tuning and adaptation, and supervision and detection.

Plenary Session title: *Discrete and Fluid Petri Nets: Dealing with Individuals, Dealing with Populations*

by *Manuel Silva* (University of Zaragoza, Spain)

Date: Thursday 18th June 2015
Time: 9:30-10:30
Room: Salón Málaga

Discrete Event Systems (DES) theory and engineering is mainly driven by needs raised by many different human-made systems (manufacturing, communications, logistic, workflow management, traffic, etc.). With the accelerated increase in complexity and size of the new technological constructions, the so called state explosion problem in DES analysis and synthesis becomes more and more acute. Two traditional conceptual and complementary means to deal with the derived computational complexities are structural techniques (which try to apply in different forms the classical divide and conquer aphorism) and fluid relaxations (natural variables of the DES are transformed into the non-negative reals). In the second case, the expected computational gains will be at the expense of the fidelity of the relaxed model and of the analyzability of certain properties.

This lecture will mainly focus on the second line. First, fluidization will be introduced and the legitimization of the hybrid and continuous approximation (both stochastic and deterministic) will be addressed. As a key advantage, the larger the population, the better is usually the approximation while the computational costs may decrease in an exponential way. Obviously, the relationship between the untimed and timed properties of the DES model and the corresponding properties of their continuous approximations is a very important issue. Moreover, the question of expressive power of the obtained formalisms – here in the Petri nets paradigm– will be raised. Together with the simulation of Turing machines (thus, presence of undecidabilities), the possibility of modelling complex and counterintuitive behaviors, as non-monotonicities, orbits or limit cycles and bifurcations due to the loss of hyperbolicity will be briefly pointed out. Finally, a broad perspective of the life-cycle of systems will be provided, and control, observation, diagnostic and implementation issues would be briefly considered.

Manuel Silva is an Industrial–Chemical Engineer (Univ. of Seville, 1974), he received the postgraduate (1975) and Ph.D. (1978) degrees in Control Engineering (INP de Grenoble). From 1975 to 1978 he worked for the CNRS at the Laboratoire d'Automatique de Grenoble. In 1978 he started the group of Systems Engineering and Computer Science at the University of Zaragoza (UZ).

His main research interests did include modeling, validation, performance evaluation, control and implementation of distributed concurrent systems using Petri Nets. He is author of the book Las Redes de Petri en la Automática y la Informática (AC, 1985; also Thomson-AC, 2002), coauthor of Practice of Petri Nets in Manufacturing (Chapman & Hall, 1993), and coeditor of Control of Discrete-Event Systems: Automata and Petri-Net Perspectives (Springer, 2013). Member or past member of the Steering Committees of the Int. Conf. on Application and Theory of Petri Nets, of the Workshops on Discrete Event Systems, and of the IFAC Int. Conf. on Analysis and Design of Hybrid Systems, was founder member of the Asociación Española de Robótica.

Prof. Silva was dean of the Centro Politécnico Superior (UZ) from 1986 to 1992, and president of the Aragon's Research Council and of the Research and Innovation Committee of the French–Spanish Comisión de Trabajo de los Pirineos (1993-1995).

Interested in the History of Technology, is the editor of Técnica e Ingeniería en España (in Spanish: http://www.raing.es/es/publicaciones/libros/colecci-n-t-cnica-e-ingenier-en-espa; some 6.000 pages edited). Prof. Silva has been distinguished with a medal from the city of Lille (France) and by the Association of Telecommunication Engineers of Aragón. He is Honoris Causa Doctorate by the University of Reims-Champagne-Ardennes, member of the Royal Academy of Engineering of Spain, and member of the Royal Academy of Sciences of Zaragoza.

Plenary Session title: *Heterogeneous Multi Robot Systems: Smaller, Smarter, Specialized Teams*

by *Magnus Egerstedt* (Georgia Institute of Technology, USA)

Date: Friday 19th June 2015
Time: 9:30-10:30
Room: Salón Málaga

Biology has served as a rich source of inspiration when developing coordination and control strategies for distributed multi-agent systems, with algorithms derived from schooling fish or flocking birds having found their way into formation control strategies. However, as the cognitive ability of the animals increases, the team sizes tend to go down, with more specialized, heterogeneous roles emerging among the members of the team. In this talk, we investigate how heterogeneity can be formally understood in the context of control of multi-robot systems, present some initial findings as to why heterogeneous solutions are better than homogeneous ones, as well as discuss a number of open problems.

Magnus Egerstedt is the Schlumberger Professor in the School of Electrical and Computer Engineering at the Georgia Institute of Technology, where he serves as Associate Chair for Research and External Affairs. He received the M.S. degree in Engineering Physics and the Ph.D. degree in Applied Mathematics from the Royal Institute of Technology, Stockholm, Sweden, the B.A. degree in Philosophy from Stockholm University, and was a Postdoctoral Scholar at Harvard University. Dr. Egerstedt conducts research in the areas of control theory and robotics, with particular focus on control and coordination of complex networks, such as multi-robot systems, mobile sensor networks, and cyber-physical systems. Magnus Egerstedt is the Deputy Editor-in-Chief for the IEEE Transactions on Network Control Systems, the director of the Georgia Robotics and Intelligent Systems Laboratory (GRITS Lab), a Fellow of the IEEE, and a recipient of the ECE/GT Outstanding Junior Faculty Member Award, the HKN Outstanding Teacher Award, the Alum of the Year Award from the Royal Institute of Technology, and the U.S. National Science Foundation CAREER Award.

Technical Program for Wednesday June 17, 2015

WeAT1	Salón Málaga
Uav Guidance and Control Applications (Invited Session)	
Organizer: Olivares-Mendez, Miguel A.	SnT - Univ. of Luxembourg
Organizer: Shin, Hyo-Sang	Cranfield Univ

11:00-11:20 WeAT1.1

A Proposal of Methodology for Multi-UAV Mission Modeling (I), pp. 1-7

Roldán, Juan Jesús (Centre for Automation and Robotics (UPM-CSIC)), Del Cerro, Jaime (Centre for Robotics and Automation UPM-CSIC), barrientos, antonio (Univ. Pol. De Madrid)

The emergence of multi-UAV missions poses a set of challenges. The control and monitoring of these missions requires to increase the autonomy of fleets and to reduce the workload of operators. The development of an appropriate mission model is fundamental not only for specification and planning but also for control and monitoring. This model allows determining the mission and fleet states and, therefore, providing the operator with adequate information of the mission. This paper poses a methodology to develop multi-UAV mission models and analyzes different modeling techniques, such as Petri nets or hidden Markov models.

11:20-11:40 WeAT1.2

Task-Priority Based Task Allocation of Multiple UAVs with Resource Constraints (I), pp. 8-13

Shin, Hyo-Sang (Cranfield Univ), Tang, Biwei (Northwestern Pol. Univ), Zhu, Zhanxia (Northwestern Pol. Univ), Tsourdos, Antonios (Cranfield Univ)

We propose a task allocation approach that combines the task's priority with a two-stage coalition formation algorithm in the context of multiple UAVs attacking multiple tasks. During the stage of forming a coalition for a task, the resource constraint of the coalition and resource depletion of a UAV are taken into consideration. When multiple UAVs are assigned to attack a complex task, it is reasonable to require those UAVs to simultaneously arrive at the task. In this paper, we develop a simultaneous arrival mechanism based on Dubins curves. Finally, we have conducted some simulation experiments to investigate the flexibility and applicability of the proposed approach.

11:40-12:00 WeAT1.3

Vision Based Fuzzy Control Autonomous Landing with UAVs: From V-REP to Real Experiments (I), pp. 14-21

Olivares-Mendez, Miguel A. (SnT - Univ. of Luxembourg), Kannan, Somasundar (Univ. of Luxembourg), Voos, Holger (Univ. of Luxembourg)

This paper is focused on the design of a vision based control approach for the autonomous landing task of Vertical Take-off and Landing (VTOL) Unmanned Aerial Vehicles (UAVs). Here is presented the setup of a simulated environment developed in V-REP connected to ROS, and its uses for tuning a vision based control approach. In this work, a Fuzzy control approach was proposed to command the UAV's vertical, longitudinal, lateral and orientation velocities. The UAV's pose estimation was done based on a vision algorithm and the knowledge of the landing target. Real experiments with a quadrotor landing in a moving platform are also presented.

12:00-12:20 WeAT1.4

A Guidance Reconfiguration Strategy to Handle Aileron Actuator Fault (I), pp. 22-27

Shin, Hyo-Sang (Cranfield Univ), Lo, Chang How (Cranfield Univ), Tsourdos, Antonios (Cranfield Univ)

Actuator faults reduce the amount of control authority remaining in the UAV system which may impact its ability to follow a particular path profile required to successfully complete its mission. Fault tolerant guidance may be deployed to enhance the mission success rate when fault tolerant control may not be sufficient alone. This paper proposes a method of reconfiguring guidance to accommodate the degraded system's aileron capability, based on the severity of the fault and the desired path's profile acceleration demand. Using both the path planner and path following algorithms parameters, the proposed method provides an additional degree of freedom in design to allow for more flexibility in the handling of the fault. Simulations using an Aerosonde UAV model show the proposed method is able to improve on the guidance path tracking performance when a large stuck aileron fault occurs.

12:20-12:40 WeAT1.5

Optimal Conflict Resolution for Multiple UAVs Using Pseudospectral Collocation (I), pp. 28-35

Vera, Santiago (Univ. of Seville), Cobano, Jose Antonio (Univ. of Seville), Alejo, David (Univ. of Seville), Heredia, Guillermo (Univ. of Seville), Ollero, Anibal (Univ. De Sevilla)

This paper presents an optimal conflict resolution method for multiple unmanned aerial vehicles based on pseudospectral collocation which solves numerically optimal control problems by using non-linear programming. The trajectory of each aerial vehicle is defined by a set of waypoints and the time of arrival at each waypoint. The maneuvers allowed to solve the conflicts are the changes of speed of each aerial vehicle. A novel aspect is the application of this kind of methods to multiple aerial vehicles. The main characteristic of the method is the low execution time in the addressed problem. Moreover, the scalability of the proposed method is studied and the execution time is compared with another optimal solver. Several simulations in different scenarios are performed to test the behavior of the method.

12:40-13:00 WeAT1.6

Multi-UAV Ground Control Station for Gliding Aircraft (I), pp. 36-43

del Arco, Juan Carlos (Univ. De Sevilla), Alejo, David (Univ. of Seville), Arrue, B.C. (Escuela Superior De Ingenieros, Univ. De Sevilla), Cobano, Jose Antonio (Univ. of Seville), Heredia, Guillermo (Univ. of Seville), Ollero, Anibal (Univ. De Sevilla)

This paper presents a Ground Control Station based on the Robot Operating System (ROS) which has been developed in order to monitor highly automated multi-UAV missions. The proposed system has been designed in order to easily perform Hardware in the Loop (HIL) simulations. This allows to test the desired algorithms in an environment as close as possible to the one found in real experimentation, which will reduce the costs related to field experiments. The architecture of the system is fully based on open source software, protocols and hardware. Furthermore a new user interface has been developed in order to provide relevant information in multi-UAV gliding experiments. This tool allows the operator to allocate tasks to the UAV and to monitor the operational information. This information can be complemented with the use of open source control stations. The proposed system has been demonstrated in both HIL simulation and in field experimentation. These results are compared in order to indicate how close the simulated behaviour was with respect to the real.

WeAT2	Salón Torremolinos A
Adaptive Control (Regular Session)	

11:00-11:20 WeAT2.1

Active Learning for Adaptive Brain Machine Interface Based on Software Agent, pp. 44-48

Castillo Garcia, Javier Ferney (Univ. Del Valle), Bastos, Teodiano

(Univ. Federal Do Espirito Santo), Caicedo, Eduardo (Univ. Del Valle), Azorin, Jose M. (Univ. Miguel Hernandez De Elche), Hortal, Enrique (Miguel Hernández Univ. of Elche), Iañez, Eduardo (Univ. Miguel Hernandez De Elche)

Brain Machine Interface (BMI) and Software Agent (SA) can provide some new adaptive strategies for robust BMI implementations. In this work, a non- invasive Adaptive BMI is introduced, which has been designed to discriminate four mental tasks. The SA allows tracking features to contribute for an adaptive process, while the user's engagement state provides a feedback between BMI and the environment. The Silhouette's width is the performance measurement used for the active learning process. The results show that the implemented system allows high accuracy (74.74%) in the classification process.

11:20-11:40 WeAT2.2

LPV Water Delivery Canal Control Based on Prescribed Order Models, pp. 49-54

Caiado, Daniela (INESC-ID), Lemos, Joao M. (INESC-ID), Igreja, José Manuel Cardoso (Inst. Superior De Engenharia De Lisboa / INESC-ID)

This article addresses the problem of designing an LPV controller for a water delivery canal based on reduced complexity linear models with a priori chosen order. For that sake, by applying a method based on the Laplace transform and the linearization of the Saint-Venant equations, a finite dimensional rational transfer function is obtained for each canal reach. An LPV gain-scheduling controller that relies on H-infinity optimization is then designed for local upstream canal control. The scheduling variables are the inlet canal flow and the downstream-reach mean level. The uncertainty bound is computed on the basis of the high frequency error of the frequency response of the model used with respect to the one of the infinite-dimensional model by linearizing the Sain-Venant equations. This approach has the advantage of yielding an LPV controller that relies on a model with specified complexity and to relate model uncertainty to physical canal parameters, allowing operation over an extended envelop of water flow and level equilibria.

11:40-12:00 WeAT2.3

Periodic Disturbance Compensation of an Angular Velocity Drive-Load Servo Control System with Self-Excited Oscillations, pp. 55-60

Alsogkier, Izziddien (TU-Clausthal), Bohn, Christian (Clausthal Univ. of Tech)

An algorithm for modeling, identification and control of periodic disturbances previously proposed by the author is applied as an add-on (adaptive) feed-forward controller to compensate the self-excited oscillations generated in an angular velocity drive-load servo control system. These oscillations take place mainly because the load machine has a crankshaft mechanism that induces these angle dependent periodic disturbances.

12:00-12:20 WeAT2.4

Adaptive Control of a Master-Slave System for Teleoperated Needle Insertion under MRI-Guidance, pp. 61-67

Franco, Enrico (Imperial Coll. London)

This paper presents the control of a master-slave system for teleoperated needle insertion under guidance by Magnetic Resonance Imaging (MRI). The primary aim of our research is the robot-assisted laser ablation of liver tumors. The master-slave system consists of a master unit that sits next to the operator, outside the scanner room, and of a slave unit located inside the cylindrical MRI scanner. The needle insertion force is measured with a specially designed fiber optic force sensor mounted on the slave unit. Pneumatic actuation is employed in both master and slave in order to minimize the interference with the MRI environment. Accurate position control of the slave unit is achieved with a Time Delay Control scheme (TDC). Differently from previous designs, the force feedback on the master unit is provided by an adaptive controller that compensates the friction of the pneumatic actuator. The advantages over a baseline force controller are demonstrated with experiments on silicone rubber phantoms.

12:20-12:40 WeAT2.5

Bond Graph Model-Based Fault Accommodation in Power Electronic Systems, pp. 68-75

Borutzky, Wolfgang (Bonn-Rhein-Sieg Univ. of Applied Sciences)

The paper presents a bond graph model-based approach to active fault tolerant control (FTC) that makes use of residuals of analytical redundancy relations (ARRs). The latter ones are computed in order to decide whether a fault has occurred. Given a single fault hypothesis can be adopted, an advantage is that the time for isolating a fault among potential fault candidates that contribute to an ARR by means of parameter estimation may be saved and as long as ARR residuals are within their thresholds no input reconstruction at all is needed. It is shown that ARR residuals can be used for estimation of faults that can be isolated. ARR based input reconstruction is demonstrated by application to a buck-converter driven DC motor as a simple example of a switched power electronic system for which an averaged bond graph model is used. Scilab simulation runs confirm analytical results. If a required input cannot be determined be determined analytically, it can be obtained by numerically solving a differential-algebraic equations (DAE) system.

WeAT3 Salón Torremolinos B

Automative Control (Regular Session)

11:00-11:20 WeAT3.1

Dynamical Modeling and Optimal State Estimation Using Kalman-Bucy Filter for a Seamless Two-Speed Transmission for Electric Vehicles, pp. 76-81

Rahimi Mousavi, Mir Saman (McGill Univ), Boulet, Benoit (McGill Univ)

A seamless two-speed transmission that incorporates a two-stage planetary gear set with common sun and common ring gears and two braking mechanisms to control the flow of power is introduced. For an electric vehicle equipped with such a transmission, a detailed dynamical model of the driveline including the half shaft stiffness and longitudinal vehicle dynamics is derived by exploiting the torque balance and virtual work principle. A deterministic Luenberger observer and a stochastic Kalman-Bucy filter are designed to estimate the unmeasured states. These observers estimate the speed of the sun and ring gears and the input and output torques of the transmission based on the measured speeds of the electric motor and the vehicle. Due to nonlinearities in the system such as the longitudinal vehicle dynamics, nonlinear observer methods generally apply for the observer design. However, the nonlinearities are only function of measurable states. Hence, using linear output injection to design an observer results in linear error dynamics. Therefore, the nonlinear observer design problem is transformed into the design of an observer for a linear system. The simulation and experimental results are presented to verify and compare the performance of the deterministic Luenberger estimator with stochastic Kalman-Bucy filter when the system encounters noise.

11:20-11:40 WeAT3.2

Predictive Cruise Control for Energy Saving in REEV Using V2I Information, pp. 82-87

Alrifaee, Bassam (RWTH Aachen Univ), Granados Jodar, Jaime (Univ. of M´alaga), Abel, Dirk (RWTH Aachen Univ)

This paper proposes a Predictive Cruise Control for a Range Extended Electric Vehicle that uses the information of upcoming traffic lights to arrive at a green or to reduce idling at a red light. Simultaneously, it is decided in a predictive manner, which is the best energy management strategy to operate the vehicle's powertrain. The main goals are to reduce fuel consumption and to increase energy efficiency. The control algorithm is formulated based on Model Predictive Control theory, which also allows the controller to operate in the absence of traffic light information as an Adaptive Cruise Control with predictive energy management. The controller tracks an optimal velocity trajectory, computed based on current traffic light's timing, and decides how much energy

must be provided from the battery and from the generator. The simulation results show a significant reduction in fuel and energy consumption.

11:40-12:00 WeAT3.3

Vehicle Sideslip Estimation Using Tyre Force Measurements, pp. 88-93

Kunnappillil Madhusudhanan, Anil (Delft Univ. of Tech), Corno, Matteo (Pol. Di Milano), Holweg, Edward (Delft Univ. of Tech)

Estimating vehicle sideslip is challenging as well as important for vehicle safety systems such as Electronic Stability Control. In this work, a Kalman filter is proposed to estimate vehicle sideslip using tyre force measurements. Most of the vehicle sideslip estimators do not use tyre force measurements and are based on tyre force model. Because of the tyre force model nonlinearities and uncertainties, the estimator accuracy depends highly on factors such as tyre-road friction, vertical load, temperature, tyre pressure, etc. Therefore availability of tyre force measurements offers benefits in vehicle sideslip estimation. The proposed estimator also has advantage over accelerometer based estimators as the later can have estimation errors from roll and pitch dynamics. The estimator is studied in a multi-body vehicle simulator for various maneuvers.

12:00-12:20 WeAT3.4

Flatness Based Control of Nonlinear Half-Car Active Suspension System, pp. 94-101

Velagić, Jasmin (Univ. of Sarajevo), Islamović, Berina (Univ. of Sarajevo, Faculty of Electrical Engineering)

This paper presents a methodology to design the flatness-based controller (FBC) for a nonlinear half-car hydraulic active suspension system. Vehicle dynamics is provided by using handling the trade-off of the ride comfort and safety. For this purpose, considered output variables are vertical acceleration and displacement of the car and vertical displacements of front and rear wheel. The main objective is to design a differential FBC which can isolate car body from the vibrations due to road disturbances acting and provide efficient control under model uncertainty. Extensive simulations are performed for different road profiles and different values of suspension parameters. The obtained results show that the proposed controller performed well in improving the ride comfort and road handling for the half-car model with a hydraulically actuated suspension system.

12:20-12:40 WeAT3.5

Development of a Compact Regenerative Braking System for Electric Vehicles, pp. 102-108

Tzortzis, Ioannis (Tech. Univ. of Crete), Amargianos, Alexandros (Tech. Univ. of Crete), Piperidis, Savvas (Tech. Univ. of Crete), KOUTROULIS, EFTICHIOS (Tech. Univ. OF CRETE), Tsourveloudis, Nikos (Tech. Univ. of Crete)

In this paper, a detailed study and implementation of a reliable and efficient regenerative braking system is presented. It is applied on a prototype electric vehicle, that uses a hydrogen fuel cell as its only power source. Supercapacitors are used to store the energy that is generated during braking, transistors for switching the alternative circuits and an embedded computer controller program undertakes the synchronization of the system tasks. A finite state machine was designed to create a simple but robust technique to control the transistor switches according to the system's sensory inputs. The system is powered by its own supercapacitors, and thus it may be used in a plug-and-play manner. On-road test drives proved the system's reliability and efficiency.

12:40-13:00 WeAT3.6

Influence of the Temperature on the Dry-Clutch Engagement Control in Gear-Shift Manoeuvres, pp. 109-116

Pisaturo, Mario (Univ. of Salerno), Cirrincione, Maurizio Cirrincione (UTBM), Senatore, Adolfo (Univ. of Salerno)

Recent evolutions in the developments of automated dry clutches and the associated control algorithms has led to a rapid diffusion of this transmission type. However the chosen control strategy affects strongly the passenger's comfort and moreover the control action, particularly with regard to the clutch engagement, is influenced by the clutch torque characteristic model implemented in the Transmission Control Unit (TCU). Thus, to use a phenomenological approach to model the torque transmitted by the specific clutch architecture is a crucial issue in order to design robust engagement control strategies. Thus, to use a phenomenological approach to model the torque transmitted by the specific clutch architecture is a crucial step in order to design robust engagement control strategies.

For these reasons this paper investigates the engagement performance of an actuated dry clutch by taking into account the thermal effects both on the cushion spring reaction and on the facing materials and consequently on the clutch torque characteristic. The outcome of this analysis could prove valuable for designers of automated clutches and control engineers to overcome the well known poor engagement problem.

WeAT4 Salón Torremolinos C

Biomedical Engineering (Regular Session)

11:00-11:20 WeAT4.1

Modeling and Simulation of the Short-Term Arterial Pressure Control System Using an Object Oriented Approach, pp. 117-123

Fernandez de Canete, Javier (Univ. of Malaga), Muñoz-Martinez, Victor Fernando (Univ. of Malaga), Luque, Joaquin (Univ. of Seville), Barbancho, Julio (Univ. of Seville), Rozan, John (Univ. of Malaga)

Object-oriented modeling is spreading in current simulation environments through the use of the individual components of the model and its interconnections to define the underlying dynamic equations. In this paper we describe the use of the SIMSCAPE simulation environment in the object-oriented modeling of the short-term arterial pressure control system when is applied to patients undergoing different situations as hemorrhage, liquid uptake or hemodialysis treatment. Results show the effectiveness of the baroreceptor control mechanism to compensate for the hypotension induced by the hemodialysis treatment. The described approach represents a valuable tool in the teaching of physiology for graduate medical and biomedical engineering students when facing to alternate hemodialysis treatment.

11:20-11:40 WeAT4.2

An Optimal Control Approach to Reference Level Tracking in General Anesthesia, pp. 124-129

Almeida, Juliana (Faculdade De Engenharia - Univ. Do Porto), Paiva, Luis Tiago (Univ. Do Porto), Mendonça, Teresa (Univ. Do Porto), Rocha, Paula (Univ. of Aveiro, NIF: 501461108)

In this paper the neuromuscular blockade level and the bispectral index level tracking problems by means of automatic control are considered in the context of general anesthesia. These tracking problems are formulated as optimal control problems that are numerically solved using direct methods. The results shown in this paper are preliminary but illustrate a good performance of this strategy when applied to biomedical problems.

11:40-12:00 WeAT4.3

A Low Cost Smart Glove for Visually Impaired People Mobility, pp. 130-135

Bernieri, Giuseppe (Univ. Degli Studi Roma Tre), Faramondi, Luca (Univ. Degli Studi Roma Tre), Pascucci, Federica (Univ. Degli Studi Roma Tre)

Degradation of the visual system reduces the mobility of a person that relies only on his sense of touch and hearing. This paper presents the prototype of a low cost smart glove to improve the mobility of the visually impaired people. The glove is equipped with rangefinders to explore the surroundings: it provides a vibro-tactile feedback on the position of the closest obstacles in range by means of vibration motors. The system is designed to operate with the white cane, enhancing the reliability of this traditional tool.

12:00-12:20 WeAT4.4

Stability Analysis of Cardiovascular Regulation, pp. 136-142

Codrean, Alexandru ("Pol. Univ. of Timisoara, Faculty Ofautomation And), Dragomir, Toma-Leonida ("Pol. Univ. of Timisoara, Faculty Ofautomation And)

Stability analysis for models of cardiovascular regulation is extremely complex due to multiple nonlinearities and multiple time delays. Most studies resume only to empirical results using simulations. The current work addresses the stability problem for a qualitative averaged model of cardiovascular regulation, focusing on deriving new insights on the role of time delays in generating stability or instability, along with assuring some global properties, like trajectory convergence and boundedness.

12:20-12:40 WeAT4.5

Experimental Architecture for Synchronized Recordings of Cerebral, Muscular and Biomechanical Data During Lower Limb Activities, pp. 143-149

Iáñez, Eduardo (Brain-Machine Interface Systems Lab, Univ. Miguel Hernande), Costa, Álvaro (Brain-Machine Interface Systems Lab, Miguel Hernández Univ), Ceseracciu, Elena (Univ. of Padova, Department of Management and Engineering,), Márquez-Sánchez, Ester (Biomechanics and Tech. Aids Unit, Physical Medicine and Reha), Piñuela-Martín, Elisa (Biomechanics and Tech. Aids Unit, Physical Medicine and Reha), Asín, Guillermo (BioEngineering Group, National Council for Scientific Res), del-Ama, Antonio J. (Biomechanics and Tech. Aids Unit, Physical Medicine and Reha), Gil-Agudo, Ángel (Biomechanics and Tech. Aids Unit, Physical Medicine and Reha), Reggiani, Monica (Univ. of Padova, Department of Management and Engineering,), Pons, José L. (Human Locomotion Lab. Neural Rehabilitation Group, Cajal), Moreno, Juan C. (Cajal Inst. National Council for Scientific Res. Argan), Azorin, Jose M. (Univ. Miguel Hernandez De Elche)

In this paper, an architecture that allows the synchronized register of cerebral, muscular and biomechanical data during lower limb activities has been designed. The synchronization issue has been addressed. The goal is to analyze the relationship between the different signals, first during simple lower limbs movements, and then extend on the analysis to the gait cycle. Five incomplete spinal cord injury patients and four healthy users have performed experiments to validate the architecture. The users were asked to perform simple movements that implies only one or two joints, particularly knee and ankle. Future studies with the registered data will address several issues, such as creating neuromusculoskeletal model that relate biomechanical data with EMG information, improving the decoding of the angles of the lower limb through EEG signals, or analyzing the coherence between the EEG signals and the EMG information.

12:40-13:00 WeAT4.6

Receding Horizon Control of Tumor Growth Based on Optimal Control, pp. 150-155

Lemos, Joao M. (INESC-ID), Caiado, Daniela (INESC-ID)

Receding horizon control (RH) is a powerful and well known technique used to embed feedback in the solution of a dynamic optimization problem. In most published approaches RH control is associated to model predictive control and amounts to minimize a cost defined over a time horizon that slides in time. The optimization is done with respect to a sequence of candidate values for the manipulated variable of which only the first is used. When considering nonlinear control problems, if the candidate sequence of the manipulated variables is left free of any constraint related to the plant dynamics (apart from operational constraints), there is the danger that the numerical method used converges to a local minimum. In this paper, instead, the minimization is performed using a relaxation algorithm that approximates the solution of Pontryagin's optimality conditions. This approach has the advantage of shaping the solution using the state and adjoint equations and, in addition, provides a natural approach to continuous RH problems. This algorithm is applied here to design therapies for tumor growth, modeled by the Gompertz model. A comparison of quadratic costs with costs that lead to sparse control signals, i. e. that are zero instead of assuming a small value, is also done.

WeAT5 Salón Torremolinos D

Fault Diagnosis I (Regular Session)

11:00-11:20 WeAT5.1

Fault Detection with Distributed PCA Methods in Water Distribution Networks, pp. 156-161

Sanchez-Fernandez, Alvar (Univ. De Valladolid), Fuente, Maria Jesus (Univ. De Valladolid. Q4718001C), Sainz, Gregorio (Univ. De Valladolid)

This paper describes a fault detection and diagnosis method applied to a water distribution system. The main purpose, in this kind of system with a very big amount of data, is to find a fault detection method which can achieve the best performance, while reducing computation and communication costs. The approach proposed here divides the installation sensors into several and possibly overlapping blocks, in each of which a local principal component analysis (PCA) is performed to detect and diagnose faults. After that, a central processor will receive the minimal possible information from all the nodes to take a global decision about fault detection and identification, i.e., the variable most responsible for the fault, for the whole plant. This distributed PCA method (DPCA) is compared with other distributed PCA methods, as well as a centralized PCA model, in order to get an idea of how good the proposed method is. Experimental results on the water network demonstrate that this DPCA method with local PCA models achieves good performance.

11:20-11:40 WeAT5.2

Energetic Fault Detection through Hamiltonian Bond Graph Formalism, pp. 162-167

atitallah, manel (ENIG), el harabi, rafika (Univ. of Gabès ENIG MACS Unit), Abdelkrim, Mohamed Naceur (ENIG)

A recent communication has proposed a fault detection using Bond graph or Hamiltonian formalism. In this paper, we used the combination between this formalisms called Hamiltonian Bond Graph formalism in order to guarantee the advantages of both energetics formalisms. More in detail we show that by use passivity theory coupled with a system energy balance, the energetic residual signals is generated. The applicability of the proposed method is shown through DC Motor examples.

11:40-12:00 WeAT5.3

Robust Unknown Input Observer Design for Unknown Input Nonlinear Systems: Application to Fault Estimation, pp. 168-173

Witczak, Marcin (Univ. of Zielona Gora), Puig, Vicenc (Univ. Pol. De Catalunya), Rotondo, Damiano (Univ. Pol. De Catalunya (UPC)), de Rozprza-Faygel, Michał (Univ. of Zielona Gora), Mrugalski, Marcin (Univ. of Zielona Gora)

The paper is devoted to the problem of designing robust unknown input observer (UIO) for fault estimation purpose. The proposed approach is based on the Takagi-Sugeno models which can be effectively applied for modelling of the wide class of nonlinear systems. It also revisits the recent results proposed in the literature and provides a less restrictive design procedure of a robust UIO. In particular, the general UIO strategy and the $mathcal{H}_{infty}$ framework are provided to design a robust fault estimation methodology. The resulting design procedure guarantees that a prescribed disturbance attenuation level is achieved with respect to the state estimation error. The main advantage of the proposed approach boils down to its simplicity because it reduces to solving a set of Linear Matrix Inequalities (LMIs). The final part of the paper presents an illustrative example devoted to the fault estimation of a three blade 1 MW variable-speed, variable-pitch wind turbine.

12:00-12:20 WeAT5.4

Sensors Selection for K-Diagnosability of Petri Nets Via Integer Linear Programming, pp. 174-181

Basile, Francesco (Univ. Degli Studi Di Salerno), De Tommasi, Gianmaria (Univ. Degl Studi Di Napoli), Sterle, Claudio (DIETI - Univ. Degli Studio Di Napoli Federico II)

This paper studies the problem of static sensor selection for ensuring K-diagnosability in bounded Petri nets. An integer linear programming problem is formulated to determine the minimal number of randomly selected sensors that make K-diagnosable net system with respect to a fault. This value is an estimate of the minimum number of sensors that assures the K-diagnosability of a given fault, which can be further improved taking into account some elements of the net structures.

12:20-12:40 WeAT5.5

A Packet Address Driven Test Strategy for Stuck-At Faults in Networks-On-Chip Interconnects, pp. 182-189

Bhowmik, Biswajit (IIT Guwahati), Biswas, Santosh (IIT GuwahatiINDIA), Deka, J (IIT Guwahati)

With the rapid advancements of deep submicron and nano technologies the dimension of a chip is ever shrinking. With continuous shrinking of chip dimensions, immense interconnects are associated on a die to satisfy high bandwidth requirements and make a network-on-chip (NoC) architecture prone to large number of interconnect faults. Therefore the reliability becomes a crucial issue for the communicating parties in a NoC communication fabric. This paper presents a packet address driven test strategy that diagnoses NoC interconnects experiencing stuck-at (stuck-at-0 and stuck-at-1) faults. The proposed strategy is scalable to all sizes and types of mesh NoCs and can be extended to other NoCs. The simulation is done on a number of mesh NoCs to establish the scalability. The simulation results show the performance measured in terms of test and fault coverages that can reach to 100% at the expense of few CPU clocks.

12:40-13:00 WeAT5.6

Comparative Study of Inter-Turn Short Circuit Fault in Stator and Rotor Windings on a Small and Medium Power Wound Rotor Induction Machine, pp. 190-195

RAZAFIMAHEFA, David Tsivalalaina (Univ. of Corsica, CNRS SPE UMR 6134), HERAUD, Nicolas (Univ. of Corsica), Eric Jean Roy, SAMBATRA (Intitut Supérieur De Tech. D'antsiranana), WAILLY, Olivier (Cnrs Umr 6134)

An accurate model and reliable detection system of an induction motor is a very important tool for diagnostic and fault detection. This paper deals with modelling of an inter-turn short circuit in stator and rotor windings of an induction machine and the fault detection at start-up. Winding function approach is chosen for the fault modeling and time-frequency analysis is proposed for the detection of fault. The detection method is based on detection of sidebands at certain frequencies using Wigner-Ville Distribution.

WeBT1 Salón Málaga

On Robust and Fault Tolerant Control of Nonlinear Systems (Invited Session)

Organizer: Aitouche, Abdel CRISTAL/HEI

Organizer: El Hajjaji, Ahmed Univ. De Picardie-Jules Verne

Organizer: WANG, Haoping Nanjing Univ. of Science and Tech

14:30-14:50 WeBT1.1

Active Fault Tolerant Control for Pitch Actuators Failures Tested in a Hardware-In-The-Loop Simulation for Wind Turbine Controllers (I), pp. 196-202

Vidal, Yolanda (Univ. Pol. De Catalunya), Rodellar, Jose (Tech. Univ. of Catalonia), Acho, Leonardo (Univ. Pol. De Catalunya-EUETIB), Tutivén, Christian (Univ. Pol. De Catalunya)

The number and complexity of control systems in wind turbines (WT) is expanding rapidly, and their design can be the difference between an immensely profitable system or a damaged system. Designing a robust control system requires to test the control algorithms in the actual controller hardware. However, WT are large and expensive, thus we would like to perform this test virtually, without using prototypes of the WT. This work develops a fault diagnosis (FD) and fault tolerant control (FTC) of pitch actuators in wind turbines. This is accomplished by combining a disturbance compensator with a controller, both of which are formulated in the discrete-time domain. The disturbance compensator has a dual purpose: to reconstruct the actuator fault (which is used by the FD technique) and to design the discrete-time controller to obtain a FTC. That is, the actuator faults are reconstructed and then the control inputs are modified to achieve a FTC with a comparable behavior to the fault-free case. The performance of the FD and FTC schemes is tested in a Hardware-in-the-Loop (HiL) testbed for WT controllers. The used controller hardware is an open hardware Arduino board which is connected to the virtual WT via USB. The onshore 5MW turbine is simulated on the open-source National Renewable Energy Laboratory WT simulator FAST (Fatigue, Aerodynamics, Structures, and Turbulence). The proposed HiL is used to characterize the behavior of the WT in the full load region in normal operation as well as under fault operation.

14:50-15:10 WeBT1.2

Design of Fault Isolation Filter for Control Reconfiguration : Application to Energy Efficiency Control in Buildings (I), pp. 203-208

Sauter, Dominique (Lorraine Univ), Yamé, Joseph-Julien (Univ. De Lorraine), Aubrun, Christophe (Univ. of Lorraine), Hamelin, Frederic (Univ. of Lorraine)

In this paper, fault adaptive control is developed for building Heating Ventilation and Air Conditioning (HVAC) systems. That is, the control system parameters and objective functions are adapted/reconfigured in the presence of a fault or performance deviation by means of an intermediate reconfigurable control layer. It allows maintaining building and HVAC operation within its specified energy and comfort performance requirements when a mechanical or operational fault takes place, until the fault is corrected. An integrated design, composed of two levels, respectively fault diagnosis and reconfiguration mechanism is proposed to recover performances after fault occurrence. This approach is applied to a 3 zones building and simulation results are given to show its effectiveness.

15:10-15:30 WeBT1.3

Adaptive Type-2 Fuzzy Sliding Mode Control for MIMO Nonlinear Systems: Application to a Turbocharged Diesel Engine (I), pp. 209-216

Larguech, Samia (National School of Engineers of Sfax), Aloui, Sinda (Univ. of Picardie Jules Verne, France), Pages, Olivier (Univ. of Picardie Jules Verne), El Hajjaji, Ahmed (Univ. De Picardie-Jules Verne), CHAARI, Abdessattar (National Engineering School of Sfax)

In this paper, an Adaptive Type-2 Fuzzy Sliding Mode Control (AT2FSMC) is designed for a class of nonlinear Multi-Input Multi-Output (MIMO) systems with unknown partially dynamics and in presence of external disturbances. To estimate the unknown functions, a Sliding Mode Control (SMC) combined with Type-2 Fuzzy Logic are developed. The discontinuous term of the classical sliding mode law is substituted with an adaptive Proportional Derivative (PD) term to reduce the chattering phenomenon. All parameters, adaptive laws and robustifying control terms are derived based on Lyapunov stability analysis, so that convergence to zero of tracking errors and boudedness of all signals in the closedloop system are guaranteed. The proposed approach is applied to a Turbocharged Diesel Engine and simulation results are presented to show the efficiency of the proposed method.

15:30-15:50 WeBT1.4

Robustness Evaluation of Real-Time Fuzzy Logic Control of the VGT and EGR on a Diesel Engine (I), pp. 217-223

Cheng, Li (Univ. of Sussex, Brighton), Wang, William (Sussex Univ), Aitouche, Abdel (CRISTAL/HEI), Peng, Jun (Univ. of Hertfordshire)

Abstract--- Real-time fuzzy logic controllers (RFLC) have been developed for the VGT and EGR control on a heavy-duty diesel engine. Previous studies show that compared to the VGT and EGR controlled by conventional PID controllers, there is a increase of engine torque and a reduction of engine emissions when the engine is running on the same condition. This work carried out robustness evaluation of the RFLC control using the 1D transient engine model

built in AVL-BOOST simulation platform. The evaluation includes a sudden air leak test and a turbocharger mechanical efficiency deterioration test. Simulation results show that the fuzzy logic controller is able to make necessary adjustments in both tests. It is able to compensate for the inlet pressure and flow loss either due to the air leak or the efficiency drop without losing engine torque and producing excessive increase of the soot and NOx.

15:50-16:10 WeBT1.5

Fault-Tolerant Control Scheme Based on Reference Adjustments for a 4WD Electric Vehicle with Actuator Faults and Constraints (I), pp. 224-229

Zhang, Xian (Lille 1), Cocquempot, Vincent (Lille 1 Univ), Aitouche, Abdel (CRISTAL/HEI)

A fault-tolerant control scheme for the path tracking of an electric vehicle (EV), which has four electromechanical wheel systems, is proposed. With considering wheel slip constraints and certain faults, a passive fault-tolerant controller based on the low-high gain control is developed to maintain the system's stability and guarantee an acceptable performance. If the performance degrades under a given threshold, an active fault diagnosis (AFD) approach is used to isolate and to evaluate the fault more precisely. A reference adjustment technique with the designed controller is used to guarantee the safe implementation of AFD. As soon as the diagnosis information is available, an accommodated controller is reconstructed to recover the degraded performance as best as possible. Finally, simulations of traction engine faults for a 4WD EV are conducted to illustrate the proposed scheme.

16:10-16:30 WeBT1.6

H-Infinity Criteria for Robust Actuator Fault Reconstruction for Nonlinear Systems in Takagi-Sugeno's Form Using Sliding Modes (I), pp. 230-236

Schulte, Horst (HTW-Berlin, Univ. of Applied Sciences), Pöschke, Florian (HTW Berlin)

In this paper, two criteria for robust actuator fault reconstruction with sliding mode observation for a class of uncertain nonlinear systems are derived. It is known, even though the sliding mode technique is robust against unknown but bounded uncertainties, that the quality of fault reconstruction under real conditions is not as good as assumed in the design stage. This is often due to the fact that the unmodeled dynamics and external disturbances have a greater variability and dimension as expected. Even if the dimension is known, it is formally limited by the existence condition for an exponentially stable error dynamics. Therefore, H-infinity criteria are derived to obtain a threshold for the accuracy of fault reconstruction during sliding motion. The validity and applicability of the design approach is demonstrated by the inverted pendulum benchmark.

WeBT2 Salón Torremolinos A

Process Control I (Regular Session)

14:30-14:50 WeBT2.1

Robust Decentralized Adaptive Control of a Quadrotor UAV, pp. 237-242

Prljaca, Naser (Univ. of Tuzla), Bjelic, Ahmed (Univ. of Tuzla, Faculty of Electrical Engineering)

Abstract— The application of robust decentralized adaptive control of the quadrotor attitude and altitude is presented in this paper. Robust decentralized model reference adaptive control (MRAC) based on Lyapunov stability theory is employed. The MRAC controller is augmented with integral control action leading to high accuracy in steady state conditions. The control scheme is robust with respect to a wide range of parametric uncertainties (inertial, loss-of-thrust degradations/faults) and neglected (unmodeled) dynamic uncertainties (driving motor dynamics, aerodynamic effects) in subsystem dynamics as well as in nonlinear subsystem couplings. The performance of the control scheme is verified by simulations and simulation results are given.

14:50-15:10 WeBT2.2

Performance Analysis of PI and PI+CI Compensation for an IPDT Process, pp. 243-248

Mercader Gómez, Pedro (Univ. of Murcia), Davó Navarro, Miguel Angel (Univ. of Murcia), BAÑOS, ALFONSO (Univ. OF MURCIA)

In this work, it is performed a comparison between the performance of PI and PI+CI compensators, in terms of a balanced index (servo/regulatory) based on the integrated absolute error (IAE). The plant is modelled by an integrating plus dead time (IPDT) process. The purporse of this work is to provide insight into the benefit of reset compensation both in servo and regulatory problems. This is accomplished by providing a tuning rule for the PI+CI, that allows to analyze the performance index in the compensator parameter space. The analysis done is independent of the process parameters.

15:10-15:30 WeBT2.3

Estimate of the Farthest Possible Non-Dominant Pole Locations with PID Controllers, pp. 249-253

Dincel, Emre (Istanbul Tech. Univ), Söylemez, Mehmet Turan (Istanbul Tech. Univ)

It is important to know how far non-dominant poles can be located away from the dominant poles since the closed-loop system transient response may not be as expected, if the non-dominant poles are not placed far enough from the dominant pole pair. Even if the arbitrary pole assignment is possible with a full state feedback or an output feedback controller with the order of plant order minus one, low order controllers and especially PID controllers are used in most practical applications. Therefore, the farthest possible non-dominant pole locations with PID controllers are found for all pole systems in this study. Proposed calculation method is demonstrated on two different examples and the closed-loop system performance is investigated with the designed PID controllers.

15:30-15:50 WeBT2.4

A Future Internet Interface to Control Programmable Networks, pp. 254-260

Battilotti, Stefano (Univ. La Sapienza), Cimorelli, Federico (Univ. of Rome "La Sapienza"), Cusani, Roberto (Univ. of Rome "La Sapienza"), Delli Priscoli, Francesco (Univ. Di Roma), Gori Giorgi, Claudio (Sapienza Univ. of Rome), Suraci, Vincenzo (Univ. Degli Studi E-Campus), Zuccaro, Letterio (Univ. of Rome "La Sapienza")

Current internet infrastructure is still configured and managed manually or adopting a limited level of automation. The Future Internet aims to provide the network resources as a service to ease the process of automatic designing, controlling and supervising the telecommunication infrastructure. A key enabler of Future Internet is the virtualization of the available resources and of the related functionalities. The widespread of cloud, Software Defined Network (SDN) and Network Function Virtualization (NFV) technologies opened the way for a total control of programmable networks. Many open and commercial implementations have adopted this paradigm, but they expose a fragmented set of dissimilar interfaces that often offer similar or even overlapping functionalities. The result is that uncontrolled, open-loop routines and procedures still require a manual intervention. In this paper, we describe an open interface to control programmable networks adopting a novel, closed-loop approach based on end users feedbacks. The proposed interface has been implemented as a Future Internet Generic Enabler named OFNIC, within the research work carried out in the FI-CORE project and published in the FI-WARE catalogue.

15:50-16:10 WeBT2.5

Discrete Direct Adaptive Sliding Mode Control Using Adaptive Switching Gain, pp. 261-267

znidi, aicha (National Engineering School of Gabes, Univ. of Gabes, Tunis), Dehri, Khadija (Univ. of Gabes), Nouri, Ahmed Said (National School of Engineering of Gabes)

Sliding mode control has attracted a great interest in all automatic filed. However, the presence of relatively high uncertainties involved a robustness problems and led to the deterioration of the desired performances. In order to overcome this problem we propose to combine the sliding mode control with the adaptive control. The proposed strategy consists in the synthesis of an adaptive equivalent control law based on Matrix Recursive Least Square

algorithm (M-RLS) and adaptive switching gain. The obtained results of the proposed control illustrate a considerable improvement of the desired closed loop performances for uncertain systems.

16:10-16:30 WeBT2.6

Optimal PID Control in Discrete Time Using Sensitivity Function, pp. 268-273

Tajika, Hiroshi (Univ. of Hyogo), Sato, Takao (Univ. of Hyogo), Vilanova, Ramon (Univ. Autonoma De Barcelona), Konishi, Yasuo (Univ. of Hyogo)

The present paper discusses the design of a discrete-time PID control system for a first-order plus dead-time model. The optimal PID parameters of the PID control system are determined based on the desired robustness using the maximum value of the sensitivity function. In the present study, the load-disturbance or the set-point performance is optimized in order to achieve the specified robustness. Finally, the effectiveness of the proposed design method is demonstrated through a numerical simulation.

WeBT3 Salón Torremolinos B

Robotics I (Regular Session)

14:30-14:50 WeBT3.1

Design of a Teleoperated Wall Climbing Robot for Oil Tank Inspection, pp. 274-280

San-Millan, Andres (Univ. of Castilla-La Mancha)

This paper presents a climbing robot with wheeled locomotion which uses permanent magnets as adhesion mechanism. The robot designed is intended for the inspection of various types of ferromagnetic structures, such as ship hulls, wind turbine towers, bridges, and fuel tanks, in order to detect surface faults or cracks caused by, for example aging or atmospheric corrosion. The proposed robotic system consists of a cordless teleoperated mobile platform which can move on vertical ferromagnetic walls. The robot can be equipped with the various testing probes and cameras that are necessary for different inspection tasks. First, different prototypes of magnetic wall climbing robots are analyzed in order to establish the current state-of-the-art, and to provide the background required to analyse the main advantages and drawbacks of the prototypes presented. The design of the proposed robotic system is then explained, and details are provided of the new approach for the design of the permanent magnetic adhesion mechanism. Finally the mechanical and electrical construction, the control architecture implemented, and the human-machine interface for its control and teleoperation are presented too.

14:50-15:10 WeBT3.2

Study of Dexterous Robotic Grasping for Deformable Objects Manipulation, pp. 281-285

Mira, Damián (Univ. of Alicante), Delgado, Angel (Univ. of Alicante), Mateo, Carlos M. (Univ. of Alicante), Puente Méndez, Santiago T. (Univ. De Alicante), Candelas Herias, Francisco A. (Univ. of Alicante), Torres, Fernando (Univ. of Alicante)

Most works in dexterous manipulation consider Force Closure Grasp (FCG), not only for rigid object but also, for flexible ones, though in the second case a force readjustment is also necessary. However, there are situations in which FCG is nonviable. This paper deals with the situation of a flexible object that must be necessarily grasped from one of its sides, taking advantage of its flexibility. This situation is common in packaging processes, or other everyday situations carried out by people. The paper presents first a new solution based on a planner that reproduces the actions of a human hand, aided by a database with knowledge about previous tasks. The paper is focused on describing the first tests done to evaluate the effectiveness of the planner for grasping different basic flexible objects, compared to a human hand.

15:10-15:30 WeBT3.3

Steerability Analysis on Slopes of a Mobile Robot with a Ground Contact Arm, pp. 286-291

García, Jesús M. (Univ. Nacional Experimental Del Ta´ Chira), Martinez, Jorge L. (Univ. of Malaga), Mandow, Anthony (Univ. De Málaga), Garcia-Cerezo, A. (Univ. De Malaga)

Mobile robot navigation through sloped terrains is a relevant problem for field robotics. In this context, mobile manipulators can improve tip-over stability by exerting ground contact with the end-effector of the onboard arm. However, this contact can affect vehicle steerability. This paper proposes a case study on the effect of arm ground contact on skid steering locomotion on inclined surfaces. To this end, a new four-wheeled mobile robot has been specifically designed with an onboard arm to provide one additional support point. Experimental results are obtained via ADAMS simulations on undulating surfaces, and include a comparison with center-of-gravity control for non- contact tip-over stability.

15:30-15:50 WeBT3.4

Trajectory-Tracking Control Design and Modeling for Quadrotor Aerial Vehicles, pp. 292-296

Margun, Alexey (ITMO Univ), Bazylev, Dmitry (ITMO Univ), Zimenko, Konstantin (ITMO Univ), Kremlev, Artem (ITMO Univ)

A control algorithm for finite-time tracking of quadrotor is introduced. The algorithm is based on use of feedback linearization method and finite-time output control. In comparison with commonly used in practice control methods like PD-controller the proposed method allows to estimate the first derivatives of the generalized coordinates, that allows to reduce the number of necessary sensors and thereby reduce the cost of the quadrotor. Moreover, the method is robust with respect to external disturbances and discretization that is useful for quadrotor control due to operating in open areas and digitality of sensors and controller. The performance and effectiveness of the method is demonstrated by simulation results of the system with external perturbations and signal discretization.

15:50-16:10 WeBT3.5

Dynamics-Compatible Potential Fields Using Stochastic Perturbations, pp. 297-302

Shah, Shridhar K. (Univ. of Delaware), Tanner, Herbert G. (Univ. of Delaware)

This paper suggests a method for numerically constructing almost globally converging artificial potential fields for motion planning, in a way that ensures that the resulting gradient field is compatible with the dynamics of the navigating robot. Convergence to an arbitrarily small destination set can be guaranteed, and the size of the destination set can be reduced at the expense of additional off-line computational time. The construction is based on the solution of the Hamilton-Jacobi- Bellman (HJB) equation associated with a related stochastic optimal control problem. This partial differential equation (PDE) is solved numerically by simulating paths of the system with Gaussian random perturbation applied to the input. The resulting control laws are optimal in terms of the magnitude of control actuation. The method is applied to the case of a Dubin's car navigating amongst obstacles.

WeBT4 Salón Torremolinos C

Power Systems and Smart Grid I (Regular Session)

14:30-14:50 WeBT4.1

PWM Based Modulation Strategy with Variable Switching Frequency for an Active Rectifier Stage with Flexible DC-Voltage Output, pp. 303-310

Dost, Philip (Ruhr-Univ. Bochum), Sourkounis, Constantinos (Ruhr-Univ. Bochum)

A modulation strategy for an active rectifier is discussed in this paper. It is designed for an inverter which is structurally based on the topology of the rectifier stage in an indirect matrix converter. This modulation strategy is based on a carrier signal whilst the switching frequency remains variable within a certain range. The switching frequency is dependent on the input value for the inverter output voltage. This modulation strategy allows easy set-up of the output voltage within a wide range and with that allows the use of energy storage systems which demand high flexibility. This Modulation scheme allows a reduction of switching processes depending on the working point while it remains based on the

underlying PWM signal. The implementation of this strategy is illustrated in this paper as well as simulation results which demonstrate the variance in the switching frequency.

14:50-15:10 WeBT4.2

Decentralized Frequency Control of a DDG-PV Microgrid in Islanded Mode, pp. 311-316

Gong, Kuangye (Tech. Univ. Darmstadt), Lenz, Eric (Tech. Univ. Darmstadt), Konigorski, U. (Tech. Univ. Darmstadt)

This paper presents an innovative approach to control the frequency in Diesel-Driven Generator (DDG)-Photovoltaic (PV) Microgrid (MG) in islanded mode. The common approach is based on hierarchical control: primary control and secondary control. The conventional primary controller is a P-controller. Compared to this, we propose a novel primary controller for PV to mimic the dynamic behavior of the conventional synchronous generator (SG) so that more inertia in the MG can be obtained. The proposed secondary control is accomplished decentralized, too, so that no communication links for the real-time control are required and the single point of failure can be avoided. Although in this approach every controller works locally, the controllers and their parameters are designed centrally. This means, the controllers can be appropriately adjusted, when the parameters or the topology of the system change. The parameters of the controllers are optimized by minimizing the H-inf-norm using a known non-smooth method.

15:10-15:30 WeBT4.3

A PSO-Based MPPT Re-Initialised by Incremental Conductance Method for a Standalone PV System, pp. 317-322

Mirbagheri Golroodbari, Sayedeh Zahra (The Univ. of Melbourne), Aldeen, Mohammad (Univ. of Melbourne), Saha, Sajeeb (Melbourne Univ)

This paper presents a modified maximum power point tracker (MPPT) for a standalone PV system. In this research a Particle Swarm Optimization (PSO)-based method is re-initialised by a variable step size (VSS) incremental conductance (IncCond) MPPT. The main motivation in this research is to eliminate the output ripple, and also to shorten the tracking time in rapidly changing insolation condition (RCIC). Used in this study, PSO-based method, precisely designed based on the dynamic behaviors of introduced system. The functionality of proposed method is evaluated by MATLAB/SIMULINK. Compared to IncCond method, the advantage of proposed one is that the PV outputs are more accurate and much less ripple-plotted. In comparison with standard PSO-based MPPT method, the tracking time in this method is much shorter, notably under RCIC.

15:30-15:50 WeBT4.4

Optimal Switching Lyapunov-Based Control of a Boost DC-DC Converter, pp. 323-328

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

A new methodology for designing robust and efficient state-feedback control laws for a switched-mode boost DC-DC power converter has been recently proposed. This approach has adopted the so-called stabilizing or Lyapunov-based control paradigm which is well-known in the area of energy-based control of DC-DC converters, whereby the control law takes a state-feedback form parameterized by a positive scalar $gamma$. Extension to state-dependent switching state-feedback control laws has been proposed, where the switching surfaces are parameterized by a number of positive scalars $gamma_i$. In this paper this methodology is revisited by considering the problem of designing optimal switching state-feedback control laws, i.e. finding the optimal control parameters $gamma_i$ corresponding to the optimal position of the switching surfaces. This permits minimization of the number of switchings required for achieving an optimal performance and hence reduced complexity of the control law. Systematic derivation of gradient information to apply gradient-descent algorithms is provided. The proposed technique is numerically evaluated using the exact switched model of the converter.

15:50-16:10 WeBT4.5

Multiple Model Predictive Control of Grid Connected Solid Oxide Fuel Cell for Extending Cell Life Time, pp. 329-334

Horalek, Radek (Tech. Univ. of Liberec), Hlava, Jaroslav (Tech. Univ. in Liberec)

Solid oxide fuel cells (SOFC) can be used for both distributed electricity generation and cogeneration purposes. They have higher efficiency and certain other advantages over proton exchange membrane fuel cells. However an important weak point of SOFC cells is their lifetime and durability. In particular, high temperature and fuel utilization variations resulting from load changes contribute to stack damage and significantly decrease the cell lifetime. In this paper, a model predictive control scheme for extending the cell lifetime is proposed. It makes use of the ability of predictive control to respect range and rate constraints. SOFC stack damage is prevented by satisfying temperature, fuel utilization and air utilization operational constraints. The cell behavior is significantly nonlinear. However as nonlinear MPC still has many issues, the nonlinearity was accounted for by using MPC scheme based on multiple linear models. The control scheme considers grid connected fuel cell and the main control objective is to deliver the desired power while respecting all constraints related to cell lifetime. Simulation results show that proposed life extending controller is able to control SOFC in a wide operational range and it gives good tradeoff between the cell life time and control system performance.

WeBT5 Salón Torremolinos D

Fault Diagnosis Ii (Regular Session)

14:30-14:50 WeBT5.1

Leak Isolation Based on Extended Kalman Filter in a Plastic Pipeline under Temperature Variations with Real-Data Validation, pp. 335-340

Delgado Aguiñaga, Jorge Alejandro (Centro De Investigación Y De Estudios Avanzados Del Inst. Po), Besancon, Gildas (Ense3 - Grenoble INP), Begovich, Ofelia (CINVESTAV)

The present work is motivated by the purpose of considering a more realistic scenario than in former studies on the problem of leak isolation within a plastic pipeline, when the water can be affected by temperature changes. In order to address this situation, a state observer approach based on a model including temperature effect and an Extended Kalman Filter is proposed. Noting indeed that temperature affects some equivalent straight length of the pipe, which is used in the model, the observer estimates it together with the leak coefficients. This approach only considers head pressure and flow rate measurements coming from pipeline ends. Results with real data obtained from a pipeline prototype are shown in two different ways in order to illustrate the performance of proposed leak isolation system, as compared to the traditional approaches found at literature.

14:50-15:10 WeBT5.2

Actuator Fault Detection and Isolation Via Input Reconstruction: Application to Intensified Heat Exchanger Reactor, pp. 341-346

zhang, Mei (Univ. Paul Sabatier, Toulouse, France; Guizhou Univ. G), Dahhou, Boutaieb (LAAS-CNRS), CABASSUD, Michel (Univ. Paul Sabatier, Toulouse, France; CNRS, Lab. De), Li, Zetao (Guizhou Univ)

This paper proposes a left invertible cascade non-linear system structure with a dynamic inversion based input reconstruction laws, forming a novel model-based actuator fault detection and isolation (FDI) algorithm. Actuator is viewed as subsystem connected with the process subsystem in series, thus identifying actuator faults with advancing FDI algorithm in the subsystem whose outputs are assumed unmeasured. The left invertibility of individual subsystem is required for ensuring faults occurred in actuator subsystem can be transmitted to the process subsystem uniquely, and for

reconstructing process inputs, also actuator outputs, from measured process outputs. A key feature, opportunity and technical challenge of the system is to obtain the conditions by which the information (useful input u or faults v) issued by actuators can completely arrive the output of the process system y, thus realizing actuator faults by using the measurable output y of the process system. The idea was first demonstrated by [12] for LTI and SISO system, according to [12], when all the subsystems are invertible, then the cascade system is invertible, then actuator faults can be detected using y. In this paper, we extend the concept to nonlinear MIMO system. Moreover, an essential requirement of the combination of individual actuator with an advanced diagnostic capability to perform FDI functions is the availability and reliability of the output of the actuator subsystem ua, which is also the input of the process system. This problem is considered as input reconstruction problem, which is viewed as problem of system inversion. Effectiveness of the proposed approach is demonstrated on an intensified HEX reactor developed by the Laboratoire de Génie Chimique (LGC -Toulouse, France).

15:10-15:30 WeBT5.3

A Rolling Bearing Fault Diagnosis Techniques - Autocorrelation and Cepstrum Analyses, pp. 347-353

El Morsy, Mohamed (Czech Tech. Univ. in Prague & Helwan Univ. Egypt), Achtenová, Gabriela (Czech Tech. Univ. in Prague)

The faulty vibration signals generally represent a combination of source and transmission path effects. For example, internal forces in vehicle gearbox which are the source of vibration act on a structure whose properties may be described by a frequency response function between the point of application and the point of measurements. A conventional frequency analysis of a spectrum will have transmission path effects affecting the true source signature and also cannot pinpoint the defects accurately where the problem is associated with more than one sideband and harmonic in case of vehicle gearbox. In the present paper, the transmission path effects are additive and can be separated in autocorrelation and cepstrum analyses, also it gives an accurate detection of periodic structure in a spectrum associated with many harmonics and sidebands as a single component for each family of sidebands without any difficulty in interpreting the sideband structure like in spectrum. The test stand is equipped with two dynamometers; the input dynamometer serves as internal combustion engine, the output dynamometer introduces the load on the flange of output joint shaft. An artificial fault is introduced in vehicle gearbox bearing: an orthogonally placed groove on the inner race with the initial width of 0.6 mm approximately. The results show the effectiveness of proposed analyses in diagnosis and detection of the rolling bearing condition.

15:30-15:50 WeBT5.4

Development of Synthesis Method of Fault Tolerant Systems for Autonomous Underwater Robots with Navigation Sensors Failures, pp. 354-359

Zuev, Alexander (Inst. of Automationa and Control Processes FEB RAS), Filaretov, Vladimir (Far Eastern Federal Univ), Zhirabok, Alexey (Far Eastern Federal Univ), Procenko, Alexander (Far Eastern Federal Univ), Subudhi, Bidyadhar (National Inst. of Tech. Rourkela)

In this paper, the new synthesis method of high-quality fault tolerant control to faults arising in navigation sensors of AUR is proposed and investigated. This method consists of three main stages. On the first, the problem of detection and localization of faults based on use of robot's kinematic model and special data fusion from its sensors is solved. It provides high quality of diagnosing because the kinematic model connects all motion parameters of AUR and variables measured by its navigation sensors. At the second stage, the problem of faults size identification due to introduction in each observer of special feedback is solved. At the third stage, there is a formation of additional control signals for AUR guaranteeing the expeditious parrying of the arising faults. The advantage of proposed method is simplicity of realization and high precision of compensation of the revealed faults in the conditions of uncertainty and essential variability of parameters of environment. The results of simulation confirm the high efficiency of functioning of the synthesized system of accommodation.

15:50-16:10 WeBT5.5

Timed Discrete Event System Approach to Online Testing of Asynchronous Circuits, pp. 360-367

Biswas, Santosh (IIT GuwahatiINDIA), Biswal, Pradeep Kumar (Iit Guwahati)

Now-a-days On-line testing becomes an indispensable part of DFT (design for testability) for detecting rapidly increasing intermittent faults in deep sub-micron ICs. Much of the proposed on-line testing techniques are for synchronous circuits as compared to asynchronous circuits. The existing online testing(OLT) techniques of asynchronous circuits involve development of checkers that verify the correctness of the predefined protocol. The area overhead of this type of checkers is quit high because of Mutex blocks, which are the main component of the checker. In this paper, we have adapted the theory of Failure Detection and Diagnosis(FDD) available in the literature on Timed Discrete Event Systems(TDES) to on-line testing of asynchronous circuits. The proposed scheme includes modeling the behavior of the circuit under normal and various stuck at fault conditions and eventually, an on-chip detector circuit is designed. The detector monitors the circuit on-line and determines whether the circuit is functioning in normal or failure mode. The main advantages of this scheme are non-intrusiveness and low area overheads compared to similar schemes reported in the literature.

16:10-16:30 WeBT5.6

I^2 Diagnosability Framework for Detection of Advanced Stealth Man in the Middle Attack in Wi-Fi Networks, pp. 368-375

Agarwal, Mayank (IIT Guwahati), Biswas, Santosh (IIT GuwahatiINDIA), Nandi, Sukumar (IIT Guwahati)

The diagnosability condition for a Discrete Event System (DES) model requires that there exists no failure-indeterminate cycles in the DES diagnoser for all failure types. This stringent requirement of DES diagnosability condition renders many systems non-diagnosable. I-diagnosability framework provides a weaker notion of diagnosability than DES diagnosability by considering only those failures that are followed by certain observable event(s) known as indicator events. However, some systems are I-nondiagnosable even in the presence of an indicator event following the failure event. In this paper, we propose I2-diagnosability framework overcomes the shortcomings of the I-diagnosability framework. In I2-DES framework an empowering event ensures that the indicator event sensitizes the failure successfully. We have considered a practical example of Advanced Stealth Man in the Middle attack in Wi-Fi networks to demonstrate the effectiveness of the proposed I2-DES framework wherein the I-DES framework fails.

WeCT1 Salón Málaga

Predictive Control (Regular Session)

17:00-17:20 WeCT1.1

Prognosis of Degradation Using Remaining Useful Life Estimation, pp. 376-382

laayouj, nabil (National School of Applied Sciences Industrial Department, Ibn Z), Jamouli, Hicham (Ibn Zohr Univ)

Prognostic activity deals with prediction of the remaining useful life (RUL) of physical systems based on their actual health state and their usage conditions. RUL estimation gives operators a potent tool in decision making by quantifying how much time is left until functionality is lost. In addition, it can be used to improve the characterization of the material proprieties that govern damage propagation for the structure being monitored. RUL can be estimated by using three main approaches, namely model-based, data-driven and hybrid approaches. The prognostics methods used later in this paper are hybrid and data-driven approaches, which employ the Particle Filter in the first one and the autoregressive integrated moving average in the second. The performance of the suggested approaches is evaluated in a comparative study on data collected from lithium-ion battery of hybrid electric vehicle.

17:20-17:40 WeCT1.2

Multi-Rate Predictive Cascade Speed Control of Synchronous Machines in Automotive Electrical Traction Drives, pp. 383-389

Carpiuc, Sabin - Constantin (Gheorghe Asachi Tech. Univ. of Iasi), Lazar, Corneliu (Gheorghe Asachi Tech. Univ. of Iasi)

The speed control of electric machines employed in automotive electrical traction drives is a challenging problem. Indeed, these applications are subject to physical and computational constraints. This paper addresses this challenging problem by employing a multi-rate predictive cascade state-space control structure, focusing on the design of the outer loop controller. Firstly, the mathematical model for the outer loop control, including also the dynamics of the inner control loop, is obtained . Secondly, a model predictive control approach based on a flexible control Lyapunov function is employed to control the rotor speed. Thirdly, in order to obtain the unmeasured state and the torque load a state and disturbance observer is employed. As a consequence, offset-free operation of the control system is also obtained. A realistic simulation scenario using a previously validated model and comparison with a linear quadratic regulator scheme are considered in order to illustrate the effectiveness of the proposed method.

17:40-18:00 WeCT1.3

Two and a Half Carrots - a Versatile and Intuitive Optimisation-Based Path-Following Approach for Road Vehicles, pp. 390-396

Reiter, Matthias (RWTH Aachen Univ), Abel, Dirk (RWTH Aachen Univ)

An optimization-based path-following control scheme for the lateral control of a nonholonomous vehicle is proposed. It is formulated as a nonlinear model predictive controller. The penalty function is chosen in a way that the result of the optimization is conceptually similar to the output of a traditional ”Follow-the-Carrot” or ”Pure Pursuit” approach as long as no constraints are active. This allows for intuitive tuning of the controller. However, as the controller is based on a nonlinear path prediction, it is also very robust with respect to the smoothness (driveability) of the reference path. The reference path can be given as a simple list of 2D coordinates, no explicit path planning is necessary. Advantages are seen especially when actuation limits (admissible lateral acceleration, maximum steering angle) are reached. The proposed controller is compared to a ”Pure Pursuit” controller in simulation. Then, it is implemented on a model vehicle and experimental results are presented.

18:00-18:20 WeCT1.4

MPC Implementation in a PLC Based on Nesterov's Fast Gradient Method, pp. 397-402

Pereira Martin, Mario (Univ. De Sevilla), Limon, Daniel (Univ. De Sevilla), Muñoz de la Peña, David (Univ. of Sevilla), Alamo, Teodoro (Univ. De Sevilla)

This work presents a linear quadratic model predictive controller (MPC) implemented in an industrial programable logic controller (PLC). The control law is calculated by solving on-line the quadratic programming problem derived from the optimization control problem of MPC. Nesterov's fast gradient algorithm has been used to solve the corresponding linear quadratic MPC problems with input constraints. The predictive controller has been implemented in a Schneider Electric M340 using the standard structured language from the IEC 1131.1 norm. The memory and computational time requirements of the proposed implementation have been characterized through extensive simulations. In addition, the properties of the proposed controller have been experimentally demonstrated using a test-bed in which the MPC running in the M340 controls a model of a quadruple-tank process simulated in Matlab/Simulink through an OPC server.

18:20-18:40 WeCT1.5

Cooperative Unmanned Aerial Vehicles Formation Via Decentralized LBMPC, pp. 403-409

Hafez, Ahmed Taimour Kamaleldin (Queen's Univ), Givigi, Sidney (Royal Military Coll. of Canada), Yousefi, Shahram (Queen's Univ), Noureldin, Aboelmagd (Royal Military Coll. of Canada)

In this paper, a team of cooperative Unmanned Aerial Vehicles (UAVs) maintains a desired geometrical formation while tracking a reference trajectory using a new control approach. Decentralized Learning Based Model Predictive Control (DLBMPC) is a new control technique that combines statistical learning along with control engineering while providing guarantees on safety, robustness and convergence. The ability of the proposed DLBMPC controller in solving the problem of formation for a team of cooperative UAVs is solved in simulation. The designed controller respects the general formation constraints known as Reynold's rules of flocking. Our main contribution in this paper lays in the stabilization of a group of cooperative UAVs, in a desired formation, while tracking a reference trajectory using DLBMPC in the presence of model uncertainties.

18:40-19:00 WeCT1.6

Robust Model Predictive Control for Discrete-Time Fractional-Order Systems, pp. 410-415

Sopasakis, Pantelis (IMT Inst. for Advanced Studies Lucca), Ntouskas, Sotirios (National Tech. Univ. of Athens), Sarimveis, Haralambos (National Tech. Univ. of Athens)

In this paper we propose a tube-based robust model predictive control scheme for fractional-order discrete-time systems of the Grunwald-Letnikov type with state and input constraints. We first approximate the infinite-dimensional fractional-order system by a finite-dimensional linear system and we show that the actual dynamics can be approximated arbitrarily tight. We use the approximate dynamics to design a tube-based model predictive controller which endows to the controlled closed-loop system robust stability properties and guarantees satisfaction of the prescribed constraints.

WeCT2 Salón Torremolinos A

Linear Systems (Regular Session)

17:00-17:20 WeCT2.1

Solution of a Singular Infinite Horizon Zero-Sum Linear-Quadratic Differential Game: A Regularization Approach, pp. 416-423

Glizer, Valery Y. (ORT Braude Coll), Kelis, Oleg (Ort Braude Coll)

An infinite horizon zero-sum linear-quadratic differential game is considered. The case where the cost functional does not contain a minimizer's control cost is treated. Thus the game under consideration is singular. This game is associated with a new differential game for the same equation of dynamics. The cost functional in this new game is the sum of the original cost functional and an infinite horizon integral of the square of the minimizer control with a small positive weight coefficient. The new game is regular. Moreover, it is a cheap control game. Using the solvability conditions, the solution of this game is reduced to solution of an algebraic matrix Riccati equation, perturbed by a small parameter. Based on an asymptotic solution of this equation, the finiteness of the upper value in the original game is established. An expression of this value is derived. A minimizing sequence of feedback controls in the original game also is designed. Illustrative example is presented.

17:20-17:40 WeCT2.2

Improving Accuracy of Parallel SLICOT Model Reduction Routines for Stable Systems, pp. 424-429

Guerrero-López, David (UPV), Román, José E. (UPV)

This paper shows part of the work carried out to develop parallel versions of the SLICOT routines for model reduction of stable systems. In particular, the routines that have been parallelised are those based on the solution of Lyapunov equations. The goal is to be able to work with larger unreduced models and also to obtain better performance in the reduction process. New routines have been developed using standard libraries to improve portability and efficiency. A preliminary version was released previously by the authors, which achieved high performance. However, accuracy improvements have been necessary in order to make the new routines similar to the sequential ones in this aspect. Routines

presented in this paper preserve good performance obtained by the previous parallel implementation while maintaining high accuracy of sequential SLICOT routines.

17:40-18:00 WeCT2.3

Stability of Slowly Rotating Timoshenko Beam with Two Viscoelastic Damping Coefficients, pp. 430-433

Wozniak, Jaroslaw (Univ. of Szczecin), Firkowski, Mateusz (Univ. of Szczecin)

This paper continues the authors' previous investigations of stability of a slowly rotating Timoshenko beam whose movement is controlled by the angular acceleration of the driving motor into which the beam is rigidly clamped. We consider a viscoelastic damping operator with respect to both variables – deflection of the center line, and rotation angle of cross section area. We show that the initial unstable system becomes stable after introducing the damping.

18:00-18:20 WeCT2.4

Sensor Parametrization and the Sensor Group, pp. 434-439

Szabo, Zoltan (Mta Sztaki), Bokor, Jozsef (Hungarian Acad. of Sciences)

While sensors play an important role in the control loop, in practice they often are considered to be a part of the plant and the explicit interaction between the plant and sensor is disregarded in the further considerations. Based on an input/output perspective, this paper investigates the internal stability property of the control loop when this interface is considered explicitly. As a main result of the paper, we provide a Youla type characterization of all the sensors that renders the loop stable for a fixed plant and controller. When none of the sensors can provide the necessary performance it is time for a sensor blending or a sensor reconfiguration. The simplest form of sensor fusion, i.e., a linear combination of the sensors, does not necessarily preserve stability of the control loop. In order to design efficient algorithms that operate on the set of controllers or a set of sensors that fulfill a given property, e.g., stability or a norm bound, it is important to have an operation that preserves that property, i.e., a suitable blending method. When there is a fixed, finite number of candidates, the necessary investigations can be performed by an individual inspection. However, if more sophisticated algorithms are needed, e.g., an optimization on a suitable large set of sensors, this approach does not work.

This paper places the sensor blending problem in a more general context: an operation on stable sensors is provided under which feedback stability is preserved and under which sensors form a group, the sensor group. Under the action of this group operation changes in the relevant sensitivities can be also given in explicit terms.

18:20-18:40 WeCT2.5

Synthesis of Multiple Sensitivity Constrained Controllers for Parametric Uncertain LTI Systems, pp. 440-445

Yagoubi, Mohamed (Ec. Des Mines De Nantes (IRCCyN))

The purpose of this paper is to propose a synthesis method of multiple parametric Sensitivity constrained Linear Quadratic (SLQ) controllers for a parametric uncertain LTI system. System sensitivity to parameter variation, for each controller, is handled through an additional quadratic trajectory parametric sensitivity term in the criterion to be minimized. The controllers are supposed to cover the whole parametric uncertainty while degrading as less as possible the intrinsic robustness properties of each local linear quadratic controller. In that context, it is difficult to ensure the global optimality. Hence an efficient Particle Swarm Optimization (PSO) based algorithm is provided to find the best partition of the uncertainty set as well as the set of SLQ controllers.

WeCT3 Salón Torremolinos B

Modelling and Simulation (Regular Session)

17:00-17:20 WeCT3.1

Incorporation of Thermal Expansion in Static Force Modeling of Pneumatic Artificial Muscles, pp. 446-452

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

In this article, the thermal expansion effect is considered as the main cause of the gradual shift in the force-displacement relationship, which describes the operation of Pneumatic Artificial Muscles (PAMs). A modified static force modeling approach is proposed, based on fundamental PAM modeling techniques, while incorporating the geometrical properties that are being affected by the thermal build-up occurring during PAM's continuous operation. The effects of thermal expansion are documented via experimental studies and the acquired data are utilized for the validation of the proposed modeling method.

17:20-17:40 WeCT3.2

Modelling and Control of the UPV/EHU Stellarator, pp. 453-459

Garrido, Aitor J. (Univ. of the Basque Country), garrido, izaskun (Univ. of the Basque Country), Chalatsakos, Odysseas (Univ. of the Basque Country UPV/EHU), Viñas, Ander (Univ. of the Basque Country - UPV/EHU), Villaverde, Ainhoa (Univ. of the Basque Country - UPV/EHU), Queral, Vicente (CIEMAT), Romero, Jesus (CIEMAT)

This paper deals with the state-space modelling of the Ultra-Low Iota Super Elongated Stellarator of the UPV/EHU, using a physical lumped parameter equivalent circuit approach. The model obtained is validated by means of experimental output data showing an excellent matching with the real system. In order to test the proposed model, a MPC scheme is been successfully implemented both in simulation and experimentally using a real-time control platform, providing also a benchmarking with traditionally used PID controllers

17:40-18:00 WeCT3.3

Identification of Simple Mass Balance Models for Plant Growth - Evolving Yields and Incorporating Developmental Stages, pp. 460-465

Dochain, Denis (Univ. Catholique De Louvain), Maclean, Heather (Univ. Catholique De Louvain)

This paper deals with the development and identification of a simple mass balance model for plant growth. The basis of this work is in the development of a model intended to enable the prediction and control of a plant production chamber for MELiSSA, a regenerative life support system project developed by the ESA (European Space Agency). Photosynthesis and respiration have been selected as key reactions for biomass production. Considering these reactions, the model has been developed using a mass balance approach. Reaction kinetics were chosen based on plant physiology and standard biochemical reaction knowledge. The identification and validation of yield and kinetic parameters were performed using data from lettuce and beet experiments in a closed plant chamber. Although the model adequately predicts plant growth, the oxygen prediction can be improved by considering two stages on the basis of the photosynthetic quotient.

18:00-18:20 WeCT3.4

Dynamics of Differential Entropy Maximization Process Via the Speed Gradient Principle, pp. 466-473

Shalymov, Dmitry (Saint-Petersburg State Univ), Fradkov, Alexander L. (Acad. of Sciences of Russia)

Dynamics of non-stationary processes that follow the MaxEnt principle for differential entropy is considered. A set of equations describing the dynamics of probability density function (pdf) for such processes is proposed. Equations are derived based on the Speed-Gradient principle originated in the control theory. The uniqueness of the limit pdf and asymptotic convergence of pdf are examined under the mass conservation and energy conservation constraints.

18:20-18:40 WeCT3.5

Modeling of a Front End Loader for Control Design, pp. 474-479

Roskam, Rolf (Ostfalia Univ. of Applied Sciences, Department of Mechanica), Dobkowitz, Dirk (Ostfalia)

Front end loader are commonly used in agriculture machinery. A special feature of the loader is the parallel positioning of the bucket while lifting the boom. Modeling of the hydraulic, kinetic and kinematic behavior of the front end loader is helpful for the design of a controller for parallel positioning. In this paper we describe the mathematical background of this model. The model considers the four-bar linkage of the bucket actuation. To validate the model a graphical output and a comparison of simulation and real measurement results is presented.

18:40-19:00 WeCT3.6

Bond Graph Model of a Mechanically Pumped Biphasic Loop. (MPBL), pp. 480-485

KEBDANI, Mohamed (Ec. Centrale De Lille), Dauphin-Tanguy, Genevieve (Ec. Centrale De Lille), DAZIN, Antoine (Arts Et Métiers Paris Tech), DUPONT, Patrick (Ec. Centrale De Lille)

The MPBL is an effective technology in terms of heat flow transport capacity, with high level adaptability. A bond graph model of such a system is proposed in this paper. The model is dynamic, qualitative, configurable and pays particular attention to the dynamic of the transient regime. It aims at being a tool dedicated to designing the different components of a MPBL. It is also used for a physical analysis of the system in different operating conditions.

WeCT4 Salón Torremolinos C

Power Systems and Smart Grid Ii (Regular Session)

17:00-17:20 WeCT4.1

A Model Predictive Control Scheme for Parallel-Connected Inverter-Based Distributed Generators in Micro-Grids, pp. 486-490

Liu, Sheng (Harbin Engineering Univ), Zhu, Wanlu (Mississippi State Univ), Xing, Bowen (Univ. of Notre Dame)

In recent, microgrids have been considered as an economic and efficient way to integrate distributed renewable resources on the community level. However, the current and power sharing between each distributed generations, especially under heavy power demands and casualty conditions, is still an important issue. This paper presents a model predictive control approach for parallel-connected inverter-based distributed generators in micro-grid system under islanded operation mode. The dynamic system model is developed and used to predict future system behaviors based on the candidate control input sequences and the current states. The desired cost function is build and by minimizing the cost function designed controller chooses the optimal control solution and applied as the current control input. The proposed control scheme provides automatic and fast regulation to ensure the resultant output voltage tracks the reference waveform and minimize the circulating current between parallel-connected inverters. Several simulation scenarios are presented to show the efficiency of the proposed controller using PLECS software.

17:20-17:40 WeCT4.2

Agent-Based Modelling of Electric Vehicle Driving and Charging Behavior, pp. 491-496

Torres, Sergio (Univ. Del País Vasco. Escuela Univ. De Ingeniería), Barambones, Oscar (Basque Country Univ), Gonzalez de Durana, Jose María (Univ. of the Basque Country), Kremers, Enrique (Karlsruhe Inst. of Tech), Marzabal, Francisco (European Inst. for Energy Res. Inst. O), Wirges, Johannes (European Inst. for Energy Res. Inst. O)

Electromobility lies on the crossroad between mobility and energy systems. The individual heterogeneous behaviours, and especially the spatial distribution and dynamism of the system make it a complex one. In this work, it is proposed an agent-based model to reflect this complexity and create a bottomup model which addresses specifically driving and charging behaviours of the individual agents. The model was implemented in a simple network which included the commonly used facilities in a city. This allows the computation of the generated load curve in a geographical context for any network. Different technical parameters were varied, as well as the driving and charging behaviours. The load curve as an aggregated result showed emergent patterns such as non-trivial effects when increasing the charging power. The model provides qualitative results from an exploratory point of view, which help to better understand electromobility systems by relating its causes and effects.

17:40-18:00 WeCT4.3

Mitigation of Oscillations in DFIG-Based WECS Operating in Unbalanced Networks, pp. 497-503

Sourkounis, Constantinos (Ruhr-Univ. Bochum), Tourou, Pavlos (Ruhr-Univ. Bochum), Chhor, Johnny (Ruhr-Univ. of Bochum)

With the increasing penetration of wind energy in the electrical power system, wind energy conversion systems (WECS) will occupy an important role in the power generation and need to reliably supply electric energy. Especially in remote rural areas or in weak distribution grids, unbalanced grid voltage conditions are common and need to be addressed by appropriate control measures. They evoke negative sequence grid voltages resulting in oscillations at twice the grid frequency in torque and active/reactive power, thus inducing heavy me- chanical stress in the WECS drive-train and increasing grid load respectively. An advanced control methodology which can simultaneously regulate positive and negative sequence component based on proportional-integral and resonant controllers are presented to effectively mitigate the impact of grid voltage unbalance.

18:00-18:20 WeCT4.4

Electric Vehicle Trip Planning Integrating Autonomy Constraints and Charging Facilities, pp. 504-511

Gambuti, Raffaele (Univ. of Rome "Sapienza"), Canale, Silvia (Univ. of Rome "Sapienza"), Facchinei, Francisco (Univ. of Rome "La Sapienza"), Lanna, Andrea ("Sapienza" Univ. of Rome), Di Giorgio, Alessandro (Univ. of Rome "La Sapienza")

This paper presents a strategy for multi-modal trip planning integrating the management of fully electric vehicle range and charging services along the trip. The network graph is modelled as the superposition of layers representing different transportation means and charging infrastructure, putting in evidence the interaction between the transportation and electricity distribution grids. The presence of energy constraints on the network nodes implies to formalize the trip planning problem as a resource constrained shortest path problem, and solve it through an ad-hoc decomposition strategy. The proposed approach is validated through the simulation of realistic test cases, showing its effectiveness and potential in satisfying complex user preferences, mitigating drivers perception about limited vehicle range and availability of charging infrastructure, smoothing the impact of massive fully electric vehicle charging on distribution grids.

18:20-18:40 WeCT4.5

Real Time Optimal Power Flow Integrating Large Scale Storage Devices and Wind Generation, pp. 512-518

Di Giorgio, Alessandro (Univ. of Rome "La Sapienza"), Liberati, Francesco (Univ. of Rome "La Sapienza"), Lanna, Andrea ("Sapienza" Univ. of Rome)

This paper presents a real time strategy for optimal power flow in presence of storage devices and wind turbine driven by Doubly Fed Induction Generators. These elements work in cooperation defining a dynamic bus where the generated power is subject to temporal constraints, which establish a coupling between traditional power flow problems related to consecutive time periods; further the uncertainty in wind power generation forecasts requires a continuous update of the planned power profiles, in order to guarantee a dynamic equilibrium among demand and supply. Model predictive control is used for this purpose, considering the dynamic equations of the storage and the wind turbine rotor as prediction models. A proper target function is introduced in order to find a trade-off between the need of minimizing generation costs and the excursions of the storage state of charge and the wind turbine angular speed from reference states. In the case study under consideration storage, wind turbines and a traditional synchronous generator are operated by the Transmission System Operator in the form of a Virtual Power Plant working as slack bus to cover network losses. The proposed approach is validated on simulation basis.

WeCT5 Salón Torremolinos D

Nonlinear Control (Regular Session)

17:00-17:20 WeCT5.1

Sliding Mode Control for Diesel Generator Via Disturbance Observer, pp. 519-526

GUERMOUCHE, Mohamed (Inst. De Recherche En Systèmes électroniques Embarquées IRSEE), AHMED ALI, Sofiane (IRSEEM Rouen), Langlois, Nicolas (Irseem / Esigelec)

This paper develops a sliding mode controller via nonlinear disturbance observer for diesel generator system subject to matched and unmatched disturbances. The proposed controller is based upon a novel nonlinear disturbance observer structure which uses the concept of total disturbance estimation in order to estimate simultaneously the matched and the unmatched disturbances in the system. This estimation is incorporated then in a composite observer based controller where the Lyapunov based stability analysis is given. Simulations results illustrate the effectiveness of the proposed controller compared to the baseline sliding mode controller and shows its advantages in terms of disturbance rejection, chattering reduction and nominal performance recovery.

17:20-17:40 WeCT5.2

Defensive State Feedback Control of Asynchronous Sequential Machines, pp. 527-532

Hammer, Jacob (Univ. of Florida)

The design of state feedback controllers that protect asynchronous sequential machines from pre-programmed adversarial agents is considered. Necessary and sufficient conditions for the existence of such controllers are derived. These conditions are stated in terms of certain matrices of zeros and ones derived from the given description of the protected machine. Controller design algorithms are outlined.

17:40-18:00 WeCT5.3

The Feedback Linearisation Method for Embedded Model Control: The Borea Project Case-Study, pp. 533-539

Lotufo, Mauricio Alejandro (Pol. Di Torino), Colangelo, Luigi (Pol. Di Torino), Perez Montenegro, Carlos Norberto (Pol. Di Torino), Canuto, Enrico (Pol. Di Torino)

Feedback linearisation has been proved to be a powerful tool for making non-linear system dynamics fully or partially linear. This study investigates the use of the feedback linearisation approach as a novel way to design the internal model for Embedded Model Control. This idea is applied to the control of an Unmanned Aerial Vehicle: the Borea project quadrotor. Embedded Model Control methodology implies the design of an internal model (Embedded Model) coded into the control unit and running in parallel with the plant. The difference between the internal model output and the plant output is used to estimate the unknown disturbances. These unknown disturbances include all the non-linearities that can be rejected by means of the control law. Using a numerical simulator, we demonstrate the feasibility of this methodology for accurate design of the internal model, starting from the non-linear system. This indicates that a feedback linearisation approach allows the extension of embedded model control techniques to non-linear systems control. What is more, the EMC is successfully applied to the control of the Borea quadrotor.

18:00-18:20 WeCT5.4

Error Handling Approach of a PEM Fuel Cell System by Nonlinear Model Predictive Control, pp. 540-545

Hähnel, Christian (Helmut-Schmidt-Univ. / Univ. of the Federal Armed Forc), Aul, Vitali (Helmut-Schmidt-Univ. / Univ. of the Federal Armed Forc), Horn, Joachim (Helmut-Schmidt-Univ. / Univ. of the Federal Armed Forc)

For an efficient chemical reaction and a safe operation for both stationary and dynamic loads all values of anode and cathode gas pressures and stack temperature must fall within specific ranges. System error can result in values outside of these ranges, in turn causing serious damage to the fuel cell (FC). In addition the energy supply by the FC is at risk, because an emergency shutdown is possible. Therefore it is necessary to implement strategies for handling error cases in order to ensure safe operation. A common method for controlling the operation of PEM FC is a model predictive control, which allows for fault tolerance. In literature, error handling strategies are only considered for special parts of FC, but not for the whole system. This paper deals with real-time nonlinear model predictive control (NMPC) of electrical power with applied error handling strategies for a PEM FC system. Different types of errors are discussed in connection with various solution approaches. This fault tolerant NMPC handles all kinds of dynamic load changes and allows a safe operation of the FC in the event of errors, while maximizing power efficiency. Any emergency shutdown is not necessary and energy supply is still guaranteed. All experiments were verified on a test bench with a 4.4kW PEM FC.

18:20-18:40 WeCT5.5

Multivariable Algebraic Loops in Linear Anti-Windup Implementations, pp. 546-551

Adegbege, Ambrose Adebayo (The Coll. of New Jersey), Heath, William Paul (Univ. of Manchester)

This paper addresses the implementation aspects of multivariable algebraic loops which arise naturally in many anti-windup control schemes. Using the machinery of linear complementarity problems, a unified framework is developed for establishing well-posedness of such algebraic loops. Enforcing well-posedness is reduced to a feasibility problem that can be solved during the anti-windup design stage. Several existing anti-windup implementations appear as special cases of the unified framework presented in this paper.

18:40-19:00 WeCT5.6

Experimental Investigation of Nonlinear Controllers Applied to a 3DOF Hover: SMC Via ALQR Approach, pp. 552-556

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

This paper presents an application of sliding mode controllers obtained via amplified linear quadratic regulator (ALQR) strategy to a hover with three degrees of freedom. The purpose of the designed control system is to track reference trajectories and ensure performance and stability in spite of disturbance, noise and unmodeled dynamics. Simulations were performed using MATLAB/Simulink in order to verify/compare the performance of the nonlinear controllers proposed. For validation of the algorithm a didactic plant (3DOF Hover) was chosen produced by Quanser Consulting, that simulates typical behaviors of an VTOL ("vertical taking-off landing") aircraft, also known as X4-flyer. The dynamic of the hover can be described by a 6th order model taking as state variables the angles of yaw, pitch, roll and associated rates. The experiments showed that designed nonlinear controllers using sliding mode control via ALQR are robust to noises and for a range of unmodeled nonlinearities.

ThPL Salón Málaga

Prof. Manuel Silva. Discrete and Fluid Petri Nets: Dealing with Individuals, Dealing with Populations (Plenary Session)

09:30-10:30 ThPL.1

Discrete and Fluid Petri Nets: Dealing with Individuals and Populations, pp. 557-562

Silva, Manuel (Univ. De Zaragoza)

Two traditional ways to deal with the computational complexities of the analysis and synthesis of Discrete Event Systems (DES) are structural techniques and fluid relaxations. In the second case, the expected computational gains for analysis and synthesis problems are usually performed at the expense of the fidelity of the approximated model. Among the structural techniques, the abstraction of individuals into some populations may be very appealing. Using a basic examples-driven approach, the interest of the fluidization of DES models and of the aggregation of some local states by the decolorization of models (creation of populations) will be briefly illustrated.

ThAT1 Salón Málaga

Process Control Ii (Regular Session)

11:00-11:20 ThAT1.1

On Energy Optimization of a Pulp and Paper Refiner Based on Model Predictive Control, pp. 563-570

Giannakas, Theodoros (Univ. of Patras), Andrikopoulos, George (Univ. of Patras, Greece), Nikolakopoulos, George (Luleå Univ. of Tech. Sweden), Manesis, Stamatis (Univ. of Patras)

The aim of this article is to investigate and examine the modeling and control problem of the paper making's sub process also known as pulp refining. The existing modeling approaches developed for the pulp and paper refining process are being investigated, while the most important model approximations, extracted from the existing related literature, are being simulated and examined in detail. The main goal of the article is to determine whether the modeling approaches of the pulp and paper refining process can be successfully controlled via a Model Predictive Control (MPC) based structure and at which extend this could lead in a better control scheme and in an overall energy optimization. Extensive simulation trials are being carried out, where the MPC parameters are being fine-tuned through trial-and-error sequences in order for examining the overall performance in controlling the various modeling approaches of the process. In order to further evaluate the efficacy of the proposed control scheme, the MPC related results are being compared to experimental data extracted from a real refining system that utilized a generic industrial controller.

11:20-11:40 ThAT1.2

A Dynamic Game Model of Optimal Stockpile Management with Price Dynamics and Constraints, pp. 571-576

Lloyd, Justin (Johns Hopkins Univ), Meyer, Gerard (Johns Hopkins Univ)

More frequently examined as optimal control problems, economic problems in the optimal management of strategic resource stockpiles can be rigorously studied and solved by formulating them as differential games between competing sovereign producers and consumers. This approach, while less studied, provides a richer and more realistic model of real world stockpiling scenarios. While existing differential game models of stockpiling problems offer varying levels of complexity, several important features have been ignored in the literature. A new model incorporating some of these details is described in this paper, as well as formulations and algorithmic approaches for identifying the Nash equilibria of the model.

11:40-12:00 ThAT1.3

Design, Automation and Control of a Two-Stage, Two-Load-Demand Experimental Refrigeration Plant, pp. 577-584

Bejarano, Guillermo (Univ. of Seville), Alfaya, José A. (Univ. of Seville), Ortega, M. G. (Univ. De Sevilla), Rubio, Francisco R. (Univ. De Sevilla)

This paper describes the design, implementation and automation of a two-stage, two-load-demand experimental refrigeration plant. The facility is fully configurable, since cycles with one or two compression stages, and one or two load demands can be set up. Detailed description of the experimental facility concerning its physical components, actuators and sensors is addressed, as well as low-level control and communication bus issues. The high-level control environment and its communication with the low-level controller are also approached. Furthermore, a well-known in industry decentralised control strategy is applied to a one-stage, two-load-demand refrigeration cycle, analysing some preliminary control results from an energy efficiency point of view.

12:00-12:20 ThAT1.4

Application of Fuzzy Control on Wastewater Treatment Plant for P-Removal, pp. 585-590

Xu, Hongyang (Escola D'enginyeria, UAB), Vilanova, Ramon (Univ. Autonoma De Barcelona)

Due to the complex and non linear character, wastewater treatment process is difficult to be controlled. And the demand for removing the pollutant, especially for nitrogen (N) and phosphorus (P), as well as reducing the cost of wastewater treatment plant (WWTP) is an important research theme. This paper presents a comparision between PI and fuzzy logic control applied to the combined phosphorus removal Benchmark Simulation Model 1 (BSM1-P) wastewater treatment process to enhance the P removal. A default control strategy which contains two control loops and is similar to the one given by the original version of BSM1 was tested on BSM1-P. In addtion, another control strategy that contains three dissolved oxygen (DO) controllers for all the aerabic tanks was also applied. For each control strategy, at first the conventional PI controllers were applied to see the performance. Secondly fuzzy logic controllers replaced the PI controllers with the popurse of enhancing P removal. The simulation results showed that both control strategies were able to improve the performance of WWTP and the application of fuzzy controllers was more beneficial for the P removal.

12:20-12:40 ThAT1.5

Characterization and Tuning of Predictive SSOD-PI Controllers, pp. 591-597

RUIZ, ÁNGEL (Univ. OF CORDOBA), Jimenez Hornero, Jorge (Univ. of Cordoba), Sánchez Moreno, José (UNED), Dormido, Sebastián (UNED)

This work proposes an event-based PI control scheme focused on FOPTD (First Order Plus Time Delay) processes with simple tuning methods. The scheme, called for short predictive SSOD-PI or PSSOD (Predictive Symmetric Send On Delta)-PI, which only considers two degree of freedom to determine the expected rate of events as well as the set-point and load disturbance rejection responses. The event-based system is characterized by defining its architecture, a stability analysis, and by providing simple ad-hoc tuning rules. Simulation results prove the effectiveness of the approach.

12:40-13:00 ThAT1.6

Event-Based Control for IPTD Processes with Simple Tuning Methods, pp. 598-604

RUIZ, ÁNGEL (Univ. OF CORDOBA), Jimenez Hornero, Jorge (Univ. of Cordoba), Sánchez Moreno, José (UNED), Dormido, Sebastián (UNED)

The event-based control of Integrator Plus Time Delay (IPTD) processes is investigated in this study. A two Degree-Of-Freedom (2-DOF) structure with simple tuning methods is proposed to cope with the set-point tracking and the load disturbance rejection tasks. A stability analysis is conducted and a simple tuning methodology is provided. Simulation results prove the effectiveness of the approach.

ThAT2 Salón Torremolinos A

Nonlinear Systems (Regular Session)

11:00-11:20 ThAT2.1

Relaxed Sufficient Conditions for Asymptotic Stability for a Class of Underdamped Nonautonomous Hamiltonian Systems, pp. 605-610

Androulidakis, Evangelos (Dept of Electrical Engineering, Univ. of Patras, Greece), Alexandridis, Antonios (Univ. of Patras)

The asymptotic stability to the origin for a class of underdamped, nonautonomous, nonlinear, Hamiltonian systems is investigated. For this class of systems, the step from stability to uniform asymptotic stability needs some hard additional conditions to hold true. In principle, these conditions are of observability type, that are difficult to be checked due to the nonlinearities and nonautonomous nature of the system. In this paper, in Proposition 1 and Corollary 1, it is proven that the required uniform observability condition can be expressed as a sufficient, time-running, matrix-rank condition. However, since to check this condition is not always an easy task, a simple but much more constrained sufficient, time-invariant rank condition can be obtained as presented in Proposition 2. An illustrative example is performed and simulated to verify the theoretical analysis.

11:20-11:40 ThAT2.2

An Algorithmic Approach for Lessening Conservativeness of Criteria Determining Absolute Stability, pp. 611-616

Materassi, Donatello (Univ. of Tennessee, Knoxville), Salapaka, Murti V. (Univ. of Minnessota)

Lur'e systems are the feedback interconnection of a linear time-invariant system with a memoryless static operator. In this paper, we derive an algorithmic method to incorporate the information given by additional Lyapunov functions in order to enlarge the estimate of the domain of attraction of a Lur'e system. The methodology, limited for simplicity to quadratic Lyapunov functions, relies on the solution of a sequence of convex optimization programs. The ideas formulated in this article have general validity and can be extended to other scenarios (for example considering Lyapunov functions in the form of a sum of squares).

11:40-12:00 ThAT2.3

Control Strategies for Ammonia Violations Removal in BSM1 for Dry, Rain and Storm Weather Conditions, pp. 617-622

Santin, Ignacio (Univ. Autonoma De Barcelona), Vilanova, Ramon (Univ. Autonoma De Barcelona), Pedret, Carles (Univ. Autonoma De Barcelona)

This paper presents a proposal with the objective of eliminating violations of ammonia nitrogen in the effluent (NHe) of a wastewater treatment process. Furthermore, improving effluent quality and reducing operating costs and the percentage of violations of total nitrogen in the effluent (Ntot,e) are also considered. The evaluation of control strategies are conducted with the Benchmark Simulation Model No 1 (BSM1). Several controllers have been proposed: Model Predictive Control (MPC) with inlet flow rate feedforward compensation (MPCFF), Fuzzy controller and Exponential, Linear and Affine Functions. MPCFF and Fuzzy controller are applied in a hierarchical structure to improve effluent quality, to reduce operational costs and to decrease NHe peaks. Exponential, Linear and Affine Functions are implemented, along with the hierarchical control structure, to avoid NHe violations. The results are presented and compared with the default control strategy of BSM1 for dry, rain and storm weahter conditions. They show that the NHe violation removal is achieved for the three weather conditions. For dry influent also an improvement of effluent quality and a reduction of operational cost are acquired. For the rain and storm cases, an increment of operational cost is required.

12:00-12:20 ThAT2.4

Temperature Control of a Solar Tower Receiver Based on the Lyapunov Method, pp. 623-628

Costa, B.Andrade (INESC-ID/IST/ TU Lisbon), Lemos, Joao M. (INESC-ID)

This article describes an approach to design a temperature controller for a solar tower receiver that receives concentrated solar energy from a field of heliostats and is employed to transfers energy to a heat transfer fluid (HTF), such as molten salt. During the operation of solar receiver, its temperature and the temperature of the HTF fluid must be controlled to obtain the maximum economical yield constrained by operational safety margins and by the designed life span of the receiver. To attain this purpose, fluid flow and the positions of the heliostats are used as manipulated variables to control the error between the temperature reference and the temperature of the fluid at the receiver outlet. The presence of disturbances is an important factor to consider during the receiver operation. They include solar energy fluctuations caused by weather conditions, presence of moving clouds, the apparent movement of the sun, and wind that can change energy losses.

The controller is designed in two steps. In the first step, the thermal stationary operating point of the solar receiver is defined and is used to build a nonlinear dynamical equation of the temperature error. In the second step, the stability of the nonlinear error dynamics, that depends on the speed of the fluid and on the concentrating power of the heliostats, is analyzed using the Lyapunov method. From this analysis the control system is defined, resulting in a nonlinear feed-forward term used to compensate the solar energy fluctuations, and a state-feedback controller that adjusts the the fluid flow to compensate temperature deviations from the temperature reference.

12:20-12:40 ThAT2.5

Extension of the Observability Rank Condition to Nonlinear Systems Driven by Unknown Inputs, pp. 629-635

Martinelli, Agostino (INRIA Rhone Alpes)

This paper investigates the unknown input observability problem in the nonlinear case under the assumption that the unknown inputs are differentiable functions of time (up to a given order). The goal is not to design new observers but to provide simple analytic conditions in order to check the weak local observability of the state. The analysis starts by providing a new definition of indistinguishable states in the case of unknown inputs. Then, in order to separate the effect of the known inputs from the effect of the unknown inputs on the system outputs, the state is augmented. This allows us to obtain the extension of basic properties, which hold in the case of known inputs. Starting from these properties, the paper provides a sufficient analytic condition for the state observability, which is called the extended observability rank condition. The proposed approach is used to derive the observability properties of two systems. The former is very simple while the latter is very complex and describes the fusion of visual and inertial measurements.

12:40-13:00 ThAT2.6

RISE-Backsteppping Feedback Control for Induction Machine in Electric Vehicle Applications, pp. 636-642

Rkhissi Kamoun, Yosra (Ec. Nationale D'ingenieurs De Sfax ENIS), Ghommam, Jawhar (ENIS), Boukhnifer, Moussa (ESTACA Paris), Mnif, Faical (Sultan Qaboos Univ)

This paper deals with the synthesis of a speed and flux control strategy for a class of motor controlcharacterized by its highly nonlinear and multivariable dynamic, induction motor drive. A new continuous control law is proposed using a combination of the backstepping design with the Robust Integral Sign of the Error (RISE) technique in the presence of additive load disturbances. The modified backstepping design is asymptotically stable in the context of Lyapunov theory under the assumptions that the disturbances are C2 class fuctions with bounded time derivatives. Moreover, the boundedness of the closed-loop signals is ensured. Simulation results are provided to illustarte the effetiveness of the proposed approach.

ThAT3 Salón Torremolinos B

Aerospace Control (Regular Session)

11:00-11:20 ThAT3.1

Visual Landing Insensitive to the Depth with Velocity and Control Constraints: A Twisting Based Solution, pp. 643-650

Burlion, Laurent (ONERA France), de Plinval, Henry (ONERA - the French Aerospace Lab)

This paper proposes a nonlinear vision based flight control law for the automatic landing of an aircraft. Although a number of methods have been proposed in this domain, our method differs by the following features. First, we do not assume knowledge of the runway size or distance from the aircraft, or the help of a ground technology to guide the aircraft. Second, this design addresses the model nonlinearities, so that it copes for initial conditions far away from the desired trajectory. Third, the control law takes input saturations into account. Fourth, it limits overshoots during the transient phase, so that the runway motion inside the videocamera image plane is limited to a minimum, and so is the risk for it to get out of the field of view. Our approach is illustrated in simulation with a simplified aircraft model. In particular good robustness properties with respect to noisy visual features are demonstrated.

11:20-11:40 ThAT3.2

Disturbance Attenuation Problem for Overactuated Systems with Actuator Saturation: A Control Allocation Based Approach, pp. 651-656

Naskar, Asim Kr (National Inst. of Tech. Rourkela (India)), Patra, Sourav (Indian Inst. of Tech. Kharagpur), Sen, Siddhartha (Indian Inst. of Tech. Kharagpur)

In this paper, a two-stage control allocation based covariance controller design method is proposed to ensure a certain level of disturbance attenuation property for a class of overactuated systems. The proposed method is equally efficient as existing single-stage design technique for assigning a state or output covariance matrix. A set of sufficient conditions has been derived for which the actuator displacements in single-stage technique and in the proposed allocation based method become same. The design steps are formulated in the linear matrix inequality framework. In the presence of actuator saturation, the allocation based method yields better closed-loop performance compared to the single-stage design technique until the level of actuator saturation remains under the attainable range of the allocator. To elucidate the effectiveness of the proposed method, two flight control design examples have been presented.

11:40-12:00 ThAT3.3

Hybrid Visual Servoing for Aerial Graspingwith Hierarchical Task-Priority Control, pp. 657-663

Buonocore, Luca Rosario (Univ. Di Napoli Federico II), Cacace, Jonathan (Univ. Di Napoli Federico II), Lippiello, Vincenzo (Univ. Di Napoli Federico II)

In this paper a hybrid visual servoing with a dynamic and hierarchical task-priority control framework is proposed for the control of an aerial vehicle endowed with a robot arm. The proposed task composition algorithm retains the main benefits of classical image-based and position-based control scheme, that can be suitably combined in a common hybrid-control framework. Moreover, the under-actuation of the vehicle base has been systematically taken into account within a general formulation, while a dynamic smooth activation/deactivation mechanism is proposed to avoid discontinuity in the control action. Simulations have been proposed to demonstrate the effectiveness of the proposed approach.

12:00-12:20 ThAT3.4

Flexible Membrane Wing Warping Using Tendon-Sheath Mechanism, pp. 664-669

Lee, Shian (Nanyang Tech. Univ), Tjahjowidodo, Tegoeh (Nanyang Tech. Univ), Moon, Seung Ki (Nanyang Tech. Univ)

Flexible membrane wings have many advantages, but has very little roll control authority. In this paper, the flexible membrane wing is actuated using a tendon-sheath mechanism to achieve roll control and also allowing the wing to fold. The characteristics of the flexible wing, as well as the wing warping actuation approach is discussed in this paper. The experimental setup and results are shown. The characteristics of the tendon-sheath is shown to be suitable for flexible wing actuation. A simple nonlinear curve fitting model is also presented.

12:20-12:40 ThAT3.5

Monocular Image Parameter-Based Aircraft Sense and Avoid, pp. 670-677

Bauer, Peter (Inst. for Computer Science and Control, HungarianAcademyof S), Vanek, Balint (The Computer and Automation Res. Inst. HungarianAcademy), Peni, Tamas (Inst. for Computer Science and Control of Hungarian Acad), Futaki, Anna (BUDAPEST Univ. OF Tech. AND Ec), Pencz, Borbala (Hungarian Acad. of Sciences Inst. for Computer Science And), Zarándy, Ákos (Computer and Automation Res. Inst), Bokor, Jozsef (Hungarian Acad. of Sciences)

This paper deals with the problem of monocular image parameter-based sense and avoid. It considers image parameters as decision variables and selects decision thresholds related to collision and non-collision scenarios. The main contribution is non-heuristic threshold selection. Another contribution is the characterization of possible intruder threats with size-speed curves given in closed form formulae. This makes it possible to avoid the use of lookup tables. The overall decision and avoidance concept is evaluated in a software-in-the-loop simulation campaign considering threats ranging from small UAV to large airliner. The miss detection rate of the method is zero which is an excellent result, however the false alarm rate is high. The causes of this are pointed out and targeted as further developments. Finally, promising results are presented executing the method for real camera images.

ThAT4 Salón Torremolinos C

Robust Control I (Regular Session)

11:00-11:20 ThAT4.1

Stochastic Linear Systems: Robust H_infty Control Via Vertex-Dependent Approach, pp. 678-683

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

We consider linear continuous-time systems with multiplicative noise and polytopic type parameter uncertainty and we address the problems of H_infty state-feedback control and filtering of these systems. These problems are solved by applying a vertex dependent Lyapunov function that considerably reduces the over-design associated with the classical "quadratic" design that is based on a single Lyapunov function for the whole parameters range. In both problems, a cost function is defined which is the expected value of the standard H_infty performance index with respect to the stochastic multiplicative parameters.

11:20-11:40 ThAT4.2

Robust D-Stability Via Discrete Controllers for Continuous Time Uncertain Systems Using LMIs with a Scalar Parameter, pp. 684-689

Leandro, Marco (Inst. Tecnológico De Aeronáutica), Kienitz, Karl Heinz (Inst. Tecnologico De Aeronautica)

This paper addresses an alternative for the synthesis of a discrete stabilizing gains, taking into account requirements of D-stability via Linear Matrix Inequalities (LMIs) with a certain scalar parameter. Considering continuous time systems with polytopic uncertainty, this paper contributes with an alternative to incorporate D-stability requirements in the H2 and Hinfty discrete time controller synthesis from continuous time D-stable regions via Euler's approximation. From these design requirements, robust controllers were designed and implemented for a case study system of two cars connected through a spring.

11:40-12:00 ThAT4.3

Robust Control Strategies of Stick-Slip Type Actuators for Fast and Accurate Nanopositioning Operations in Scanning Mode, pp. 690-695

Oubellil, Raouia (GIPSA-Lab, Grenoble INP), Voda, Alina (Joseph Fourier Univ. of Grenoble), Boudaoud, Mokrane (Pierre and Marie Curie Univ), Régnier, Stéphane (Univ. Pierre Et Marie Curie)

This paper deals with robust closed-loop control of a nano-robotic system dedicated to fast scanning probe microscopy. The nano-robotic system is actuated by piezoelectric stick-slip actuators able to produce a millimeter range displacement with a nanometer resolution. In order to meet the requirements of fast scanning in terms of closed-loop bandwidth and vibration damping, robust control strategies are studied. We first show that a commonly used one degree of freedom (1-DOF) H_infinity controller is limited to satisfy robust performances required for fast and accurate positioning of the actuators. As such, the control strategy is defined considering two closed-loops. Results show that the 2-DOF H_infinity control scheme allows robust performances for the positioning of nanorobotic systems and lead to new perspectives for fast scanning probe microscopy using stick-slip actuators.

12:00-12:20 ThAT4.4

Design of a Robust Discrete Time Sliding Mode Repetitive Controller, pp. 696-701

Mitrevska, Maria (Swinburne Univ. of Tech), Cao, Zhenwei (Swinburne Univ. of Tech), Zheng, Jinchuan (Swinburne Univ. of Tech), Kurniawan, Edi (Indonesian Inst. of Sciences)

This paper presents the design of a robust discrete-time sliding mode repetitive controller (DSMRC) which combines the features of repetitive control (RC) and sliding mode control (SMC) to achieve fast transient response, improved robustness to various matched uncertainties, and improved steady state performance. The new control structure consists of a repetitive control component and a sliding mode control part. The task of the sliding mode component is to provide a fast dynamic response and improve the robustness of the system against various uncertainties. The repetitive control part is added to the system to reduce the periodic error and improve the steady state performance of the system. A small pure phase lead component is added to the RC structure to ensure system stability and achieve high bandwidth tracking performance in the presence of bounded uncertainties. The proposed control structure is applied to a linear actuator (LA) system subjected to payload variations. A detailed analysis of the new control structure is presented in this paper to show the significance of the proposed scheme. Simulation results verify the effectiveness of the proposed method.

12:20-12:40 ThAT4.5

Robust Set Invariance and Contractivity of Discrete-Time Systems: The Generators Approach, pp. 702-706

Bitsoris, Georges (Univ. of Patras), Vassilaki, Marina (School of Pedagogical and Tech. Education)

In this paper, the problem of robust set invariance and contractivity with respect to discrete-time dynamical systems is investigated. In contrast with the usual approach consisting in describing regions of system's state space by their border surfaces, a dual description of sets in terms of a generator matrix and a, generally nonlinear, generating function is proposed. This leads to the establishment of an associated generated system whose robust set invariance and/or contractivity properties imply corresponding properties for the initial system. This general result is then applied to the development of robust set invariance and/or robust contractivity conditions for linear systems.

ThAT5 Salón Torremolinos D

Unmanned Systems I (Regular Session)

11:00-11:20 ThAT5.1

Visual Navigation of Mobile Robots for Autonomous Patrolling and Surveillance of Urban Areas, pp. 707-714

Di Fava, Alessandro (Scuola Superiore Sant'Anna), Satler, Massimo (Percro Lab, Scuola Superiore Sant'Anna), Tripicchio, Paolo (Scuola Superiore Sant'Anna)

In many applications, robots should be able to move independently in semi-structured or unstructured environments. In most cases it is useful that the robot moves through the environment without knowledge of it. In particular, autonomous robots can be employed successfully in area patrolling tasks in order to perform surveillance of sites that are difficult to reach or in order to reduce the number of personnel involved in such tasks. To autonomously navigate in an unknown outdoor scenario, a robot should be able to acquire sensible information about the environment by means of its own sensors and in the same time perform some reasoning to decide where and how to move. In this paper we present a vision-based solution for the decision making and a behavior based low level control for the navigation. Three different testing scenarios have been employed to assess the capabilities of the proposed approach: a computer simulated scenario, an indoor test on a real robotic platform and finally an outdoor test in a city park.

11:20-11:40 ThAT5.2

Sampling-Based Receding Horizon Collision-Free Control for a Class of Micro Aerial Vehicles, pp. 715-720

Alexis, Kostas (Eidgenössische Tech. Hochschule Zürich), Papachristos, Christos (Univ. of Patras), Siegwart, Roland Y. (ETH Zürich), Tzes, Anthony (Univ. of Patras)

A novel sampling-based receding horizon control strategy that guarantees collision-free navigation for a class of aerial robots is the topic of this paper. The proposed approach combines the concepts of receding horizon control and sampling-based navigation strategies in order to derive a model-based control framework, which respects input and state constraints, and achieves avoidance of any known obstacle while remaining computationally lightweight even for systems of high-order and complex, convex or non-convex obstacles and long prediction horizons. The control law is applied for the case of a multirotor Micro Aerial Vehicle that optionally also employs its capacity to direct its thrust via a rotors' tilting mechanism. Extensive simulation studies indicate that high performance collision-free navigation is achieved and reasonably long prediction horizons can be handled while remaining applicable for on-board deployment.

11:40-12:00 ThAT5.3

The Power-Over-Tether System for Powering Small UAVs: Tethering-Line Tension Control Synthesis, pp. 721-727

Zikou, Lida (Univ. of Patras), Papachristos, Christos (Univ. of Patras), Tzes, Anthony (Univ. of Patras)

Within this work, a system for remote powering of small-scale hovering Unmanned Aerial Vehicles is developed, aiming to achieve prolonged-endurance flight times in order to address possible civilian applications with such requirements. To this purpose, the key-concept of a Power-over-Tether system is proposed, with the power bank for the UAV's operation located on the ground, and power transferred via a tethering cable. In order for the UAV to be capable of executing hovering trajectories as freely as possible, a long power cable is wound onto a custom-developed base, which is capable of releasing and retracting it when necessary. The Power-over-Tether system base is developed to operate autonomously, locally sensing when the aerial vehicle requires additional length of free cable to move to its intended goal, or when excessive cable length requires retraction, and performs the respective actions. The complete implementation of the system, both hardware and control-wise is elaborated in detail within the scope of this paper. Additionally, experimental evaluation studies are conducted, demonstrating the potential of the proposed Power-over-Tether system.

12:00-12:20 ThAT5.4

Output Feedback Control of Micro Aerial Vehicle in Indoor Environment, pp. 728-734

Efraim, Hanoch (Ben Gurion Univ. of the Negev, Be'er Sheva), Arogeti, Shai (Ben-Gurion Univ. of the Negev), Shapiro, Amir (Ben-Gurion Univ. of the Negev, Mechanical Engineering Dept), Weiss, Gera (Ben Gurion Univ. of the Negev)

A novel approach for control of a Micro Air Vehicle in indoor environment (specifically within corridors) using only vision and angular velocity sensors as measuring devices is presented. The suggested controller does not include explicit attitude feedback, thus eliminating the need for accelerometers which are susceptible to vibrations, and complex attitude estimation algorithms. Furthermore, linear velocity measurement which can be difficult to achieve in indoor environment is not required to damp the system.

A model for the hovercraft and visual measurements is presented, and stability analysis of the suggested controller is performed and supported by a complete six degrees of freedom simulation.

12:20-12:40 ThAT5.5

Flat Trajectory Generation for Way-Points Relaxations and Obstacle Avoidance, pp. 735-740

Stoican, Florin (Pol. Univ. of Bucharest), PRODAN, Ionela (Grenoble Inst. of Tech. (Grenoble INP) - Esisar), Popescu, Dan (Pol. Univ. of Bucharest)

This paper addresses some alternatives to classical trajectory generation for an autonomous vehicle which needs to pass through a priori given way-points. Using differential flatness for trajectory generation and B-splines for the flat output parametrization, the current study concentrates on constraint relaxations and on obstacle avoidance conditions. The results are validated through simulations over standard UAV dynamics.

12:40-13:00 ThAT5.6

Optimal Design and Modeling of a Tilt Wing Aircraft, pp. 741-748

Lindqvist, Adrian (Luleå Univ. of Tech), Fresk, Emil (Luleå Univ. of Tech), Nikolakopoulos, George (Luleå Univ. of Tech. Sweden)

The aim of this article is to present an optimal model for the behaviour of a tilt wing aircraft during its transition state. A tilt wing aircraft is a hybrid between a helicopter and a plane, which has the capabilities of both parts, meaning that it can stand still and hover and by tilting its wing 90 degrees to act like a regular plane. Overall, a tilt rotor aircraft has the extended merits of vertical take offs and landings, to stand still and hover in mid air, while being able to travel in long distances efficiently. The novelty of this article stems from: a) the analysis of the aircraft during the transition between helicopter mode and plane for the angles between 0-90 degrees, b) the comparison between the model extracted from the simulations and tests from a wind tunnel, and c) the proposal for an optimal design for a tilt wing UAV. The efficiency of the proposed modeling approach has been evaluated in multiple simulated and experimental verifications.

ThBT1 Salón Málaga

OPTIMIZATION (Regular Session)

14:30-14:50 ThBT1.1

Support Vector Machines for Determination of an Operational Strategy for Hybrid Electric Vehicles, pp. 749-754

Innerwinkler, Pamela (VIRTUAL VEHICLE Res. Center), Ebner, Wolfgang (VIRTUAL VEHICLE Res. Center), Stolz, Michael (VIRTUAL VEHICLE Res. Center)

In this paper a data driven operational strategy for a hybrid electric vehicle (HEV) is developed. There are two big benefits of the proposed approach: The possibility of real-time implementation within embedded control units and the high potential for automated calibration. Starting point is a user defined set of fuel-optimized driving cycles for a hybrid vehicle, which is generated applying e.g. state of the art dynamic programming techniques. From this data the introduced methodology extracts a control strategy that determines the torque-split factor for a given driving situation. The approach is based on a combination of optimization and classification, as well as regression strategies. The data created by a dynamic programming algorithm (DP) is used to train support vector machines (SVMs) in order to get rid of the necessity of a-priori knowledge of the whole driving cycle. From the resulting functions a control law is derived that is able to identify a suitable torque-split factor, independent of the further driving course. Since reducing the information input into the control law will per definition reduce performance, validation of the methodology is based on comparison with optimized driving cycles generated by dynamic programming that use the whole driving cycle information.

14:50-15:10 ThBT1.2

Nash Tuning for Optimal Balance of the Servo/Regulation Operation in Robust PID Control, pp. 755-761

Sanchez Corrales, Helem Sabina (Univ. Autonoma De Barcelona), Visioli, Antonio (Univ. of Brescia), Vilanova, Ramon (Univ. Autonoma De Barcelona)

In this paper we propose a multi-objective optimization approach for the tuning of one degree-of-freedom proportional-integral-derivative controllers where both the trade-off between the servo and regulation operation modes and the trade-off between performance and robustness are considered. After having quantified the loss of performance that occurs when robustness is taken into account in the optimal design of the controller a tuning rule is proposed based on the Nash solution. A balanced robust tuning is obtained simply starting from a first-order-plus-dead-time model of the (self-regulating) process.

15:10-15:30 ThBT1.3

On Guaranteeing Passivity and Performance with a Human Controller, pp. 762-767

Xia, Meng (Univ. of Notre Dame), Rahnama, Arash (Univ. of Notre Dame), Wang, Shige (General Motors R&D), Antsaklis, Panos J. (Univ. of Notre Dame)

While designing controllers that guarantee the passivity of a closed loop system has a long history, much less attention has been paid to the situation when the control actions are performed by a human. We consider as an example a human who is driving a car. The behavior of human controllers as drivers has been modeled in the literature as a linear time invariant system cascaded with a time delay. We show that such a human model is not passive. In order to guarantee passivity of a closed loop system with a human controller, we use a passivation method. Through an appropriate design of the passivation parameters, positive passivity indices can be guaranteed for the closed loop system. The passivation parameters can be selected by solving an optimization problem such as minimizing the tracking error. To validate our theory, we provide simulation results in CarSim and Simulink.

15:30-15:50 ThBT1.4

A Robust Eigenvalue Assignment Approach to Integrated System and Control Design, pp. 768-773

Stein, Gregor Lukas (Tech. Univ. Darmstadt), Strubel, Jan (Tech. Univ. Darmstadt), Konigorski, U. (Tech. Univ. Darmstadt)

In this contribution parameterizations of constant state feedback controllers are given that assign the closed-loop eigenvalues of a linear system to predefined locations and encompass, besides the degrees of freedom due to the controller, freedom in the choice of system parameters. These parameterizations are subsequently used in an optimization procedure in order to simultaneously obtain a controller and assign the degrees of freedom available in system design for robust and minimum gain eigenvalue assignment.

15:50-16:10 ThBT1.5

State of Charge Estimation Based on Extened Kalman Filter Algorithm Forlithium-Ion Battery, pp. 774-779

KAMAL, ELKhatib (Lab. D'automatique, Génie Informatique Etsignal, CNRS, Lil), El Hajjaji, Ahmed (Univ. De Picardie-Jules Verne)

Estimation of the state of charge (SOC) is a critical parameter for the control of propulsion systems in plug-in hybrid electric vehicles (PHEV) and the electric vehicles (EVs). This paper proposes the SOC estimator of a Lithium-Ion battery using the adaptive extended Kalman filter (EKF). This method uses an optimization algorithm to update the EKF model parameters during a charge period. Accurate knowledge of the nonlinear relationship between the open circuit voltage (OCV) and the SOC is required for adaptive SOC tracking during battery usage. EKF is employed to estimate the SOC by considering it as one of the states of the battery system. The dynamic model structure adopted is based on an equivalent circuit model whose parameters are scheduled on the SOC, temperature, and current direction. The validity of the procedure is demonstrated experimentally for an A123 systems' APR18650m1 LiFePO4 battery.

16:10-16:30 ThBT1.6

Incorporating Feedback Predictions for Optimized UAV Attack Mission Planning, pp. 780-786

Jardine, Peter Travis (Royal Military Coll. of Canada), Givigi, Sidney (Royal Military Coll. of Canada), Noureldin, Aboelmagd (Royal Military Coll. of Canada)

This study investigates Unmanned Aerial Vehicle (UAV) motion planning for ground attack missions involving enemy defenses. The UAV dynamics are modelled as a unicycle, linearized using dynamic extension and extended over a finite horizon as a piece-wise affine function. This is then formulated as a constrained, convex optimization problem in the form of Model Predictive Control (MPC) using closed-loop feedback predictions. Avoidance of enemy defenses is achieved using linear inequality constraints. The design is tested in a simulated ground attack scenario involving a layered enemy defense system using MATLAB. Preliminary results demonstrate the feasibility of using MPC to guide a UAV in ground attack missions involving complex enemy defenses.

ThBT2 Salón Torremolinos A

Image Processing (Regular Session)

14:30-14:50 ThBT2.1

Automatic Detection of Surgical Gauzes Using Computer Vision, pp. 787-791

Garcia Martinez, Alvaro (Miguel Hernandez Univ), Juan, Carlos G. (Miguel Hernández Univ), Garcia, Nicolas M. (Univ. Miguel Hernandez), Sabater, Jose M. (Univ. Miguel Hernandez)

In this paper we study the effectiveness of different algorithms for texture classification based on the Local Binary Patterns method, in order to obtain in future a tracking system for surgical gauzes during a laparoscopic operation. Due to the mobility of the camera and the lack of a precise control over its position, the algorithms must work under unknown illumination and viewpoint parameters. Our intention is to provide to surgeons a simple tracking system in order to avoid mislaid gauzes during the operations, which might be completely unattended so that the surgical team can concentrate on the patient and not on the gauze counting. Due to blood stains, color classification it is not possible, also we cannot use the shape of the gauze, neither its position relative to the camera nor its size. So, the only possibility is to obtain a texture classification algorithm able to discriminate between the gauze surface and the background of the scene, i. e. the interior of the patient, laparoscopic tools and whatever is not a surgical gauze. For this purpose we try a few operators, looking for an algorithm for gray-scale texture classification. We apply the rotation invariant of the well-known Local Binary Pattern (LBPriu2), an improved version (NI-LBPriu2) and a control operator consisting of a direct comparison between the histogram of a region of interest and the histogram of a reference image, which we call GauzeTrack Local Histograms Algorithm. All mentioned algorithms have been applied both on test textures and images extracted from a video of a real laparoscopic surgery. This way we could ensure that the proposed method works on a real situation and not only in the laboratory.

14:50-15:10 ThBT2.2

Fast 3D Object Matching with Projection Density Energy, pp. 792-798

Kechagias Stamatis, Odysseas (Cranfield Univ), Aouf, Nabil (Cranfield Univ)

We present a novel real time 3D Automatic Target Recognition algorithm appropriate for LIDAR based time critical applications. Its main contribution is the Constant False Alarm Rate adaptive threshold combined with the Projection Density Energy and the transformation of the 3D problem into multiple 2Ds. Our approach is invariant to 3D rotations combined with scale change, Gaussian noise and uniform sparse representation of the target. Applied on real targets from the UWA dataset and on military targets from the Princeton shape benchmark, we obtained 90% recognition in 77ms and 97% in 106ms respectively (in Matlab). Our approach could be considered by the Defence Community as an initial step towards LIDAR based missile seekers where data is inversely proportional to the available time to perform recognition.

15:10-15:30 ThBT2.3

A Low-Cost Stereoscopic μ P-Based Vision System for Industrial Light Objects Grasping, pp. 799-805

Kanellakis, Christoforos (Uviversity of Patras), Kyritsis, George (Uviversity of Patras), Tsilomitrou, Ourania (Univ. of Patras), Manesis, Stamatis (Univ. of Patras)

This article describes a vision-based manipulation process for real-time moving objects tracking and grasping, aiming at industrial manufacturing and assembling applications. The adoption of computer vision techniques for object recognition is implemented by means of a stereoscopic system using color based methods under OpenCV libraries. The visual software is directly coupled with the control software of the robotic arm Katana 6M90G manufactured by Neuronics AG, running under a Linux-based Operating System (OS) distribution Lubuntu, over a low-cost and powerful microprocessor Odroid U3. Experimental studies validate the effectiveness of the implementation, while remarking the advantageous effects of the 3D pose estimation process.

15:30-15:50 ThBT2.4

Occupancy Grids Generation Based on Geometric-Featured Voxel Maps, pp. 806-811

Plaza-Leiva, Victoria (Univ. De Málaga), Gomez-Ruiz, Jose Antonio (Univ. De Málaga), Ababsa, Fakhr-Eddine (Evry Univ), Garcia-Cerezo, A. (Univ. De Malaga), Mandow, Anthony (Univ. De Málaga)

Navigability assessment is useful for planning obstacles free trajectories in autonomous navigation tasks in 3D environments. Based on Geometric-Featured Voxel (GFV) maps developed in previous works, this paper proposes a method for 2D occupancy grid generation which is efficient for local navigation in natural environments. Built from a point cloud, a GFV map consists of voxels that are classified as tubular, planar, or scatter depending on the local spatial distribution of their inner points. Besides, each voxel is labelled as ground or non-ground considering slopes and rough surfaces found in unstructured scenarios. The proposed 2D occupancy grid represents accessible areas by considering the attributes and the height of each voxel over the ground level in relation to vehicle dimensions. The paper presents experimental results with 3D laser scans in natural environments.

15:50-16:10 ThBT2.5

Set-Based Direct Visual Servoing for Nanopositioning, pp. 812-816

Liu, Zhichao (Nanyang Tech. Univ), Wang, Jianliang (Nanyang Tech. Univ), Poh, Eng Kee (Nanyang Tech. Univ)

Atomic force microscopy (AFM) can be used as an image tool in nanoscale for nanopositioning and other similar works. This problem can be seen as a visual servoing problem. Traditional works for this problem use position-based algorithms, however, the correspondence problem is needed to be solved by feature matching and tracking firstly, as a prerequisite for vision-based control. The correspondence problem refers to the problem of ascertaining which parts of one image correspond to which parts of another image. To solve the problem of AFM based nanomanipulations, we present a novel set-based direct visual servoing controller (SDVSC) for nanopositioning that is based on the whole gray image and does not require feature matching and tracking.

ThBT3 Salón Torremolinos B

Renewable Energy and Sustainability (Regular Session)

14:30-14:50 ThBT3.1

Efficiency Boosting for PV Systems Using New MPPT Method, pp. 817-822

Farhat, Maissa (Univ. Del País Vasco), Barambones, Oscar (Basque Country Univ), Sbita, Lassaad (National Engineering School of Gabes (ENIG), Tunisia)

In this paper a PV system topology incorporating a new maximum power point tracking controller (MPPT) method using a PI controller

is studied. The controller is formulated based on the bijectivity in the PV generator (PVG) characteristic; therefore if the optimal voltage is reached, this means that the maximum of power is obtained. The proposed MPPT algorithm is implemented on a dSpace DS1104 controller board. In order to demonstrate the efficiency of the proposed algorithm in real time, an experimental setup using a boost converter connected to a resistive load is successfully implemented and studied. The obtained experimental results prove the validity of the proposed MPPT algorithm.

15:10-15:30 ThBT3.3

System of Systems Theory As a New Perspective on Building Control, pp. 823-828

Schild, Thomas (RWTH Aachen Univ)

Energy efficiency of buildings has been identified as a core element in facing the climate change and the scarcity of energy resources. The energy supply system for a building is, especially with view on thermal interrelations, a highly complex and heterogeneous system that emerges jointly with the building construction, the user´s behavior, the weather conditions and the surrounding energy and price policy to a real system-of-system. The building control system as the “intelligent instance” of the System of Systems (SoS) takes a special role in realizing the potential of the joint operating constituent systems due to the energy efficiency of the building or district. We apply SoS as an innovative engineering approach to a complex energy system.

15:30-15:50 ThBT3.4

Loop-Shaping Control of High-Step Converters for Fuel-Cell Applications, pp. 829-835

Diaz-Saldierna, Luis Humberto (Inst. Potosino De Investigacion Cientifica Y), Langarica Cordoba, Diego (The Inst. for Scientific and Tech. Res. of San L), Leyva-Ramos, Jesus (Inst. Potosino De Investigación Cientifica Y Tecnológica)

Fuel-cell stacks are an attractive option for power generation; however, this technology presents some drawbacks as slow dynamic response and low unregulated DC output voltage, which depends nonlinearly on the output current. In this paper, a quadratic boost converter with a single active switch is proposed as an interface between a PEM fuel-cell stack and a load. The proposed topology is used to increase the output load voltage for a given stack-converter-load system, aiming to ensure high conversion ratios. In addition, a loop-shaping average current-mode scheme using a single control signal is proposed for load-side voltage regulation. A selection procedure for controller parameters ensuring system stability and output voltage regulation is established. Experimental results are shown in a 220 V @ 400 W prototype. Finally, system stability is verified via experimental frequency response and controller performance is tested by applying step changes in the load.

15:50-16:10 ThBT3.5

Solar Membrane Distillation: A Control Perspective, pp. 836-842

Gil, Juan Diego (Univ. of Almería), Ruiz-Aguirre, Alba (Plataforma Solar De Almería - CIEMAT), Roca, Lidia (Psa - Ciemat), Zaragoza, Guillermo (PSA-CIEMAT), Berenguel, Manuel (Univ. of Almeria)

This paper presents a preliminary architecture for controlling solar membrane distillation facilities. Membrane distillation (MD) is a desalination technology under investigation, without industrial applications and with only few pilot systems. There is a general lack of information on how these systems perform during real solar-powered operation and how distillate quality deteriorates under intermittent conditions. One of the few systems that have been fully described in literature is the MD-solar pilot plant in Plataforma Solar de Almería (PSA), Spain. This paper presents a first step towards an optimal automatic operation of this system through the definition of operation modes and basic control loops. A discussion of control schemes to be implemented in the near future is also included in this work.

16:10-16:30 ThBT3.6

Real-Time Estimation of Thermal Comfort Indices in an Office Building with a Solar Powered HVAC System, pp. 843-848

RUZ, MARIO L. (Univ. OF CORDOBA. DEPARTMENT OF COMPUTER SCIENCE AND NUMERI), FRAGOSO, SERGIO (Univ. OF CORDOBA. DEPARTMENT OF COMPUTER SCIENCE AND NUMERI), Rodriguez Cantalejo, Rafael David (Univ. OF CORDOBA. DEPARTMENT OF COMPUTER SCIENCE AND NUME), Vazquez, Francisco (Univ. De Córdoba)

This paper presents an interactive software tool to monitor in real-time thermal comfort in buildings. Specifically, the tool is used to estimate predicted mean vote (PMV) and predicted percentage dissatisfied (PPD) indices, which are widely accepted in the framework of thermal comfort and recognized by international standards. In this work, the tool was tested in an office building with an HVAC system based on solar energy. To perform this task, a network architecture that enables communication between different protocols is proposed, with a TCP/IP-Modbus gateway and a web server as the main elements, providing in this way external connectivity and data collection from different sensors. The tool communicates remotely with the renewable system and proposes corrective control indications to maintain the indoor-air conditions inside the optimal comfort range.

ThBT4 Salón Torremolinos C

IDENTIFICATION (Regular Session)

14:30-14:50 ThBT4.1

AR + Noise versus AR and ARMA Models in SHM-Oriented Identification, pp. 849-854

Guidorzi, Roberto (Univ. of Bologna), Diversi, Roberto (Univ. of Bologna), Vincenzi, Loris (Univ. of Modena and Reggio Emilia), Simioli, Vittorio (Teleco SpA)

The most common approach in Structural Health Monitoring (SHM) consists in performing accelerometric measures of the response of the monitored structures to natural or artificial stimuli (e.g. wind, urban traffic, seismic events etc.) and in modeling the dynamic behavior of the structure on the basis of these measures. The models can be used, in particular, to extract and compare the main modes i.e. the main resonant frequencies and in comparing these frequencies with those concerning the initial state of integrity of the building. This paper compares the results given by traditional AR and ARMA models with those offered by AR+noise models where an additive observation error is considered and shows that these models can offer some advantages in SHM applications in that describe more accurately the stochastic context of the process. The comparisons have been performed on two different sets of data: the first one has been collected on an industrial building in occasion of an heavy seismic event whereas the second one has been collected on a medieval tower excited by urban traffic.

14:50-15:10 ThBT4.2

Dynamical Metabolic Modelling for Lipid Accumulation by Yarrowia Lipolytica Growing on Glucose, pp. 855-860

Robles-Rodriguez, Carlos Eduardo (INSA), Guillouet, Stéphane (INSA Toulouse), Bideaux, Carine (INSA Toulouse), Roux, Gilles (LAAS-CNRS), Gorret, Nathalie (INSA Toulouse), Hulin, Sébastien (TEREOS), Molina-Jouve, Carole (INSA Toulouse), Aceves-Lara, Cesar Arturo (INSA-Toulouse)

The oleaginous yeast Yarrowia lipolytica has been extensively studied due to its capacity to accumulate great amounts of lipids triggered by the excess of the carbon source and the limitation of nitrogen. However, under these conditions this yeast can also produce citric acid, which decreases lipid conversion yield. Few dynamical models are only available to describe lipid metabolism based on mass balances and different kinetic configurations. Nevertheless, cybernetic modeling has allowed extending optimization through the inclusion of internal regulation to identify the controlling steps and metabolic fluxes. In the present work a dynamic metabolic model was developed and applied with two variations, and was compared with experimental data carried out in fed-batch cultures of yeast Y. lipolytica on glucose as carbon source. Two independent data sets regarding nitrogen limitation and deficiency were used for parameter estimation. Results show a

good fit of parameters on describing the dynamics of lipids and citric acid production.

15:10-15:30 ThBT4.3

Realizing System Poles Identification on the Unit Disc Based on the Fourier Trasform of Laguerre−coefficients, pp. 861-866

Gőzse, István (Computer and Automation Res. Inst. HungarianAcademy Of), Soumelidis, Alexandros (Comp. and Automation Res. Inst)

This paper proposes a new method of identifica- tion of the poles in a discrete linear system from frequency domain data. The discrete rational transfer function is repre- sented in a rational Laguerre basis, where the basis elements can be expressed by powers of the Blaschke–function. Laguerre coefficients are considered as a sum of oscillating signals what gives the opportunity to estimate the number and place of poles of the system by the Fourier trasform of the Laguerre– coefficients. The behavior of the method is analyzed in the presence of noise in the measurements and an example is presented as an illustration of the full procedure.

15:30-15:50 ThBT4.4

Identification of Flexible Wing Aircraft Models Using Hyperbolic Metrics, pp. 867-872

Soumelidis, Alexandros (Comp. and Automation Res. Inst), Szabo, Zoltan (Mta Sztaki), Seiler, Peter (Univ. of Minnesota), Bokor, Jozsef (Hungarian Acad. of Sciences), Gupta, Abhineet (Univ. of Minnesota)

This paper proposes a novel discrete time identification method for flexible wing aircraft models from simulated data. The special properties of the dynamics arise from the fact that all the poles are located very close to the unit circle and their location changes with the flight velocity. Using identification criteria based on Euclidean metrics suffers from the problem of obtaining instability in the search and also on the possible high number of poles. The paper offers an alternative approach and associated identification method to obtain the poles directly using Laguerre--representation of the impulse responses and hyperbolic metrics for identification criteria. The method utilises the hyperbolic geometrical properties of the descriptions of discrete--time signals and systems on the unit disc, and is strictly connected to the representations in rational orthogonal bases. Beyond the conceptual clarity, examples also confirm that it forms an adequate basis for estimating poles of systems as a significant part of an identification process.

15:50-16:10 ThBT4.5

Combined Stochastic and Deterministic Interval Predictor for Time-Varying Systems, pp. 873-879

Bravo, Jose Manuel (Huelva Univ), Alamo, Teodoro (Univ. De Sevilla), Gegundez, Manuel Emilio (Univ. De Huelva), Marín, Diego (Univ. De Huelva)

This work proposes a new interval predictor for time-varying linear systems. An interval predictor is a method that provides an interval as outer estimation of the future system output. The center of the interval prediction can be used as point or nominal prediction. This interval center is obtained by a linear combination of stored past outputs. The interval width is obtained using an outer bound of the prediction error. Deterministic or Stochastic assumptions has been considered in the literature the outer bound. The novelty of this work is to use a combined deterministic and stochastic assumption on this bound to obtain the interval prediction. The aim is to achieve a low error in the central prediction and a small interval width. An example is provided to illustrate the improvement provided by the proposed predictor.

16:10-16:30 ThBT4.6

Neural Network Identification of Wastewater Treatment Plant, pp. 880-886

Liu, Qi (Univ. Autonoma De Barcelona), Ibeas, Asier (Univ. Autonoma De Barcelona), Vilanova, Ramon (Univ. Autonoma De Barcelona)

Wastewater treatment plants (WWTPs) are highly complex systems. Therefore, it is difficult to predict the key parameters of water quality. Researches show that feed-forward neural networks have strong ability to approximate nonlinear functions. In order to predict the parameters of water quality, this paper proposes a modeling method by using artificial neural networks to predict the effluent quantity, including the concentration of chemical oxygen demand, biological oxygen demand and total suspended solid. The appropriate architecture of ANN models is determined through several steps of training and testing of the model. The performance of the artificial neural network model was assessed through the correlation coefficient (R) and mean square error (MSE). The results demonstrate that the proposed modeling method is effective and useful.

ThBT5 Salón Torremolinos D

Unmanned Systems Ii (Regular Session)

14:30-14:50 ThBT5.1

Collision Avoidance Strategies for Quadrotors in Tight Formation Flying, pp. 887-892

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

The paper proposes controllers for a multi-quadrotor system that flies in a tight rigid formation. The considered model of the aerial vehicle are highly nonlinear. We propose a control strategy for avoiding collision between neighboring vehicles. The collision avoidance strategy applies in particular the flatness property of the considered system. Simulation results which demonstrate the controller effectiveness, are presented.

14:50-15:10 ThBT5.2

Design, Modeling and Control of a 5-DoF Light-Weight Robot Arm for Aerial Manipulation, pp. 893-898

Bellicoso, Carmine Dario (ETH Zurich, Autonomous Systems Lab), Buonocore, Luca Rosario (Univ. Di Napoli Federico II), Lippiello, Vincenzo (Univ. Di Napoli Federico II), Siciliano, Bruno (Univ. Degli Studi Di Napoli Federico II)

The design, modeling and control of a 5 degrees-of-freedom light-weight robot manipulator is presented in this paper. The proposed robot arm, named Prisma Ultra-Lightweight 5 ARm (PUL5AR), is employed to execute manipulation tasks equipped on board of a vertical take-off and landing unmanned aerial vehicle. The arm is compact and light-weight. Its mechanics is designed such that it can fold on itself during landing manoeuvres. Moreover, the design is conceived to constrain the center of gravity of the arm as close as possible to vehicle base, thus reducing the total inertia and static unbalancing of the system. Experimental tests have been carried out in order to validate the dynamic model, the communication library, the developed electronics, and the control schemes implemented for the designed robot arm.

15:10-15:30 ThBT5.3

Robust Control for Multi-Model Planar Robots Coordination, pp. 899-904

Jimenez-Lizarraga, Manuel (Univ. Autonoma De Nuevo Leon), Chapa, Ricardo (Autonomous Univ. of Nuevo Leon, San Nicolas, Nuevo Leon, Me), Rodriguez, Celeste (Autonomous Univ. of Nuevo Leon, San Nicolas, Nuevo Leon, Me), Arellano, Hever (Inst. Tecnologico De Nuevo Leon Mexico,), Castillo, Pedro (Unviersité De Tech. De Compiègne)

This paper proposes a robust control for the coordination of planar mobile robots based on Zero-Sum uncertain differential game model. The parameters describing the dynamics of the individual robots depend on a vector of unknown parameters, which belongs to a finite parametric set, and the solution is given in terms of the worst-case scenario. Each robot control input is associated with the worst or least favourable value of the unknown parameter. Based on the concept of robust optimality, a closed form for the robust control is provided. In the proposed coordination scheme one of the robots takes the leader role following a prescribed trajectory while the others agents follow him in a robust way. A numerical example is provided to illustrate effectiveness of the approach.

15:30-15:50 ThBT5.4

Multi-Rotor Robust Trajectory Tracking, pp. 905-910

Gil-Martínez, Montserrat (Univ. of La Rioja), Rico-Azagra, Javier (Univ. of La Rioja)

This paper develops a position control strategy of a multi-rotor system, which moves from an X-Y way-point to another at constant maximum-achievable velocity, and follows rectilinear trajectories between way-points with slight deviations during transients. In achieving this, 2D-spatial displacement breaks down in time domain ramp tracking on each axis through a trajectory generation block. Then, both axis set-points are driven to model matching feedback control structures that compute the roll and pitch angles commands. Main feedback control challenges are addressing a large model uncertainty identified for the inner attitude-controlled multi-copter, and a small control-bandwidth due to angle-saturation and due to processor sample-time. In this framework the Quantitative Feedback Theory has succeed in the robust design of feedback and feed-forward control elements. Some final tests demonstrate the expected spatial and time domain performances.

15:50-16:10 ThBT5.5

Implementation of Unmanned Ground Vehicle Navigation in Wireless Sensor and Actuator Networks, pp. 911-916

Li, Jianfeng (Louisiana Tech. Univ), Selmic, Rastko R. (Louisiana Tech. Univ)

We present implementation and experimental results of an Unmanned Ground Vehicle (UGV) navigation in a coordinate-free Wireless Sensor and Actuator Network (WSAN) environment. The UGV communicates with the network of sensors and actuators and receives the real-time feedback from the network, which navigates the UGV towards target(s). The control objective is to navigate the UGV towards fixed targets in the network. The Cricket system is used as a platform for the WSAN. The UGV is equipped with an on-board computer and an array of sensor listeners that communicate with the network of actuator beacons. Presented solution and algorithms are distributed where the UGV receives the feedback only from the neighboring sensor and actuator nodes. The results are compared with an optimal navigation path between starting point and the final destination.

ThCT1 Salón Málaga

Discrete Events and Automation (Regular Session)

17:00-17:20 ThCT1.1

Effects of Permanent Bounded Cyber Attacks on Networked Control Systems, pp. 917-922

Gerard, Benjamin (SNT, Univ. Du Luxembourg), Voos, Holger (Univ. of Luxembourg), LI, Yumei (Univ. of Luxembourg), Darouach, Mohamed (CRAN CNRS UMR 7039, Unviversité De Lorraine)

In this paper, the problem of permanent bounded cyber attacks on networked control systems is treated from a control systems perspective. After a characterization of malicious cyber attacks, the class of permanent bounded cyber attacks is defined and the impact of two types of these attacks is investigated and proved. The first type is the step attack on systems with an invariant zero with zero real part while the second type is the so called free attack. Simulation examples demonstrate the obtained results.

17:20-17:40 ThCT1.2

Modelling Spatial Surface Pellet Distribution from Rotary Pneumatic Feed Spreaders, pp. 923-928

Skøien, Kristoffer Rist (Norwegian Univ. of Science and Tech. NTNU), Alver, Morten Omholt (SINTEF Fisheries and Aquaculture), Alfredsen, Jo Arve (Norwegian Univ. of Science and Tech. NTNU)

This paper presents a combined robotic and external ballistic model to predict the feed pellet distribution pattern across the water surface generated by a pneumatic rotary feed spreader commonly used in sea cage aquaculture. Results from experimental studies have been used to parameterize and validate the model. The model can be applied to evaluate spreader performance under varying operational conditions as well as exploring alternative spreader designs and configurations in order to optimize pellet distribution and feed utilization with respect to fish growth and welfare.

17:40-18:00 ThCT1.3

A Model-Based Embedded Control Hardware/software Co-Design Approach for Optimized Sensor Selection of Industrial Systems, pp. 929-934

Deliparaschos, Kyriakos (Cut, Tcd), Michail, Konstantinos (Cyprus Univ. of Tech), Tzafestas, Spyros (National Tech. Univ. of Athens), Zolotas, Argyrios (Univ. of Lincoln)

In this work, a Field Programmable Gate Array (FPGA)-based embedded software platform coupled with a software-based plant, forming a Hardware-In-the-Loop (HIL), is used to validate a systematic sensor selection framework. The systematic sensor selection framework combines multi-objective optimization, Linear-Quadratic-Gaussian (LQG) control, and the nonlinear model of a maglev suspension. The physical process that represents the suspension plant is realized in a high-level system modeling environment, while the LQG controller is implemented on an FPGA. FPGAs allow to rapidly evaluate algorithms and test designs under real-world scenarios avoiding heavy time penalty associated with Hardware Description Language (HDL) simulators. In addition, the HIL technique implemented has shown a significant speed-up in the required execution time when compared to the software-based model.

18:00-18:20 ThCT1.4

A Simulation Model for a Cash Concentration and Disbursements System, pp. 935-942

Herrera, Carlos Antonio (Univ. Autónoma De Barcelona, Univ. Nacional Experime), Ibeas, Asier (Univ. Autonoma De Barcelona)

This paper presents a simulation model for a Cash Concentration and Disbursements System (CCDS) seen as an inventory management system, based on difference equations and systems engineering techniques. The model assumes the existence of delays due to banking procedures and analyzes the application of the zero balance accounts concept. The case of a generic company whose agencies are geographically distributed in different regions is proposed. The model assumes the existence of a centrally operated main account and minimum balance policy. This account receives money transfers from the revenues accounts of each agency and, also from the main account, money is transferred to the agencies' expense accounts in order to cover overdrafts. There exist an investment account into which any cash surpluses of the main account are deposited and a credit line in order to avoid the cash deficits. The operating rules for the CCDS are defined, and income and financial costs involved are considered. The model represents the flow of money between the identified elements of the system and the flow of money requirements or transfer orders. An equivalent model represented by algebraic equations through the Z-transform is derived, which opens perspectives for using rigorous control techniques in the field of finance.

18:20-18:40 ThCT1.5

A Unifying Decision-Making Framework to Study Secrecy in Decentralized Discrete Event Systems, pp. 943-950

Khoumsi, Ahmed (Univ. of Sherbrooke)

A discrete-event system (DES) based model has been recently developed to study secrecy, that is, how an information-flow property of a system can be kept secret from observers. With such a model, a DES is observed partially by observers, and secrecy preservation of a property (on information-flow) is modeled as the impossibility for observers to determine whether executed event sequences belong or not to a given language. This model of secrecy has then been adopted to study secrecy by using a Unifying Decision-Making Framework (UDMF) which has been recently developed; a centralized architecture has been used. In the present paper, we generalize the study with decentralized architectures, and compare our results with those obtained with a centralized architecture.

ThCT2 Salón Torremolinos A

Real-Time Control (Regular Session)

17:00-17:20 ThCT2.1

A New Practical ARC-Shaped Fractional Order Hold, pp. 951-955

Babazadeh, Mehrdad (Univ. of Zanjan), garcia, Jorge (Vestas), Lang, Walter (Univ. of Bremen)

This paper proposes a pair of new order hold techniques, Averaging method and Arc-Shaped fractional order hold which offer better approximation to a continuous time analog signal, after being sampled. To prove superiority, different order hold methods such as Zero Order Hold (ZOH), First Order Hold (FOH) and an existing improved fractional order hold are evaluated primarily. Furthermore, an automatic selective technique is introduced which can include all the benefits of the existing methods in a simple way to achieve better performance of discretization procedure. The capability of the new approach is tested by using a set of real environmental data.

17:20-17:40 ThCT2.2

A Fusion Fuzzy PID Controller with Real-Time Implementation on a Ship Course Control System, pp. 956-960

Liu, Sheng (Harbin Engineering Univ), Xing, Bowen (Univ. of Notre Dame), Zhu, Wanlu (Mississippi State Univ)

A Fuzzy PID fusion controller is designed through continuous updating of its output scaling factor. Instead of using a unitary Fuzzy or PID algorithm, a fusion weighted summation rule bases are used in parallel which improved performance of the proposed fuzzy PID controllers compared to others. Its effectiveness is studied through simulation as well as real-time experimentation in a distributed controller on a ship course control system.

17:40-18:00 ThCT2.3

Fixed Order H_∞ Controller for Quarter Car Active Suspension System, pp. 961-966

erol, bilal (Yildiz Tech. Univ), Delibasi, Akin (Yildiz Tech. Univ)

This paper presents an LMI based fixed-order controller design for quarter car active suspension system in order to ensure H_∞ performance and the stability in the predefined D-Region. The simulation results and dynamic response of the real system show the effectiveness of proposed method over improvements on ride comfort. The proposed low-order controller is compared with full-order one in simulation and application phases. The advantages of using low-order controller contrary to high-order one are discussed.

18:00-18:20 ThCT2.4

Control of Disturbed Systems with Measurement Delays: Application to Quadrotor Vehicles, pp. 967-972

Sanz-Diaz, Ricardo (Inst. De Automática E Informática Industrial Univ. Pol), Garcia Gil, Pedro José (Univ. Pol. De Valencia), Zhong, Qing-Chang (The Univ. of Sheffield), Albertos, Pedro (Univ. Pol. De Valencia)

Disturbances and uncertainties make very difficult the control of Unmanned Aerial Vehicles (UAV). The problem is even worse, if delays are involved in the process. The uncertainty and disturbance estimator (UDE) is a technique based on the idea that the unknown dynamics and disturbances of a system can be accurately approximated by passing them through a filter with the appropriate bandwidth. This makes it very easy to design and tune a controller to deal with uncertainties and disturbances. But this solution is very sensitive to time delays. In this paper, this strategy is further developed for systems with measurement delays and hence the range of systems for which it can be applied is broadened.

18:20-18:40 ThCT2.5

Extremum-Seeking Control with Anticipative Action of Microbial Fuel Cell's Power, pp. 973-979

Kebir, Anouer (École De Tech. Supérieure), Woodward, Lyne (École De Tech. Supérieure), Akhrif, Ouassima (Ec. De Tech. Superieure)

During the last decade, the microbial fuel cell (MFC) has been considered as a promising solution to produce renewable energy while reducing the excessive consumption of electrical energy in wastewater treatment centers. One of the problems facing the use of an MFC as a battery is the fact that its internal resistance varies with various external sources of disturbances causing a variation in its optimal point of operation. In this case the use of a real-time optimization method is necessary for the battery to work at its optimum. Extremum seeking control (ESC) can be applied to optimize the system. However, in the case where important external disturbances cause rapid changes in the optimal operating point, ESC converges to a point other than the desired optimum because of its very slow convergence rate. In this paper, a method which judiciously combines an ESC routine with a neural-network based anticipatory action is proposed. The anticipatory action takes into account a measurable external disturbance, namely the inlet substrate concentration. Simulation results show that the proposed scheme leads to an improvement of the convergence rate towards the desired optimum.

18:40-19:00 ThCT2.6

Motion Planning in Dynamic Environment with Bounded Time Temporal Logic Specifications, pp. 980-986

Maity, Dipankar (Univ. of Maryland, Coll. Park), Baras, John S. (Univ. of Maryland)

In this paper, we consider the problem of robotic motion planning that satisfies some bounded time high level specifications. Although temporal logic can efficiently express high level specifications such as coverage, obstacle avoidance, temporal ordering of tasks etc., it fails to address problems with explicit timing constraints. The inherent limitations of Linear Temporal Logic (LTL) to address problems with explicit timing constraints have been overcome by translating the planning problem from the workspace of the robot to a higher dimensional space called spacetime where the existing LTL semantics and grammar are sufficient to mathematically formulate the bounded time high level specifications. A discrete path will be generated, that will meet the specifications with all timing constraints and, at the same time, it will optimize some cost function. A continuous trajectory satisfying the continuous dynamics of the robot will be generated from the discrete path using proper control laws.

ThCT3 Salón Torremolinos B

Wireless Networks and Communications (Regular Session)

17:00-17:20 ThCT3.1

Position Guided Local Routing and Reconfiguration in Mobile Telecommunication Networks with Scale-Free Topology, pp. 987-992

Csercsik, Dávid (Computer & Automation Rsrch. Inst. of the HungarianAcademyof Sci), Imre, Sándor (Budapest Univ. of Tecnology and Ec. Department of Ne)

Assuming wireless communication in scale-free networks, the local routing model can be extended with a novel approach which takes spatial information into account as well. The properties of the proposed model are analyzed in this paper also when the nodes of the network are moving along straight lines in the unit square. Furthermore, we analyze how reconfiguration affects the throughput and energy efficiency of the network.

17:20-17:40 ThCT3.2

A Lightweight Sensor Scheduling Algorithm for Clustered Wireless Sensor Networks, pp. 993-999

Liberati, Francesco (Univ. of Rome "La Sapienza"), Oddi, Guido (Univ. of Rome "Sapienza"), Lanna, Andrea ("Sapienza" Univ. of Rome), Pietrabissa, Antonio (Consorzio Per La Ricerca Nell'automatica E Nelle Telecomunicazio)

This paper deals with the design of a lightweight sensor scheduling protocol in clustered wireless sensor networks (WSNs) for environmental observation. The aim is that of achieving a fair distribution of the sensing task among WSN nodes, while ensuring that other network activities, such as data fusion tasks, are not impaired by sensors scheduling. The proposed periodic scheduling policy takes into account feedback on nodes' health status and on

the quality of the information provided by the nodes to be scheduled. As a result, dynamically variable schedules are produced adapting to the current status of the WSN. Simulation results are presented to highlight the relevant features of the algorithm.

17:40-18:00 ThCT3.3

Specification Based IDS for Camouflaging Wormhole Attack in OLSR, pp. 1000-1006

Biswas Dutta, Chaitali (Univ. of Kalyani, West Bengal), Biswas, Utpal (Univ. of Kalyani)

Wireless sensor networks (WSN) face different security threats that disrupt the normal activities and degrade the performance of the networks. The wormhole attack is one of the most severe security attacks in WSN. In this paper, we analyze the effect of the wormhole attack in Optimized Link State routing (OLSR), which is a standard proactive routing protocol for WSN. A modified version of wormhole attack is developed in this paper, called camouflaging wormhole attack, and a corresponding specification based IDS is designed to detect and prevent this attack. Finally, Network Simulator (NS2) is used to measure the performance of the propose algorithm. The subsequent experimental results show that the efficiency of the proposed scheme.

18:00-18:20 ThCT3.4

Rapid Deployment Wireless Sensor Network for Sustainable Urban Mobility, pp. 1007-1012

Martín Guzmán, Miguel (Univ. De Málaga), Martín-Ávila, Juan (Univ. De Málaga), Fernández-Lozano, Juan Jesús (Univ. De Málaga), Garcia-Cerezo, A. (Univ. De Malaga)

Mobility in urban environments is constrained by a steadily growing traffic, while infrastructures usually cannot be expanded. Therefore, improving mobility and sustainability must go hand in hand with a better management of available resources, incorporating traffic control strategies that can be adapted to real conditions at any given time. One of the main obstacles is obtaining the necessary information to implement such schemes, because of either the information these systems provide, or the cost and time they require to be deployed. A feasible alternative is wireless sensor networks, which can provide information about conditions in an area of interest in order to allow more efficient planning and deployment of more sophisticated algorithms control. At the same time, such a sensor network can be deployed quickly and at a limited cost.

18:20-18:40 ThCT3.5

Open Cloud Solution for Integrating Advanced Process Control in Plant Operation, pp. 1013-1018

Chenaru, Oana (Pol. Univ. of Bucharest), Stanciu, Alexandru (National Inst. for Res. and Development in Informatics), Popescu, Dan (Pol. Univ. of Bucharest), Sima, Vasile (National Inst. for Res. and Development in Informatics,), Florea, Gheorghe ("Pol. Univ. of Bucharest), Dobrescu, Radu (Pol. Univ. of Bucharest)

This paper presents a model for integrating an advanced process control library in a cloud-based environment. The aim is to lower the development times, to reduce maintenance effort and decrease the complexity of process control applications by adopting a modular approach consisting of generic, reusable control strategies following an IEC 61499 representation. The solution uses open cloud technologies based on Heroku for the deployment in a public cloud structure and Docker for increased portability of the designed solution. The conceptual architecture of the system is presented, as well as the details of the integrated modules and the conceptual implementation model of IEC 61499 in a Docker container.

18:40-19:00 ThCT3.6

A QoE-Aware Dynamic Bandwidth Allocation Algorithm Based on Game Theory, pp. 1019-1025

Oddi, Guido (Univ. of Rome "Sapienza"), Pietrabissa, Antonio (Consorzio Per La Ricerca Nell'automatica E Nelle Telecomunicazio), Delli Priscoli, Francesco (Univ. Di Roma), Facchinei, Francisco (Univ. of Rome "La Sapienza"), Palagi, Laura (Univ. of Rome "La Sapienza" - Department of Computer, Contr), Lanna, Andrea ("Sapienza" Univ. of Rome)

Quality of Experience (QoE) is a wide concept including user perception, behavior and expectations as well as application and network performances. The Internet of the future should be able to increase the QoE offered to the users, also in relationship with their commercial profiles. This paper presents an innovative approach, based on game theory, which, according to the feedback of QoE, is able to dynamically assign the available bandwidth of a shared technology (e.g. a WLAN, a cell) to the running flows, in order to maximize the QoE of the users and to guarantee fairness. Moreover, flows could be prioritized, according to commercial profiles (e.g., flows for which users pay more must be served with higher quality). The proposed approach is independent of the way the feedback of QoE is computed (it could be given by a direct user quality expression, estimated from the QoS measurements, from the user's behavior, etc.): the only assumption is that the QoE is a non-decreasing continuous function of the bandwidth allocated to the application. Simulations, considering audio flows with different codecs for which the IQX hypothesis (i.e., exponential interdependency of QoE and QoS) holds, show high performances and fairness/prioritization properties.

ThCT4 Salón Torremolinos C

Intelligent Control (Regular Session)

17:00-17:20 ThCT4.1

Experimental Evaluation of Second Sliding Modes Observer and Extended Kalman Filter in a Sensorless Robust Control of Switched Reluctance Motor for EV Application, pp. 1026-1032

OUDDAH, Nadir (ESTACA Engineering School), Loukkas, Nassim (ESTACA Paris), Chaibet, Ahmed (ESTACA Paris), Boukhnifer, Moussa (ESTACA Paris), Monmasson, Eric (Univ. De Cergy Pontoise)

This paper proposes an observer based sensorless control of Switched Reluctance Motors (SRMs) for electric vehicles (EVs) applications. The position and speed estimations obtained from the observer are used to drive a robust speed tracking controller, which is based on H-infinity control approach. An Extended Kalman Filter (EKF) and a second order Sliding Modes Observers (SMO2) are designed to generate obtain speed and position estimations required for the close loop control. The performances of these two observers are compared, under the same operating conditions, from a control perspective in electric vehicle. The complete drive system performance is validated experimentally using a 4 phase 8/6 SRM prototype.

17:20-17:40 ThCT4.2

Musical Tempo Octave Error Reducing Based on the Statistics of Tempogram, pp. 1033-1038

Wu, Fu-Hai Frank (National Tsing Hua Univ. Taiwan)

This paper proposes the innovative features of tempogram for the selection of predominant tempo in a two-stage tempo estimation system. At stage one, a tempo-pair estimator identifies the dominant tempo pair from a given audio music. At stage two, the statistical features called tempogram shape vector (tsv) discriminates the predominant tempo from the identified tempo pair. Our experiments demonstrate that the performance, reducing octave error, of the tempo estimation is superior to the previously published results and the proposed two-stage scheme is unique from the others.

17:40-18:00 ThCT4.3

A Fuzzy Controller for Visual Comfort Inside a Meeting-Room, pp. 1039-1046

Rodríguez-Torres, José Manuel (Univ. of Almería), CASTILLA, MARIA DEL MAR (Univ. OF ALMERÍA), Álvarez Hervás, José Domingo (Univ. of Seville), Rodríguez-Díaz, Francisco (Univ. of Almería), Berenguel, Manuel (Univ. of Almeria)

In general, human beings receive most part of information through eyesight. Therefore, light is an essential element which allows people to distinguish the shape, colour and perspective of the environment around them. Moreover, energy efficiency in buildings is a problem that is being widely analysed since energy

consumption inside them represents approximately 40% of total world energy consumption. In addition, illumination supposes around 20% of total energy consumption in houses and between 40% and 70% in shops and offices. This paper presents a fuzzy logic controller which allows maintaining visual comfort inside a meeting-room through an efficient use of both natural and artificial lights. In order to probe the effectiveness of the proposed control system, suitable real results obtained in a meeting-room of the CIESOL bioclimatic building are included and commented.

18:00-18:20 ThCT4.4

Gait Generation through a Feature Based Linear Periodic Function, pp. 1047-1053

Ranganath, Avinash (Univ. Carlos III of Madrid), Moreno, Luis (Univ. Carlos III)

By considering locomotion as a set of coordinated oscillations, a method for generating a wide variety of periodic linear gait trajectories is proposed. The shape of the generated trajectory can be defined as a set of features such as symmetry, skewness, signal width, duality and squareness, along with amplitude, offset, phase and frequency parameters. Taking previously proven nonlinear bipedal gait trajectories as reference, a set of linear approximates are modeled, and is tested on a simulated humanoid robot. Then, gait trajectories for producing stable and faster bipedal gait on the same humanoid robot are learned using Genetic Algorithm, through a bottom-up approach.

18:20-18:40 ThCT4.5

Geometrically Constrained Path Planning with Fast Marching Square, pp. 1054-1059

Alvarez, David (Univ. Carlos III), Gomez, Javier V. (Univ. Carlos III), Garrido, Santiago (Univ. Carlos III De Madrid), Moreno, Luis (Univ. Carlos III)

This research presents a novel approach for geometrically constrained path planning. The methodology introduced is based on the standard Fast Marching Square (FM2) method and a path extraction approach based on an optimisation process named Differential Evolution (DE). The geometric constraints are introduced in the path extraction phase. This step uses both the funnel potential of the environment created with FM 2 and the geometric constraints as a cost function to be minimised. The use of an optimisation process permits to get a close-to-optimal path, while mostly keeping the characteristics of the paths computed with FM 2 . In the presented simulations, two kinds of restrictions have been applied: soft and hard ones. The first allows some flexibility in the constraints, while the last force the constraints to be met along all the path. The method has been tried with a simple bar, an articulated double bar and a finger-like kinematic chain in different environments. Results show the potential of this method in constrained path computation.

18:40-19:00 ThCT4.6

A New Control Allocation Method for Power Converters and Its Application to the Four-Leg Two-Level Inverter, pp. 1060-1066

Bouarfa, Abdelkader (INPT-LAPLACE-CNRS), Fadel, Maurice (LAPLACE), Bodson, Marc (Univ. of Utah), LIN, Jun (Univ. of Yantai-LAPLACE)

The deployment of renewable energies requires power electronic converters to produce sinusoidal voltages of appropriate magnitude and frequency. In the case of isolated microgrids, unbalanced loads can result in off-nominal voltages on the loads. A solution to this problem consists in replacing the conventional three-leg converter by a four-leg converter with neutral wire. Four-leg converters have not been studied as extensively as three-leg converters, and existing approaches to control them are based on geometric properties that become difficult to extend to converters with a higher number of lev-els/switches. The objective of the paper is to show that an ap-proach developed in the context of flight control can be applied to this problem with great advantages. Specifically, control allocation methods are shown to be applicable to a four-leg two-level three-phase inverter. The method offers a single generic control scheme regardless on the number of switches. In addition, the approach may offer the incorporation of interest-ing converter properties, such as the minimization of switching (or conduction) losses, or the reconfiguration of the inverter in the event of a fault detected on a switch, if redundancies allow it.

ThCT5 Salón Torremolinos D

Agent-Based Systems (Regular Session)

17:00-17:20 ThCT5.1

Leader-Follower Tracking with Prescribed Transient and Steady State Performance Guarantees for a Class of Unknown Nonlinear Multi-Agent Systems, pp. 1067-1072

Katsoukis, Ilias (Aristotle Univ. of Thessaloniki), Rovithakis, George A. (Aristotle Univ. of Thessaloniki)

In this paper, we consider the leader-follower synchronization problem for a class of second order nonlinear multiagent systems with unknown dynamics and enviromental disturbances. The proposed scheme utilizes only local relative state infromation, it is fully distributed and solves the problem with transient and steady state performance guarantees. In fact, the designed controller has build-in the capability of enforcing predetermined and designer specified performance bounds on the state tracking errors. Despite the high amount of uncertainty, the controller is structurally and computationally simple, avoiding the use of approximating structures i.e., neural networks, fuzzy systems etc. Simulations are also provided to clarify and verify the approach.

17:20-17:40 ThCT5.2

Distributed Consensus Networks of Neutral Type, pp. 1073-1078

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

We propose and study a network of autonomous agents which evolve their state under a distributed consensus algorithm of non-linear neutral type. We provide sufficient conditions for convergence to a common consensus point, by means of a stability in variation argument and fixed point theory. Our approach provides both an estimation on the rate of convergence and an implicit expression for the consensus point.

17:40-18:00 ThCT5.3

Non-Fragile H-Infinity Consensus of Linear Multi-Agent Systems with Interval-Bounded Variations, pp. 1079-1084

Guo, Xianggui (Tianjin Univ. of Tech), Wang, Jianliang (Nanyang Tech. Univ), Liao, Fang (National Univ. of Singapore)

This paper studies the distributed non-fragile H-infinity consensus problems for linear multi-agent systems with external disturbances and unknown initial disturbances under switching weighted balanced directed topologies. The designed controllers are insensitive to multiplicative controller coefficient variations. Sufficient conditions for the existence of the proposed control strategy are also obtained by using linear matrix inequality (LMI) technique. It is worth mentioning that instead of requiring the coupling strength among neighboring agents to be larger than a threshold value as in previous literature, the coupling strength in this paper can be determined by solving some LMIs. Finally, a numerical example is presented to show the effectiveness of the proposed method.

18:00-18:20 ThCT5.4

A Q-Learning Based Approach to Quality of Experience Control in Cognitive Future Internet Networks, pp. 1085-1092

Ricciardi Celsi, Lorenzo (Univ. Di Roma "La Sapienza"), Battilotti, Stefano (Univ. La Sapienza), Cimorelli, Federico (Univ. of Rome "La Sapienza"), Gori Giorgi, Claudio (Sapienza Univ. of Rome), Monaco, Salvatore (Univ. Di Roma La Sapienza), Panfili, Martina ("Sapienza" Univ. Di Roma,), Suraci, Vincenzo (Univ. Degli Studi E-Campus), Delli Priscoli, Francesco (Univ. Di Roma)

The paper describes an innovative and fully cognitive approach which offers the opportunity to cope with some key limitations of the present telecommunication networks by means of the introduction

of a novel architecture design in the perspective of the emerging Future Internet framework. Within this architecture, the Quality of Experience (QoE) Management functionalities are aimed at approaching the desired QoE level of the applications by dynamically selecting the most appropriate Class of Service supported by the network. In the present work, this selection is driven by an optimal and adaptive control strategy based on the renowned Q-Learning algorithm. The proposed dynamic approach differs from the traffic classification approaches found in the literature, where a static assignment of Classes of Service to applications is performed.

18:20-18:40 ThCT5.5

A Distributed Analysis and Design Method for the Synchronization of Linear Heterogeneous SISO Systems by Static State Control, pp. 1093-1098

Khodaverdian, Saman (Tech. Univ. Darmstadt), Adamy, Juergen (Tech. Univ. Darmstadt)

We present a design scheme for the synchronization of linear heterogeneous SISO systems by static feedback controllers. Extending some recent results, a distributed method is provided for synchronizing non-identical agents by a simple synchronization controller for homogeneous agents. In [4], it was shown that for a special condition heterogeneous agents can be synchronized by static controllers. In this paper, we present a constructive approach to analyze the satisfiability of this condition in a distributed manner and to design an appropriate controller.

FrAT1 Salón Málaga

Distributed Systems (Regular Session)

11:00-11:20 FrAT1.1

Throughput Optimality of Extended Back-Pressure Traffic Signal Control Algorithm, pp. 1099-1104

Xiao, Nan (Singapore-MIT Alliance for Res. and Tech. Centre), Frazzoli, Emilio (Massachusetts Inst. of Tech), Luo, Yiwen (Singapore-MIT Alliance for Res. and Tech), Li, Yitong (Singapore-MIT Alliance for Res. and Tech), Wang, Yu (Nanyang Tech. Univ), Wang, Danwei (Nanyang Tech. Univ)

The back-pressure/max-pressure traffic signal control algorithm proposed in the existing literature is distributed, maximizes network throughput, and can be implemented without knowing traffic arrival rates. In this paper, we present an extended back-pressure traffic signal control algorithm, which can further handle bounded measurement/estimation noises in queue lengths and incorporate online estimation of turning ratios and saturated flow rates. Therefore, the extended back-pressure algorithm forms an important step towards the real application of distributed traffic signal control. We prove that under certain conditions, the extended backpressure algorithm still achieves maximum throughput, i.e., the expected long-term average of total queues is bounded from above under the extended back-pressure algorithm for largest possible set of arrival vectors.

11:20-11:40 FrAT1.2

State Estimator Synthesis for Position Dependent Flexible Systems with Position Independent Error Convergence, pp. 1105-1110

Verkerk, K.W. (Eindhoven Univ. of Tech), Kasemsinsup, Yanin (Eindhoven Univ. of Tech), Butler, Hans (ASML), Weiland, Siep (Eindhoven Univ. of Tech)

In this paper a state estimator for high tech flexible systems with an inherent nonlinearity in the output dynamics is proposed. We consider an application in which sensor measurements of the flexible system become parameter (position) dependent. An LPV setting is proposed for the design of estimators that estimate flexible modes of the system. The possibility of pole placement for the error dynamics is investigated and characterized. In particular, necessary and sufficient conditions are derived for the estimator convergence to be parameter independent. In addition, an eigenvalue-shifting technique that improves the convergence of the estimated flexible modes is presented. Simulation results on a basic example and a full flexible system model are used to demonstrate the merits of the proposed estimation algorithms.

11:40-12:00 FrAT1.3

Smoothly Adjustable Autonomy for the Low-Level Remote Control of Mobile Robots That Is Independent of the Navigation Algorithm, pp. 1111-1118

Martinez-Tenor, Angel (Univ. De Malaga), Fernández-Madrigal, Juan-Antonio (Univ. of Málaga)

Autonomy in robotics can be seen as a continuum in which we can select different levels of collaborative control between humans and robots, ranging from tele-operation (full control by the human) to full autonomy. In many practical applications, the main issues are which intermediate levels of autonomy are available and how to change from one to another. In this paper we are interested in providing smoothly adjustable autonomy to remotely controlled mobile robots, that is, an automatic mechanism for selecting the degree of collaborative control that remains mostly unnoticed to the human in normal situations, providing him/her the maximum sense of control that is possible at every time. Adjustable autonomy has been reported previously, but not pursuing simultaneously: i) to control remotely a mobile robot at the servo-process level (i.e., direct control commands), ii) to be independent from the use of a given particular navigation algorithm, and iii) to change the autonomy level smoothly. Our solution is based on a motion demultiplexer that predicts, using the robot kinematics, target locations where the user intends to place the mobile platform in the future. Our experiments show that all the requirements of our approach can be satisfied with minimum modifications to existing robotic control software.

12:00-12:20 FrAT1.4

An Algorithm with Low Computational Requirements to Constrain the Shapley Value in Coalitional Networks, pp. 1119-1124

Muros Ponce, Francisco Javier (Univ. of Seville), Maestre, J. M. (Univ. of Seville), Algaba, Encarnación (Univ. of Seville), Alamo, Teodoro (Univ. De Sevilla), Camacho, Eduardo F. (Univ. of Sevilla)

In this paper, we deal with a distributed control scheme for linear systems in which the local controllers work cooperatively whenever the benefits from a control perspective are higher than the corresponding communication requirements. To this end, the network topology may vary with time so that all the communication links with a minor contribution to the overall performance are disconnected. Hence, there is also a change in the overall control law, which must be adapted to the information flows enabled by the network topology. This whole framework can be modeled as a cooperative game, which allows us to apply tools such as the Shapley value to gain an insight into the distributed control problem. In particular, we show an alternative way to impose restrictions on this value by using a more computationally efficient design procedure.

Keywords: Coalitional Control, Cooperative Game Theory, Shapley Value, Linear Matrix Inequalities.

12:20-12:40 FrAT1.5

Profiled QoE Based Network Controller, pp. 1125-1131

Canale, Silvia (Univ. of Rome "Sapienza"), Cimorelli, Federico (Univ. of Rome "La Sapienza"), Facchinei, Francisco (Univ. of Rome "La Sapienza"), Gambuti, Raffaele (Univ. of Rome "Sapienza"), Palagi, Laura (Univ. of Rome "La Sapienza" - Department of Computer, Contr), Suraci, Vincenzo (Univ. Degli Studi E-Campus)

Internet evolution follows the customer needs, each algorithm, protocol, architecture, equipment, functionality succeeded when the users perceived a real benefit in using it. Taking into account the impact of customer experience when designing promising and future proof technologies is essential. In this paper we investigate how it is possible to control network resources on the base of the Quality of Experience (QoE), defined as the quality of service perceived by a user when using a specific service. QoE is a subjective measure and typically differs from objective and structured measures of quality of service that are under the service provider's control. We consider the problem of identifying a set of QoE profiles that describes the user behavior when enjoying specific class of services, by analyzing the data related to the users' feedback in different contextual scenarios. We formulated the mathematical model and performed a validation on the base of preliminary field trials.

FrAT2 Salón Torremolinos A

Robotics Ii (Regular Session)

11:00-11:20 FrAT2.1

Incorporating Set-Based Control within the Singularity-Robust Multiple Task-Priority Inverse Kinematics, pp. 1132-1137

Antonelli, Gianluca (Univ. of Cassino and Southern Lazio), Moe, Signe (PhD Candidate), Pettersen, Kristin Y. (Norwegian Univ. of Science and Tech)

Inverse kinematics is an active research domain in robotics since several years due to its importance in multiple robotics application. Among the various approaches, differential inverse kinematics is widely used due to the possibility to real-time implementation. Redundant robotic systems exhibit more degrees of freedom than those strictly required to execute a given end-effector task, in such a case, multiple tasks can be handled simultaneously in, e.g., a task-priority architecture. This paper addresses the systematic extension of the multiple tasks singularity robust solution, also known as Null-space Based Behavioral control, to the case of set-

based control tasks, i.e., tasks for which a range, rather than a specific value, is assigned. This is the case for several variables such as, for example, mechanical joint limits of robotic arms as well as obstacle avoidance for any kind of robots. Numerical validation are provided to support the solution proposed.

11:20-11:40 FrAT2.2

A Two-Stage Control Scheme of Single-Link Flexible Manipulators, pp. 1138-1145

San-Millan, Andres (Univ. of Castilla-La Mancha), Feliu, Vicente (Univ. of Castilla-La Mancha), Garcia-Cerezo, A. (Univ. De Malaga)

A new control scheme composed of two independent stages utilised to achieve precise positioning of single-link flexible manipulators is presented herein. Traditional techniques for the control of single-link flexible manipulators utilise only one actuator and two types of sensor measurement (e.g the angular position of the motor and acceleration or strain measurements) to move the manipulator and in order to damp the residual vibrations produced in the displacement of the manipulator. However, in the proposed control scheme another additionally pair actuator-sensor is utilised to improve the speed and precision of the controlled system. On the one hand a motor and the readings of a rotary encoder are utilised in a first stage to displace the manipulator, using the strain measurements in order to damp the high amplitude and low frequency residual vibrations. On the other hand piezoelectric actuators are utilised in conjunction with displacement measures of the tip of the manipulator in order to damp the low amplitude and high frequency residual vibrations which deteriorate the accuracy of the positioning achieved by the traditional control techniques. Simulation and experimental results are carried out to illustrate these improvements.

11:40-12:00 FrAT2.3

Towards Achieving Rolling Contact Motion in a Spherical Robotic Fingertip, pp. 1146-1151

Droukas, Leonidas (Aristotle Univ. of Thessaloniki), Rovithakis, George A. (Aristotle Univ. of Thessaloniki), Doulgeri, Zoe (Aristotle Univ. of Thessaloniki)

Dexterity in human hand is connected with the fingertip rolling ability. Controlling the rolling motion of a spherical robot's tip upon a contacted surface is in this work addressed by solving the control of a wheel's rolling motion, moving upon the robot tip's line path. A model free prescribed performance controller of low complexity is proposed guaranteeing the wheel's rolling under any surface friction conditions. The stability of the closed loop system is proved while simulation results verify the achievement of the wheel's rolling motion towards a desired target location.

12:00-12:20 FrAT2.4

Navigation of Miniature Legged Robots Using a New Template, pp. 1152-1157

Karydis, Konstantinos (Univ. of Delaware), Liu, Yan (Univ. of Delaware), Poulakakis, Ioannis (Univ. of Delaware), Tanner, Herbert G. (Univ. of Delaware)

This paper contributes to the area of miniature legged robots by investigating how a recently introduced bio-inspired template for such robots can be used for navigation. The model is simple and intuitive, and capable of capturing the salient features of the horizontal-plane behavior of an eight-legged miniature robot. We validate that the model can be combined with readily available navigation techniques, and then use it to plan the motion of the eight-legged miniature robot, which is tasked to crawl at low speeds, in obstacle-cluttered environments.

12:20-12:40 FrAT2.5

3D Global Asymptotic Stabilization of Autonomous Underactuated Underwater Vehicles, pp. 1158-1164

Mirzaei, Morteza (Amirkabir), Abdollahi, Farzaneh (Concordia Univ), Meskin, Nader (Qatar Univ), Mehdipour, Noushin (Amirkabir Univ. of Tech)

In this paper, global asymptotic stabilization of an autonomous underactuated underwater vehicle (AUUV) is investigated, where the number of actuators of the AUUV is less than the vehicle's degrees of freedom. The model that is considered describes both the kinematics and dynamics of the AUUV with six degrees of freedom and four actuators. To cope with the underactuation characteristics of AUUV a state transformation is proposed to change the model of the vehicle to a cascade nonlinear system. Then a switching control algorithm is proposed where based on the stability properties of cascade systems, the stability of the whole vehicle is guaranteed. To illustrate the performance of the proposed approach, simulation results are provided.

FrAT3 Salón Torremolinos B

Bio-Inspired Systems (Regular Session)

11:00-11:20 FrAT3.1

A Complete Epidemiological Model of a Class of Genetic Diseases, pp. 1165-1170

Verrilli, Francesca (Univ. of Sannio in Benevento), Del Vecchio, Carmen (Univ. of Sannio), Glielmo, Luigi (Univ. of Sannio), Corless, Martin J. (Purdue Univ)

The epidemiology of X-linked recessive diseases, a class of genetic disorders, has been modeled through a discrete time, structured, non linear mathematical system. The model version presented in this paper completely captures the disease epidemiology as it includes the spread of affected women within a population that has not been considered in other works. Moreover the model allows for de novo mutations (i.e. affected sibling born to unaffected parents) and distinct reproduction rates of individuals depending on their health conditions. Among our contributions, we consider the analytical study of the properties of model's equilibrium point, that is the distribution of the population among healthy, carrier and affected subjects, and the proof of the stability properties of the equilibrium point through the Lyapunov method. Model sensitivity analysis has been carried out to quantify the influence of model parameters on system response.

11:20-11:40 FrAT3.2

Energy Efficiency of Underwater Snake Robot Locomotion, pp. 1171-1178

Kelasidi, Eleni (Norwegian Univ. of Science and Tech), Pettersen, Kristin Y. (Norwegian Univ. of Science and Tech), Gravdahl, Jan Tommy (Norwegian Univ. of Science & Tech)

Energy efficiency is one of the main challenges for long-term autonomy of underwater robotic systems. In this paper, we present results regarding the power consumption of underwater snake robots. In particular, we investigate the relationship between the parameters of the gait patterns, the consumed energy and the forward velocity for different motion patterns for underwater snake robots. Based on a simulation study, we propose empirical rules to choose the parameters of the gait patterns, taking into account both the desired forward velocity and the power consumption of the system. The simulation results show that with respect to the cost of transportation metric, increasing the number of links the energy efficiency decreases for both lateral undulation and eel-like motion.

11:40-12:00 FrAT3.3

Model Reduction and Process Analysis of Biological Models, pp. 1179-1186

Casagranda, Stefano (INRIA), Ropers, Delphine (INRIA), Gouze, Jean-Luc (INRIA)

Understanding the dynamical behavior of biological networks is complicated due to their large number of components and interactions. We present a method to analyse key processes for the system behavior, based on the a priori knowledge of the system trajectory and the simplification of mathematical models of these networks. The method consists of the model decomposition into biologically meaningful processes, whose activity or inactivity is evaluated during the time evolution of the system. The structure of the model is reduced to the core mechanisms involving active processes only. We assess the quality of the reduction by means of global relative errors and apply our method to two models of the circadian rhythm in Drosophila and the influence of RKIP on the ERK signaling pathway.

12:00-12:20 FrAT3.4

Computing Core Reactions of Uncertain Polynomial Kinetic Systems, pp. 1187-1194

Tuza, Zoltan Andras (Pazmany Peter Catholic Univ), Szederkényi, Gábor (Pazmany Peter Catholic Univ)

Kinetic systems form a wide nonlinear system class with good descriptive power that can efficiently be used for the dynamical modeling of non-negative models emerging not only in (bio)chemistry but in other important scientific and engineering fields as well. The directed graph structure assigned to kinetic models give us important information about the qualitative dynamical properties of the system. In this paper we extend the previous results for computing structurally invariant directed edges (called core reactions) for uncertain kinetic polynomial models, where the uncertainty is represented as a multi-dimensional interval in the space of monomial coefficients. We show that the computation can be put into the framework of linear programming. Using illustrative examples we demonstrate the properties of the computed structures and the potential application of the method in the support of structural identification of biochemical networks.

12:20-12:40 FrAT3.5

Position Tracking Controller Based on Transformed Equations of Horizontal Motion for a Class of Vehicles, pp. 1195-1200

Herman, Przemyslaw (Poznan Univ. of Tech), Kowalczyk, Wojciech (Poznan Univ. of Tech)

This paper proposes an approach to the design of trajectory tracking controller for a class of vehicles, moving in the horizontal plane, that takes into account dynamical couplings in the inertia matrix. To this aim the equations of motion are transformed to the form which arises from the inertia matrix decomposition. The main feature of this approach is that the mechanical couplings are included in the control algorithm. It results from the fact that dynamics of the vehicle is taken into account in the velocity gain matrix. The stability of the designed control scheme is shown using the Lyapunov method. Effectiveness of the strategy is given via simulation on a 3-DOF hovercraft model.

FrAT4 Salón Torremolinos C

Robust Control Ii (Regular Session)

11:00-11:20 FrAT4.1

A Class of Decentralized Robust Controllers of Uncertain Large Scale Time-Delay Systems with Unknown Upper Bounds of Uncertainties, pp. 1201-1206

Wu, Hansheng (Prefectural Univ. of Hiroshima)

A design method of decentralized local robust state feedback controllers is presented for a class of uncertain large scale interconnected time-delay dynamical systems. In this paper, the upper bounds of delayed state perturbations, uncertainties, interconnection terms, and external disturbances are assumed to be completely unknown, and the delays are assumed to be any nonnegative constants. A class of adaptation-free decentralized local robust state feedback controllers is proposed, which can guarantee that the solutions of uncertain large scale interconnected time-delay systems are uniformly ultimately bounded. Finally, as an application to the practical mechanical systems, some simulations of a numerical example are provided to demonstrate the validity of the theoretical results.

11:20-11:40 FrAT4.2

Low Level Control of an Omnidirectional Mobile Robot, pp. 1207-1213

Comasolivas, Ramon (Advanced Control Systems (SAC), Univ), Quevedo, Joseba (Tech. Univ. of Catalonia), Escobet, Teresa (Univ. Pol. De Catalunya), Escobet, Antoni (UPC), Romera, Juli (UPC)

This paper presents the low level control of a four-wheel omnidirectional mobile robot. A robust control technique named Quantitative Feedback Theory (QFT), based on an uncertain linear model has been selected to design the PID speed controllers for the four-wheeled robot. A piecewise model has been estimated by means of the least squares estimation approach based on experimental results of the robot in closed loop. In particular, the control is designed using this piecewise model. The performances of the proposed approach are analyzed in real time domain.

11:40-12:00 FrAT4.3

Analyzing Limits of One Type of Disturbance Observer Based PI Control by the Performance Portrait Method, pp. 1214-1220

Huba, Mikulas (Slovak Univ. of Tech. in Bratislava)

This paper deals with a performance portrait based robustness and performance analysis of one of the first disturbance observer (DO) based PI controllers applied to the first order plants. The chosen structure has been established as a PI control augmented by a DO with the aim to improve the disturbance response and to increase the loop robustness. Thereby, three possible DO filters have been introduced, which should guarantee a gradually increasing loop robustness. This expectation will be discussed in dealing with control loops under high performance requirements on the step responses shapes. A special attention is paid to the unmodelled dynamics limiting significantly the achievable control performance.

12:00-12:20 FrAT4.4

Fractional Order Controllers for Urban Wastewater Treatment Systems, pp. 1221-1226

Barbu, Marian (Dunarea De Jos Univ. of Galati), Ceanga, Emil (Dunarea De Jos Univ. of Galati)

One of the important issues affecting the quality of the results obtained in the control of wastewater treatment plants is the influence of influent variations on the effluent. Thus, treating the influent as a periodical disturbance has enabled us already to obtain a significant result in the control of these systems. But the results are more modest if there are irregularities on the influent diurnal variation. In the present paper a new solution has been proposed to the problem of reducing the effect of quasi-periodic disturbances in wastewater treatment urban plants, solution that uses a fractional-order subsystem. Since the process parameters change with the operating regime and the controller contain a fractional-order subsystem, the Quantitative Feedback Theory (QFT) frequency method has been used in order to design a robust controller for the considered control loop. The proposed control structure has been validated on a Activated Sludge Model No. 1 (ASM1) based WWTP implemented in SIMBA®.

12:20-12:40 FrAT4.5

Single-Step Feedback Linearization with Assignable Dynamics for Hyperbolic PDE, pp. 1227-1232

Aksikas, Ilyasse (Qatar Univ), Dubljevic, Stevan (Univ. of Alberta)

The present work proposes an extension of singlestep feedback linearization with pole-placement formulation to the class of nonlinear hyperbolic systems. In particular, the mathematical formulation in the context of singular PDE theory is utilized via system of first order quasi-linear singular PDEs within the nonlinear hyperbolic PDE setting to obtain single step state nonlinear transformation and feedback control law with prescribed closed loop dynamics. The solution of quasi linear singular PDE is guaranteed by the Lyapunov's auxiliary theorem and locally invertible analytic transformation is applied by the full state feedback law to yield desired stable hyperbolic PDE system with assignable dynamics. The simultaneous state transformation and feedback linearization are realized in one step, avoiding the restrictions existing in other approaches.

FrAT5 Salón Torremolinos D

Education and Training (Regular Session)

11:00-11:20 FrAT5.1

LMI Based Output PS Control Design for Discrete-Time Linear MIMO Systems, pp. 1233-1238

Krokavec, Dusan (Tech. Univ. of Kosice), Filasova, Anna (Tech. Univ. of Kosice)

The paper is concerned with the problem of feedback control law design in the form of PS output controller for linear discrete-time systems. Since these tasks generally make towards bilinear optimization problems, using the standard quadratic form of Lyapunov function and a symmetric positive definite slack matrix, an enhanced form of algorithm is introduced. The solution, obtained through linear matrix inequalities and equalities formulation, also unifies the control law design procedure. The obtained results, offering the conditions of PS output controller existence, are illustrated with numerical examples to note effectiveness and applicability of the considered approach.

11:20-11:40 FrAT5.2

Active Tuned Mass Damper, pp. 1239-1244

Azzam, Baher (Texas A&M Univ. at Qatar), Mondal, Jitaditya (Texas A&M Univ. at Qatar), Abuhelaiqa, Mousa (Texas A&M Univ. at Qatar), Tafreshi, Reza (Texas A&M Univ. at Qatar)

The objective of this paper is to demonstrate the design and implementation of an Active Tuned Mass Damper (ATMD) and to determine its effectiveness experimentally and theoretically. ATMDs are damping units placed in structures where a mass is actuated to move out of phase with respect to the movement of the structure to reduce vibrations. In this paper, an ATMD is used to reduce the vibrations of a scaled-down four-story building. The building is subjected to base excitation through a crank-slider motor mechanism on the bottom floor. The ATMD consists of a mass which is actuated through a DC motor. Using feedback from an accelerometer placed on the topmost floor, a proportional gain controller is implemented through LabVIEW to control the motion of the mass. The results show that the ATMD system has damped approximately 49.7% of the vibrational amplitude.

11:40-12:00 FrAT5.3

Level Control of a Coupled-Tank System Via Eigenvalue Assignment and LQG Control, pp. 1245-1250

Engules, Deniz (ITU), Hot, Murat (ITU), Alikoc, Baran (ITU)

This paper presents the state-space modeling and control of a coupled-tank liquid level system. Observed-state feedback controller via eigenvalue assignment and LQG control are designed in discrete-time and implemented by an industrial controller PLC. Both control design methods are augmented with integral action for a reference tracking without steady-state error for step inputs. The aim of the study is to examine the control performances of the methods subject to reference tracking, noise attenuation, disturbance rejection. The experimental results are presented and discussed for this purpose.

12:00-12:20 FrAT5.4

Enhancement of a Commercial Multicopter for Research in Autonomous Navigation, pp. 1251-1256

Gongora, Andres (Univ. of Malaga), Gonzalez-Jimenez, Javier (Univ. of Malaga)

Multicopters are lightweight and maneuverable aerial vehicles yet unable to carry heavy payloads, such as large sensors or computers required for indoor autonomous navigation. Therefore, localization is usually performed by using vision-based solutions employing of either lightweight on-board cameras or external fixed cameras and a ground station for data-processing. Nevertheless, the current tendency is to use a low-power on-board computers to perform all computation on the multicopter itself. This paper covers the enhancement of a commercial multicopter, also called drone, with computation ability and sensorial devices for autonomous flight without the need of a ground-station. We describe the hardware and software integrated into the drone, which will be used for the future development of 6DoF navigation algorithms. The resulting system is able to work with most standard sensors and has the possibility to change them as needed. Also, we demonstrate the correct behavior of the drone by using a test navigation program that autonomously follows a moving beacon at constant distance and controlled altitude using an RGB-D camera and a sonar.

12:20-12:40 FrAT5.5

Full Building of a Sun Tracker and Control, pp. 1257-1262

Garcia, F. Javier (Univ. De Valladolid), Moya, Eduardo (ITAP - Univ. De Valladolid)

As a complement to the studies of industrial engineering, students have the opportunity of making projects to improve their practical knowledge. In this case a sun tracker was built and controlled using and Arduino microprocessor. The main objective is to build an experimental plant that could be used by the students to practice in control courses. This project has been successfully used in various courses in the educational programs of teaching automatic control.

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