30th MEDITERRANEAN CONFERENCE ON CONTROL & AUTOMATION (MED'22)

June 28 – July 1, 2022
Divani Apollon Palace & Thalasso
Vouliagmeni - Athens, Greece

FINAL PROGRAM & BOOK OF ABSTRACTS

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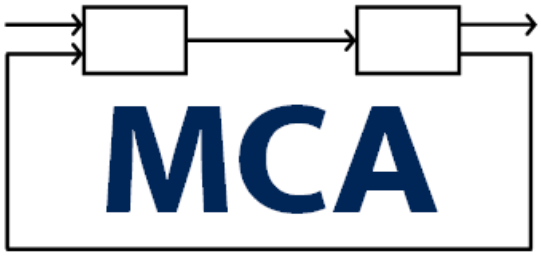

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THIRTY YEARS OF MED – A TOUCH OF HISTORY

Acknowledgement: Credit to NASA

Thirty years have passed since the first MED took place in 1993, in Chania, Crete, in Greece. Since then, the conference is organized annually, and now, in 2022, we celebrate the 30th MED that takes place in the Divani Apolon Palace and Thalasso, in Vouliagmeni, which is part of the Athenian Riviera.

It was thirty-one years ago, not far from Vouliagmeni, in Glyfada, where the idea of launching and organizing a conference on Control and Automation was proposed by Prof. Manolis Christodoulou, during a dinner at his place. The idea was to first organize the conference in Greece and perhaps, pending success, rotating it to other Mediterranean countries. We all agreed, and it was decided, that a key element for a successful conference was high technical quality of contributions, and Technical Co-sponsorship from IEEE Control Systems Society (CSS), which was secured even at the first 1993 MED conference. In fact, our goal was, and it still is, to run the MED conference following and implementing the same review standards as in the highest quality control conferences. We all thought that high quality was the key to longevity and success. Manolis should be very proud of this vision that has served us exceptionally well for 30 years. He, sadly and suddenly, passed away earlier this year. We take this as a further opportunity to offer our deep and sincere condolences to his family.

During the first baby steps of MED, the selection of general chairs and sites was handled informally. However, in 1998 the Mediterranean Control Association (MCA) was founded, see www.med-control.org, to address the high interest of the technical community in the MED conferences. The MCA Board is the governing body; its members, who have all served as general chairs of past MEDs, approve proposals for future MEDs. In addition, they use their extensive experience to guide and help MED organizers, sharing best practices. Every

conference since the first one in 1993 has been technically co-sponsored by the IEEE CSS and later by the Robotics and Automation Society (RAS) as well.

MCA has honored a small number of prominent members of our technical community with two awards. The ***MCA Founders*** award was awarded to Manolis Christodoulou in 2005. This award recognizes outstanding long-term service to the MCA and MED. The ***MCA Ktesibios Award***, first awarded in 2000, was established "*to recognize exceptional contributions to theory, design, or practice in the areas of systems, control, or automation, sustained over a long period of time*". The recipient should have a demonstrated solid record of scientific and professional activities that have directly impacted countries in the Mediterranean region. The award is a silver replica of a "Kantharos," an ancient drinking vessel." Starting in 2000, the recipients have been: Alberto Isidori, Spyros Tzafestas, Michael Athans, and George Saridis.

In the following pages you will find the complete list of the first 30 MED conferences including dates, venues, and general, honorary, and program chairs. Also, the Keynote speakers for each MED are listed. We are very proud of consistently attracting such well-known speakers, which highlights the high technical quality of the MED conferences.

Panos Antsaklis, President
Mediterranean Control Association

HISTORY OF 30 YEARS OF MED CONFERENCES

30th Mediterranean Conference on Control and Automation (MED'22)
June 28-July 1, 2022, Vouliagmeni-Athens, Greece
GC: Kimon P. Valavanis, Maria Prandini
HC: Panos J. Antsaklis, Zalman Palmor
PC: Andrea Monteriù, Alessandro V. Papadopoulos
Plenaries: Frank Allgöwer, Sandra Hirche, John Lygeros, Nick Sigrimis

29th Mediterranean Conference on Control and Automation (MED'21)
June 22-25, 2021, Bari, Italy
GC: Mariagrazia Dotoli, Laura Giarrè
PC: Laura Giarrè, Elisa Franco
Plenaries: Anuradha Annaswamy, Anna Stefanopoulou, Giuseppe Notarstefano

28th Mediterranean Conference on Control and Automation (MED'20)
September 16-18, 2020, Saint-Raphaël, France
GC: Didier Maquin
PC: Kimon P. Valavanis, Didier Theilliol
Plenaries: Alexander Medvedev, Daniel Zelazo, Charles Poussot-Vassal

27th Mediterranean Conference on Control and Automation (MED'19)
July 1-4, 2019, Akko, Israel
GC: Tal Shima, Zalman Palmor
PC: Leonid Mirkin, Daniel Zelazo
Plenaries: Shimon Marom, Martina Maggio, Florian Dörfler

26th Mediterranean Conference on Control and Automation (MED'18)
June 19-22, 2018, Zadar, Croatia
GC: Stjepan Bogdan, Sandra Hirche
HC: Panos J. Antsaklis, Kimon Valavanis
PC: Nikola Miskovic, Roberto Galeazzi
Plenaries: Bart De Moor, Maryam Kamgarpour, Yasamin Mostofi

25th Mediterranean Conference on Control and Automation (MED'17)
July 3-6, 2017, Valletta, Malta
GC: Simon G. Fabri, Didier Theilliol
PC: Marvin Bugeja, Xenofon Koutsoukos
Plenaries: Raffaello D'Andrea, Visakan Kadirkamanathan, Marios Polycarpou

24th Mediterranean Conference on Control and Automation (MED'16)
June 21-24, 2016, Athens, Greece
GC: Panos J. Antsaklis, Kimon P. Valavanis
PC: Didier Theilliol, Anthony Tzes
Plenaries: Alessandro Astolfi, David Harari, Yannis A. Phillis, Roland Siegwart, Roberto Tempo

23rd Mediterranean Conference on Control and Automation (MED'15)
June 16-19, 2015, Torremolinos, Spain

GC: Joseba Quevedo, Victor Fernando Muñoz
PC: Sebastian Dormido, Didier Maquin
Plenaries: Tore Hägglund, Manuel Silva, Magnus Egerstedt

22nd Mediterranean Conference on Control and Automation (MED'14)
June 16-19, 2014, Palermo, Italy
GC: Laura Giarré, Francesco Alonge
PC: Giuseppe Conte
Plenaries: Stephen P. Boyd, Munther A. Dahleh, Mustafa Khammash

21st Mediterranean Conference on Control and Automation (MED'13)
June 25-28, 2013, Platanias-Chania, Crete, Greece
GC: Panos J. Antsaklis, Kimon P. Valavanis
PC: Nikos C. Tsourveloudis
Plenaries: Anibal Ollero, Frank L. Lewis, Thomas Parisini, Petros A. Ioannou

20th Mediterranean Conference on Control and Automation (MED'12)
July 3-6, 2012, Barcelona, Spain
GC: Joseba Quevedo
PC: Pedro Albertos
Plenaries: Mario Sznaier, Sergio Bittanti, Alicia Casais

19th Mediterranean Conference on Control and Automation (MED'11)
June 20-23, 2011, Aquis Corfu Holiday Palace, Corfu, Greece
GC: Anthony Tzes
PC: George Pappas
Plenaries: Roger Goodall, John S. Baras, Claire Tomlin, John N. Tsitsiklis

18th Mediterranean Conference on Control and Automation (MED'10)
June 23-25, 2010, Congress Palace, Marrakech, Morocco
GC: Abdellah Benzaouia & Ahmed El Hajjaji
PC: Dominique Sauter
Plenaries: Marcel Staroswiecki, Christos G. Cassandras, Zalman J. Palmor, Antonio Sala

17th Mediterranean Conference on Control and Automation (MED'09)
June 24-26, 2009, Makedonia Palace, Thessaloniki, Greece
GC: Vassilios Petridis, Frank L. Lewis
PC: Thomas Parisini
Plenaries: Petros Ioannou, Jie Huang, Tony Vardulakis, Libor Kral, Alkis Konstantellos

16th Mediterranean Conference on Control and Automation (MED'08)
June 25-27, 2008, Congress Center, Ajaccio-Corsica, France
GC: Dominique Sauter
HC: Panos Antsaklis
PC: Ron Patton
Plenaries: Miroslav Krstic, Silviu-Iulan Niculescu, Andrea Bobbio

15th Mediterranean Conference on Control and Automation (MED'07)
June 27-29, 2007, Divani Caravel Hotel, Athens, Greece
GC: Panos Antsaklis, Kimon Valavanis

PC: Zdenko Kovacic
Plenaries: Mike J. Grimble, Joerg Raisch, Karl Henrik Johansson, Tariq Samad

14th Mediterranean Conference on Control and Automation (MED'06)
June 28-30, 2006, Università Politecnica delle Marche, Ancona, Italy
GC: Giuseppe Conte, Marcello Napolitano
Plenaries: Siva S. Banda, Kevin M. Passino, Gilead Tadmor, Bernd R. Noack, Marek Morzynski

13th Mediterranean Conference on Control and Automation (MED'05)
June 27-29, 2005, Hawaii Grand Hotel & Resort, Limassol, Cyprus
GC: Marios M. Polycarpou
PC: Michael A. Demetriou
Plenaries: Christos Cassandras, Eduardo Sontag, Julie Chen

12th Mediterranean Conference on Control and Automation (MED'04)
June 6-9, 2004, Kusadasi, Turkey
GC: Okyay Kaynak
HC: Tamer Basar
PC: Petros Loannou, Robert King, Li Qiu
Plenaries: Oussama Khatib, Xi-Ren Cao, George J. Vachtsevanos, Umit Ozgüner

11th Mediterranean Conference on Control and Automation (MED'03)
June 18-20, 2003, Rodos Palace Hotel, Rhodes, Greece
GC: Frank L. Lewis, Kimon P. Valavanis
PC: Stjepan Bogdan
Plenaries: Panos Antsaklis, Gerd Hirzinger, Manfred Morari, Shankar Sastry

10th Mediterranean Conference on Control and Automation (MED'02)
July 9-13, 2002, Lisbon, Portugal
GC: Joao J.S. Sentieiro
PC: Michael Athans
Plenaries: H. I. Christensen, J. C. Doyle, P. Varaiya, O. Faugeras, R. Kumar, M. A. Dahleh, E. Crawley, D. G. Luenberger

9th Mediterranean Conference on Control and Automation (MED'01)
June 27-29, 2001, Hotel Excelsior, Dubrovnik, Croatia
GC: Zoran Vukic, Kimon P. Valavanis
PC: Zdenko Kovacic, Kostas J. Kyriakopoulos
Plenaries: Michael Athans, Petar Kokotovic, Murat Arcak, Vladimir Muljevic, Lotfi Zadeh

8th Mediterranean Conference on Control and Automation (MED'00)
July 17-19, 2000, University of Patras, Rio, Greece
GC: Peter P. Groumpos, Panos Antsaklis
PC: Nick T. Koussoulas
Plenaries: George Metakides, Shankar Sastry

7th Mediterranean Conference on Control and Automation (MED'99)
June 28-30, 1999, Dan Panorama Hotel, Haifa, Israel
GC: Zalman J. Palmor, Howard Kaufman

PC: Arie Feuer
Plenaries: Graham Goodwin, Michael Heymann, Stephen Boyd, Yaakov Bar-Shalom, David Bayard

6th Mediterranean Conference on Control and Automation (MED'98)
June 9-11, 1998, Hotel Carlos V, Alghero, Sardinia, Italy
GC: Antonio Tornambe
PC: Giuseppe Conte

5th Mediterranean Conference on Control, Systems (MED'97)
July 21-23, 1997, Phaethon Beach Hotel Club, Paphos, Cyprus
GC/PC: Theodore E. Djaferis
Keynote: Sanjoy Mitter

4th Mediterranean Symposium on Control and Automation (MED'96)
June 10-13, 1996, Louis Maleme Beach Hotel, Chania, Crete, Greece
GC: Frank L. Lewis, Petros P. Groumpos, Paris N. Paraskevopoulos
HC: Panos J. Antsaklis
PC: Kostas Kyriakopoulos, Petros G. Voulgaris
Plenaries: Frank L. Lewis, Dave Boland, Vladimir Kucera

3rd Mediterranean Symposium on Control and Automation (MED'95)
July 11-13, 1995, Limassol, Cyprus
GC: Petros A. Ioannou
PC: Frank L. Lewis

2nd Mediterranean Symposium on New Directions in Control and Automation (MED'94)
June 19-21, 1994, Louis Maleme Beach Hotel, Chania, Crete, Greece
GC: Kimon P. Valavanis
HC: George N. Saridis
PC: Frank L. Lewis

1st Mediterranean Symposium on New Directions in Control Theory, Applications (MED'93)
June 21-23, 1993, Handris Hotel, Maleme, Chania, Crete, Greece
GC: Manolis A. Christodoulou
PC: Manolis A. Christodoulou, Petros Ioannou
Plenaries: George N. Saridis, H. E. Rauch

Legend: GC: general chair(s) and co-chair(s). PC: program chair(s) and co-chair(s). HC: Honorary chair(s). For details, visit https://www.med-control.org/main/conferences/.

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WELCOME MESSAGE FROM THE MCA PRESIDENT

Dear participants:

On behalf of the Mediterranean Control Association (MCA), the parent organization of the MED conferences, I would like to welcome you to the 2022 MED, the 30th Mediterranean Conference on Control and Automation, which takes place in Vouliagmeni, in the Athenian Riviera.

All MED conferences have always been about bringing together researchers in Control Systems and Automation from the Mediterranean countries, who share much more than technical interests, among other things, culture, and history. Since the beginning, all MED conferences have been technically co-sponsored by the IEEE Control Systems Society and later on by the IEEE Robotics and Automation Society as well. 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 due to the tremendous effort of all the volunteers who are involved in the technical evaluation of the submitted papers and in the organization of the conferences. I would like to take this opportunity to thank all of them for their time, effort, and wonderful work. Thank you!

The hope was that by June 2022, well over 2 years after COVID-19 first appeared, we would have put the epidemic to rest and would have resumed our normal activities. Unfortunately, that was not to be, even after very effective vaccines were made available. MED'22 is run in hybrid mode, accommodating both physically present and remote participants. Running a successful conference is already difficult enough; it is at least twice as hard to run the conference in dual mode. For this, I would like to extend my sincere thanks to the members of the organizing committee, especially Kimon Valavanis who has devoted countless hours considering every detail of the MED'22 to maximize its chances of success.

The Mediterranean Control Association (MCA) is the sponsoring organization of all MED conferences. MCA selects the organizers and the venues and oversees all conferences. ***The*** MED has been organized in Cyprus, Malta, Italy, France, Croatia, Turkey, Israel, Portugal, Morocco, Spain, and several times in Greece. For a complete list of the MED conferences, see www.med-control.org where you may also find the Book of Abstracts and conference reports of previous MED that have appeared in the IEEE Control Systems Magazine. The list has also been included in the present Book of Abstracts in celebration of the 30th anniversary of MED.

MED Conference Proceedings may be found online at http://ieeexplore.ieee.org. The Proceedings of early MED Conferences may be downloaded from www.med-control.org.

Looking ahead, MED'23 goes to Limassol, Cyprus, (June 26 – 29, 2023) and I am looking forward to seeing you all there!

Thank you for your participation and contributions to MED'22, the 30th Mediterranean Conference on Control and Automation!

Enjoy the conference!

Panos Antsaklis, President
Mediterranean Control Association (MCA)

WELCOME MESSAGE FROM THE GENERAL CHAIRS

Dear authors and attendees:

On behalf of the 2022 MED Organizing Committee, it is a privilege and a great pleasure to welcome you to this year's Conference. The 2022 MED is coming back to Greece, in the Athenian Riviera, celebrating its 30th anniversary. The three-day Conference, June 29 – July 1, is preceded by a one-day Workshop program, on June 28. The Conference venue is the luxurious Divani Apollon Palace and Thalasso in Vouliagmeni, in the Athenian Riviera. The conference venue is one of the top-rated hotels in Europe and Greece. We are certain that you will be very pleased with the conference venue.

Conference attendees represent academia, industry, government agencies and students, all having deep interest in the state-of-the-art and future directions in control and automation. In response to the Call for Papers, we received 328 contributed and invited session papers. Following a very thorough and in-depth peer review process in which each paper had at least three reviews we accepted a total of 181 contributed and invited session papers, and we have assembled a full three-day top quality Technical Program.

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

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

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

We also thank the hotel management and particularly Mr. Spyros Maganiotis, Ms. Stella Kyrgetsou and Ms. Argyro Pagoni for their professionalism and hospitality.

Last but not the least, we thank you for your participation and contribution. We hope you will enjoy the Conference and take advantage of what Vouliagmeni, Athens, and Greece has to offer.

With our warmest regards,

Kimon P. Valavanis and Maria Prandini
General Chairs

WELCOME MESSAGE FROM THE PROGRAM CHAIRS

Dear authors and attendees:

It is with great pleasure that we welcome you to the 30th Mediterranean Conference on Control and Automation, which returns to its birthplace, in Greece. This year, in response to the call for papers, we received 220 technical and invited session papers from authors residing in 40 different countries.

The paper review process has been extremely thorough and rigorous. All papers were also checked for originality using the iThenticate Document Viewer Guide. Our objective was for each paper to have at least three reviews. We met and exceeded this goal as each of the submitted papers, in addition to the reviews, was also checked and reviewed by one of the Program Chairs or members of the Organizing Committee.

Authors of submitted papers used among the following key words to classify their paper: Adaptive control; Aerospace control; Automotive control; Autonomous systems; Biologically inspired systems; Biomedical engineering; Computational intelligence; Computational methods; Cyber-physical systems; Decentralized control; Discrete-event systems; Distributed systems; Disturbance rejection; Education and training; Embedded control systems; Energy efficient systems; Fault diagnosis; Fault tolerant control; Formation control; Fuzzy logic and fuzzy control; Genetic and evolutionary computation; Guidance; Hybrid systems; Image processing; Implicit and hybrid structures; Industrial automation; Manufacturing; Intelligent control systems; Intelligent transportation systems; Linear systems; Marine control; Mechatronic systems; Micro and nano systems; Modelling and simulation; Multi-agent systems; Navigation; Networked systems; Neural networks; Nonlinear control; Nonlinear systems; Optimisation; Petri nets; Power systems and smart grid; Predictive control; Process control; Robotics; Robust control; Switching systems; System identification; Systems biology; Time-delay systems; Unmanned systems; Wireless sensor networks.

The review process resulted in the technical program composed of 181 contributed and invited session peer reviewed papers scheduled in 36 technical sessions. Table I shows the contributed and accepted papers per country. The technical program spans three days, during which all accepted papers are presented, physically or virtually, in addition to the two Tutorial Workshops and the four Plenary Sessions.

Table I: Submitted - Accepted Papers per Country

Country	***Submitted***	***Accepted***
Italy	31	30
Greece	33	28
Germany	19	18
United States of America	17	16
Sweden	17	15
France	18	15
India	12	6
Brazil	7	5
Romania	9	5
Russia	7	5
Turkey	6	5
Croatia	5	4
Hungary	4	4
Canada	3	3

United Kingdom	5	3
Austria	2	2
Poland	2	2
Spain	2	2
Tunisia	3	2
Chile	1	1
China	2	1
Cyprus	1	1
Czech Republic	2	1
Denmark	1	1
Iran	1	1
Israel	2	1
South Korea	2	1
New Zealand	1	1
Slovakia	1	1
Switzerland	1	1
Morocco	2	0
Norway	1	0
Totals	**220**	**181**

We would like to thank everyone who contributed to the program for their enthusiastic involvement and substantial efforts. In particular, we want to acknowledge the Associate Editors for their kind support during the review process. Special thanks go to the organizers of Workshops and Invited Sessions. Our gratitude goes to all reviewers for their valuable contributions and, finally, to all authors for submitting their work to MED.

Thanks also to Dr. Pradeep Misra who helped us in working and effectively using the on-line paper submission and review system. He has been very responsive and helpful in technical issues related to the on-line system.

We really hope that the 2022 MED will provide all attendees and participants with a unique chance to extend their knowledge and network of contacts, to generate new ideas, and to get a better understanding of what is going on in control and automation.

Enjoy not only the technical aspects of the conference but also your stay in Athens and Vouliagmeni. Have a look around to see what this fascinating city offers.

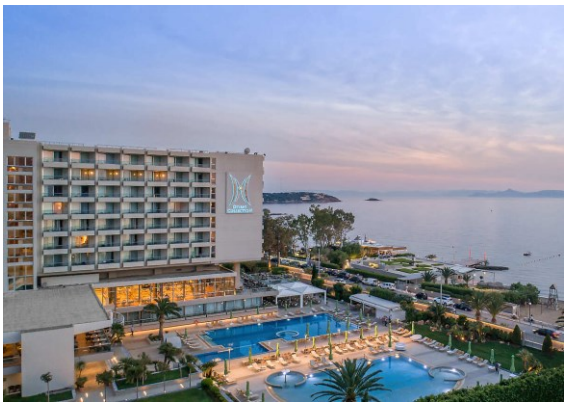
Stay safe around the ‘equilibrium’, to the next MED!

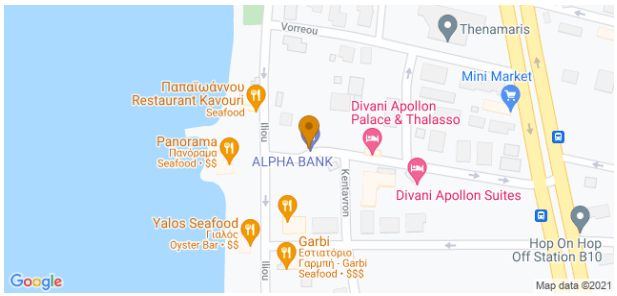
Andrea Monteriù and Alessandro P. Papadopoulos
Program Chairs

MED'22 INFORMATION

The Venue

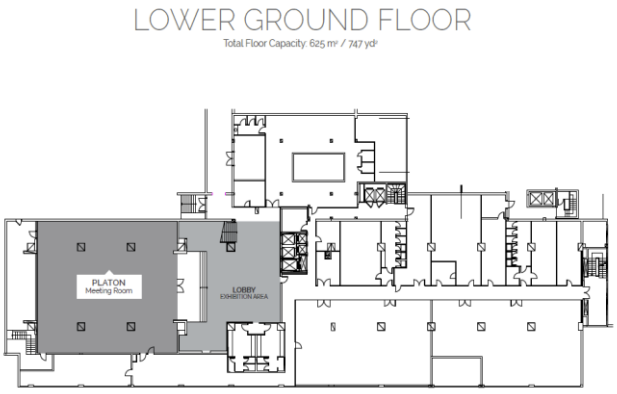
The Conference will take place in Vouliagmeni, Greece. The venue is the luxurius Divani Apollon Palace and Thalasso Hotel. For detailed information about the venue and the surrounding area, visit https://divaniapollonhotel.com/.

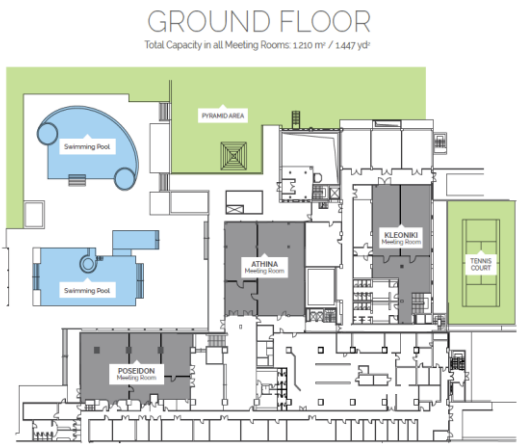




General Information

The conference area is situated on the Ground Floor and on the Lower Ground Floor. All Workshops (Tuesday, June 28) and Technical Sessions (June 29 – July 1) will be in *Platon Hall*, *Athina A*, *Athina B* and *Poseidon C*. Plenary talks will also take place in *Platon Hall*. Registration will be in the *Foyer* of the Ground Floor. For a 360º Panorama View of the space visit https://divaniapollonhotel.com/conference-rooms-360-panoramas/.





Conference Technical Sessions - Wednesday, June 29 - Friday, July 1
There are four parallel technical sessions each day. All conference sessions, including Workshops will be in *Platon Hall*, *Athina A*, *Athina B* and *Poseidon C*.

Exhibits and Promotional Material
Exhibits and promotional material will be on the Ground Floor, close to the Registration area.

Conference Registration
All Conference attendees must register by using the on-line registration when they upload the final version of their papers. Late and on-site registration is also available for non-authors who want to attend the conference. It is not required to present a paper in the conference program to register and to attend the conference. All registered participants must check in at the Registration Desk to pick up their registration packages. Personal badges will be provided to all registered participants. Attendees must always wear their badges when attending any MED'22 event. Conference details will be posted and updated daily in the registration area. To register, follow the steps:

- ✓ Go to https://controls.papercept.net
- ✓ Scroll down the list until you find MED 2022 - Choose MED 2022 (from the list of conferences)
- ✓ Click on Register for MED 2022
- ✓ Login with your PIN and Password. *First time users must create a 'profile', to get a PIN and Password.*
- ✓ After you Log in, choose **Registree**
- ✓ Follow the self-explained screens to register.

The registration area is the *Foyer* area on the Ground Hall. The registration desk will be open during the following hours:

TUESDAY, JUNE 28:	*Workshop Registration* **only**	8:00 AM – 10:00 AM
	Conference Registration	3:00 PM – 5:00 PM
WEDNESDAY, JUNE 29:		8:00 AM – 5:00 PM
THURSDAY, JUNE 30:		8:00 AM – 4:00 PM
FRIDAY, JULY 1:		8:00 AM – 9:00 AM

On-site conference registration policy & fees
Attendees will be able to register for the Conference under the following registration categories and rates:

Attendee Status	Late/Onsite
Regular Registration – (Physical Presence)	$670
Regular Registration – (Virtual Presence)	$480
Student Registration (Physical Presence)	$420
Student Registration (Virtual Presence)	$360
Retiree Registration (Virtual, physical)	$200

T1: Active methods in Autonomous Navigation, June 28, 9:00 AM – 5:00 PM (Physical Presence)	$240
T1: Active methods in Autonomous Navigation, June 28, 9:00 AM – 5:00 PM (Virtual Presence)	$120
T2: Multimodal Sensing for Localization, Planning and Scene Understanding, June 28, 9:00 AM – 5:00 PM (Physical Presence)	$240
T2: Multimodal Sensing for Localization, Planning and Scene Understanding, June 28, 9:00 AM – 5:00 PM (Virtual Presence)	$120
Extra Welcome Reception Ticket	$50
Extra Farewell Reception Ticket	$50
Extra Banquet Ticket	$100
Extra Proceedings	$50

Internet Access
All registered attendees will have complementary internet access.

Coffee Breaks with snacks
There will be two coffee breaks per day for all registered participants, one in the morning and one in the afternoon.

Events and Receptions
The MED 2022 social agenda includes the *Welcome Reception* on Tuesday, June 28, the *Banquet*, on Thursday, June 30, and a small *Farewell* event on July 1. Lunches will be offered to registered participants on June 29, 30 and July 1.

Travel to Athens
Athens, Greece, is easily accessible by air, sea, and road. Once there, the public transportation system provides a safe, dependable, and efficient way to move around the city. The public transportation network consists of underground (metro), train, suburban railways, buses, trolley buses, and trams. Athens is also connected with other parts of the mainland through a network of roads and railways.

Visitors arriving by air will land in the *Athens International Airport "Eleftherios Venizelos"* (IATA code: ATH). This award-winning airport is one of the world's leading airports in overall passenger satisfaction.

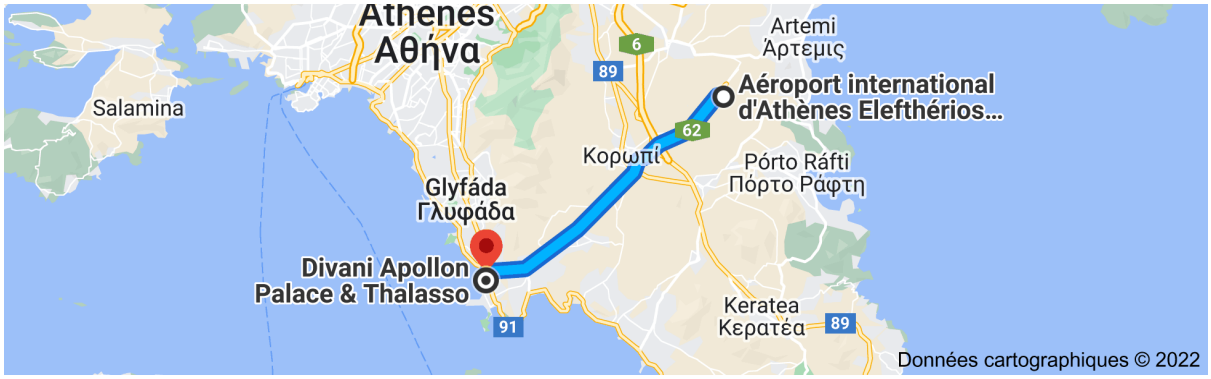
The Athens International Airport is serviced by all major airlines, offering direct non-stop flights from/to most of the European cities, New York, Philadelphia, Montreal/Toronto, North Africa, Gulf States, South Africa, and easy connections to the rest of the world. ATH is also serviced by low-cost and/or charter airlines that offer attractive packages.

Transportation from/to Airport to/from Divani Apollon Palace and Thalasso Hotel
Upon arrival to the airport, the easiest way to reach the venue is by taxi and private car (if you also plan to stay for vacation).

Taxi: Taxis are available at the designated taxi waiting area located by Exit 3 at the Arrivals level. Ask the driver to get you to the Divani Apollon Palace Hotel. The average cost on normal traffic is 30 EUR and it takes about 30 minutes to arrive at the hotel. Moreover, the drive from

the airport to locations in the Athens city center takes about 35-40 minutes and costs 38-45 EUR (flat rate – regular fare, from 5 a.m. until midnight) and 54-60 EUR (flat rate – night fare, from midnight to 5 a.m.).

Car: The driving distance is 21.3 km. Exit the Airport, follow the signs to Vari, then Vouliagmeni and Kavouri.



PLENARY LECTURES

The 30th Mediterranean Conference on Control and Automation includes four Keynote Lectures given by leading authorities in their respective fields. All Plenary Lectures will take place in the ***Platon Hall.*** The Plenary Lectures schedule is shown below.

PLENARY LECTURES		
Day	**Time**	**Platon Hall**
Wednesday June 29	09:00 – 10:00	***Data enabled predictive control***, John Lygeros, ETH Zürich
	14:00 – 15:00	***Control Intelligence in Agriculture 4.0***, Nick Sigrimis, Agricultural University of Athens, and Geosmart.gr, CTO
Thursday June 30	09:00 - 10:00	***High performance control for robots in extreme environments***, Sandra Hirche, Technical University of Munich
Friday July 1	09:00-10:00	***Data-driven MPC: from linear to nonlinear systems with guarantees***, Frank Allgöwer, University of Stuttgart

WORKSHOPS

MED'22 offers two pre-conference Workshops that will take place on Tuesday, June 28.

T1: 9:00 AM – 5:00 PM
Active Vision Methods in Autonomous Navigation
T2: 2:00 PM – 5:30 PM
Multimodal Sensing for Localization, Planning and Scene Understanding

TECHNICAL SESSIONS IN MEMORIAM

MED 2022 includes two Sessions "In Memoriam" of two of our colleagues who passed away recently:

a. Dr. Manolis Christodoulou, who was one of the founders of MCA. The Session is organized by his long-term colleagues Drs. Petros Ioannou, Elias Kosmatopoulos and George Rovithakis.
b. Dr. Nikos Karkanias, a regular contributor to MED conferences. The Session is organized by his long-term colleagues Drs. Antonis Vardulakis and Ioannis Leventidis.

MED 2022 TECHNICAL PROGRAM AT A GLANCE

Technical Program Wednesday June 29, 2022

Track 1	Track 2	Track 3	Track 4
08:45-09:00 WeOO **Platon Hall** Opening Session			
09:00-10:00 WePL1 **Platon Hall** **Data Enabled Predictive Control (John Lygeros, ETH Zürich)**			
10:30-12:10 WeA1 **Platon Hall** Predictive Control I	10:30-12:10 WeA2 **Athina A** Optimisation I	10:30-12:10 WeA3 **Athina B** Decentralized Control	10:30-12:10 WeA4 **Poseidon C** Nonlinear Systems
14:00-15:00 WePL2 **Platon Hall** **Control Intelligence in Agriculture 4.0 (Nick Sigrimis, Agricultural University of Athens, and, Geosmart.gr, CTO)**			
15:30-17:10 WeB1 **Platon Hall** Predictive Control II	15:30-17:10 WeB2 **Athina A** Optimisation II	15:30-17:10 WeB3 **Athina B** Intelligent Data Processing from Sensors in Control and Decision Support Systems	15:30-17:10 WeB4 **Poseidon C** Nonlinear Control
17:30-19:10 WeC1 **Platon Hall** Linear Systems	17:30-19:10 WeC2 **Athina A** Robust Control	17:30-19:10 WeC3 **Athina B** Neural Networks	17:30-19:10 WeC4 **Poseidon C** System Identification

MED 2022 Technical Program Thursday June 30, 2022

Track 1	Track 2	Track 3	Track 4
09:00-10:00 ThPL1 **Platon Hall** **High Performance Control for Robots in Extreme Environments (Sandra Hirche, Technical University of Munich)**			
10:30-12:30 ThA1 **Platon Hall** Autonomous Systems I	10:30-12:10 ThA2 **Athina A** Guidance	10:30-12:10 ThA3 **Athina B** Modeling and Flight Control Design for Aerospace Systems	10:30-12:10 ThA4 **Poseidon C** Robotics I
14:00-16:00 ThB1 **Platon Hall** Autonomous Systems II	14:00-15:40 ThB2 **Athina A** Navigation	14:00-15:40 ThB3 **Athina B** Aerospace Control	14:00-15:40 ThB4 **Poseidon C** Robotics II

16:30-18:10 ThC1 **Platon Hall** Multi-Agent Systems	16:30-18:10 ThC2 **Athina A** Multimodal Sensing for Localization, Planning and Scene Understanding	16:30-18:10 ThC3 **Athina B** Marine Control and Identification	16:30-18:10 ThC4 **Poseidon C** Robotics III

MED 2022 Technical Program Friday July 1, 2022

Track 1	Track 2	Track 3	Track 4
09:00-10:00 FrPL1 **Platon Hall** **Data-Driven MPC: From Linear to Nonlinear Systems with Guarantees (Frank Allgöwer, University of Stuttgart)**			

10:30-12:10 FrA1 **Platon Hall** Fault Diagnosis	10:30-12:10 FrA2 **Athina A** Networked Systems	10:30-12:10 FrA3 **Athina B** Cyber-Physical Systems	10:30-12:10 FrA4 **Poseidon C** Robotics IV

14:00-15:40 FrB1 **Platon Hall** Fault Tolerant Control	14:00-15:40 FrB2 **Athina A** Distributed Systems	14:00-15:40 FrB3 **Athina B** Automotive Control	14:00-15:40 FrB4 **Poseidon C** Robotics V

16:30-18:10 FrC1 **Platon Hall** Discrete-Event and Hybrid Systems	16:30-18:10 FrC2 **Athina A** Power Systems and Smart Grid	16:30-18:10 FrC3 **Athina B** Control, Optimization, and Learning Methods for Emerging Mobility Systems in Smart Cities	16:30-18:10 FrC4 **Poseidon C** Applications

CONTENT LIST

Technical Program for Wednesday June 29, 2022

Vagg, Christopher — University of Bath
Burke, Richard — University of Bath

11:30-11:50 — WeA2.4

Optimal Control of a Grid-Connected Service Area for Plug-In Electric Vehicles Fast Charging under Uncertain Power Demand, pp. 49-55.

De Santis, Emanuele — Sapienza Università di Roma
Liberati, Francesco — Consortium for the Research in Automation and Telecommunication
Di Giorgio, Alessandro — Sapienza Università di Roma

11:50-12:10 — WeA2.5

Reinforcement Learning Based Multi-Objective Optimization for Broadband Newtonian Noise Cancellation in GW Detectors, pp. 56-61.

Jose, Roselyn — Indian Institute of Technology Madras
Kalaimani, Rachel Kalpana — Indian Institute of Technology Madras

WeA3 — Athina B

Decentralized Control (Regular Session)

Chair: Iftar, Altug — Eskisehir Technical University
Co-Chair: Dotoli, Mariagrazia — Politecnico Di Bari

10:30-10:50 — WeA3.1

Overlapping Decompositions and Decentralized Robust Controller Design for Neutral Time-Delay Systems, pp. 62-66.

Iftar, Altug — Eskisehir Technical University

10:50-11:10 — WeA3.2

Multi-Block ADMM Approach for Decentralized Demand Response of Energy Communities with Flexible Loads and Shared Energy Storage System, pp. 67-72.

Hosseini, Seyed Mohsen — Free University of Bolzano
Carli, Raffaele — Politecnico di Bari
Jantzen, Jan — Politecnico di Bari
Dotoli, Mariagrazia — Politecnico di Bari

11:10-11:30 — WeA3.3

Group and Socially Aware Multi-Agent Reinforcement Learning, pp. 73-78.

Vallecha, Manav — Indian Institute of Information Technology Allahabad
Kala, Rahul — Indian Institute of Information Technology Allahabad

11:30-11:50 — WeA3.4

Coordinated Navigation of Holonomic Robot Swarms in Complex Workspaces Via Dynamic Formation Tracking Control, pp. 79-84.

Trakas, Panagiotis — University of Patras
Bechlioulis, Charalampos — University of Patras
Rovithakis, George A. — Aristotle University of Thessaloniki

11:50-12:10 — WeA3.5

Extension Principle and Controller Design for Neutral Time-Delay Systems, pp. 85-90.

Iftar, Altug — Eskisehir Technical University

WeA4 — Poseidon AB

Nonlinear Systems (Regular Session)

Chair: Ailon, Amit — Ben Gurion University of the Negev
Co-Chair: Theodosis, Dionysios — Technical University of Crete

10:30-10:50 — WeA4.1

A New Matrix Multiplier-Based LMI Approach for Nonlinear Observers, pp. 91-96.

Mohite, Shivaraj — University of Lorraine
Alma, Marouane — University of Lorraine
Zemouche, Ali — University of Lorraine

10:50-11:10 — WeA4.2

Achieving Prescribed Performance for Euler-Lagrange Systems with Impulsive Behaviour, pp. 97-102.

Kechagias, Andreas — Aristotle University of Thessaloniki

Rovithakis, George A.	Aristotle University of Thessaloniki

11:10-11:30 WeA4.3

Sampled-Data Controllers for Autonomous Vehicles on Lane-Free Roads, pp. 103-108.

Theodosis, Dionysios	Technical University of Crete
Tzortzoglou, Filippos N.	Technical University of Crete
Karafyllis, Iasson	National Technical University of Athens
Papamichail, Ioannis	Technical University of Crete
Papageorgiou, Markos	Technical University of Crete

11:30-11:50 WeA4.4

Point-To-Point Control and Set-Point Regulation by Steering in a Two-Wheeled Tilting Dynamic Model, pp. 109-114.

Ailon, Amit	Ben-Gurion University of the Negev

11:50-12:10 WeA4.5

Finite Frequency H∞ Control of 2-D Continuous Takagi-Sugeno Systems, pp. 115-120.

Er-rachid, Ismail	University Sultan Moulay Slimane
Zoulagh, Taha	University of Santiago De Chile
Tadeo, Fernando	University of Valladolid
Merzouki, Hassnae	University Sultan Moulay Slimane
Tissir, El Houssaine	Université Sidi Mohamed Ben Abdellah

WeB1 Platon Hall

Predictive Control II (Regular Session)

Chair: Menezes Morato, Marcelo	Universidade Federal De Santa Catarina
Co-Chair: Stoffel, Phillip	RWTH Aachen University

15:30-15:50 WeB1.1

Combining Data-Driven and Physics-Based Process Models for Hybrid Model Predictive Control of Building Energy Systems, pp. 121-126.

Stoffel, Phillip	RWTH Aachen University
Löffler, Charlotte	RWTH Aachen University
Eser, Steffen	RWTH Aachen University
Kümpel, Alexander	RWTH Aachen University
Müller, Dirk	RWTH Aachen University

15:50-16:10 WeB1.2

Switching Predictive Controller for Building Optimal Thermal Comfort, pp. 127-132.

Rajaoarisoa, Lala Herimanjaka	Institut Mines Télécom Nord Europe
Benzaama, Mohammed Hichem	Ecole Supérieure d'Ingénieurs Des Travaux De La Construct
M'Sirdi, Kouider Nacer	Laboratoire d'Informatique Et Systèmes UMR 7020
Clavier, Laurent	Institut Mines Télécom Nord Europe
Sayed-mouchaweh, Moamar	Institut Mines Télécom Nord Europe

16:30-16:50 WeB1.3

Effective Inventory Control in Supply Chains with Large Uncertain Decay Factor Using Robust Model Predictive Control, pp. 133-138.

Orsini, Valentina	Università Politecnica Delle Marche
Letto, Beatrice	Università Politecnica Delle Marche

16:10-16:30 WeB1.4

Self-Triggered Controller Co-Design Using LASSO Regression, pp. 139-144.

Etienne, Lucien	Institut Mines Télécom Nord Europe
Langueh, Kokou Anani	Institut Mines Télécom Nord Europe
Rajaoarisoa, Lala Herimanjaka	Institut Mines Télécom Nord Europe

16:50-17:10 WeB1.5

An Observer Based Field Oriented Economic Model Predictive Control Approach for Permanent Magnet Synchronous Motors, pp. 145-151.

Geweth, Daniel	Bosch GmbH
Vollmer, Ulrich	Bosch GmbH
Diehl, Moritz	Albert-Ludwigs-Universität Freiburg

WeB2	Athina A
Optimisation II (Regular Session)	
Chair: Stylios, Chrysostomos	Athena Research Center
Co-Chair: Manzoni, Eleonora	Università Degli Studi Di Padova
15:30-15:50	WeB2.1
Optimal MmWave Sensor Selection for Bearing-Only Localization in Smart Environments, pp. 152-157.	
Vlachos, Evangelos	Athena Research Center
Spyrou, Evangelos	University of Ioannina
Stylios, Chrysostomos	Athena Research Center
Berberidis, Konstantinos	University of Patras
15:50-16:10	WeB2.2
Robust Finite-Frequency H∞ Model Reduction for Uncertain 2D Discrete Systems, pp. 158-163.	
El-Amrani, Abderrahim	Université Sidi Mohamed Ben Abdellah
El Hajjaji, Ahmed	University of Picardie Jules Verne
Bosche, Jerome	University of Picardie Jules Verne
Aitouche, Abdel	CRISTAL/JUNIA
16:30-16:50	WeB2.3
Reinforcement Q-Learning for Closed-Loop Hypnosis Depth Control in Anesthesia, pp. 164-169.	
Calvi, Giulia	Università Degli Studi di Padova
Manzoni, Eleonora	Università Degli Studi di Padova
Rampazzo, Mirco	Università Degli Studi di Padova
16:10-16:30	WeB2.4
Feedback Strategies for Threshold Crossing of Protein Levels at a Prescribed Time, pp. 170-175.	
Nieto, Cesar	University of Delaware
Ghusinga, Khem Raj	University of North Carolina at Chapel Hill
Singh, Abhyudai	University of Delaware
16:50-17:10	WeB2.5
The Refined Optimal Control Problem and Synthesized Control Methods for Its Solution, pp. 176-181.	
Diveev, Askhat	Federal Research Center

WeB3	Athina B
Intelligent Data Processing from Sensors in Control and Decision Support Systems (Invited Session)	
Chair: Popescu, Dan	Politehnica University of Bucharest
Co-Chair: Mavridis, Christos	University of Maryland College Park
Organizer: Popescu, Dan	Politehnica University of Bucharest
Organizer: Lazar, Corneliu	Gheorghe Asachi Technical University of Iasi
Organizer: Ichim, Loretta	Politehnica University of Bucharest
Organizer: Stamatescu, Grigore	Politehnica University of Bucharest
15:30-15:50	WeB3.1
Comparative Study of Neural Networks Used in Halyomorpha Halys Detection (I), pp. 182-187.	
Popescu, Dan	Politehnica University of Bucharest
Ichim, Loretta	Politehnica University of Bucharest
Dimoiu, Mihai	Politehnica University of Bucharest
Trufelea, Raluca	Politehnica University of Bucharest
15:50-16:10	WeB3.2
Detection of Early Pregnancy in Ultrasound Images Using YOLOv3 (I), pp. 188-193.	
Teodor, Oana Mihaela	Politehnica University of Bucharest
Cirstoiu, Monica Mihaela	Carol Davila University of Medicine and Pharmacy
Ichim, Loretta	Politehnica University of Bucharest
Popescu, Dan	Politehnica University of Bucharest
16:30-16:50	WeB3.3
Risk Sensitivity and Entropy Regularization in Prototype-Based Learning, pp. 194-199.	
Mavridis, Christos	University of Maryland College Park
Noorani, Erfaun	University of Maryland College Park

Baras, John S.	University of Maryland College Park

16:10-16:30 WeB3.4

Single Image Dehazing Using Local Detail Enhancement, pp. 200-204.

Ok, Jiheon	Yonsei University
Jeong, Taeuk	Yonsei University
Lee, Chulhee	Yonsei University

16:50-17:10 WeB3.5

Model-Free iPI Controller Design and Application to a Thermal Plant (I), pp. 205-210.

Baciu, Andrei	Gheorghe Asachi Technical University of Iasi
Lazar, Corneliu	Gheorghe Asachi Technical University of Iasi
Caruntu, Constantin-Florin	Gheorghe Asachi Technical University of Iasi

WeB4 — Poseidon AB

Nonlinear Control (Regular Session)

Chair: Dritsas, Leonidas	ASPETE
Co-Chair: Heshmati Alamdari, Shahab	Aalborg University

15:30-15:50 WeB4.1

Revisiting the Derivation of Stage Costs in Infinite Horizon Discrete-Time Optimal Control, pp. 211-216.

Fiedler, Christian	RWTH Aachen University
Trimpe, Sebastian	RWTH Aachen University

15:50-16:10 WeB4.2

State Feedback Control with Providing Inputs and Outputs in Given Sets, pp. 217-220.

Furtat, Igor	Russian Academy of Sciences
Gushchin, Pavel	Gubkin Russian State University of Oil and Gas
Nguyen, Ba Huy	Russian Academy of Sciences
Vrazhevsky, Sergey	ITMO University

16:30-16:50 WeB4.3

An Aperiodic Prescribed Performance Control Scheme for Uncertain Nonlinear Systems, pp. 221-226.

Nikou, Alexandros	Ericsson AB
Verginis, Christos	Uppsala University
Heshmati Alamdari, Shahab	Aalborg University

16:10-16:30 WeB4.4

Robust Tracking Control for a Class of Uncertain Systems with Matched and Unmatched Nonlinearities, pp. 227-232.

Dritsas, Leonidas	ASPETE

16:50-17:10 WeB4.5

Incremental Nonlinear Dynamic Inversion with Sparse Online Gaussian Processes Adaptation for Partially Unknown Systems, pp. 233-238.

Ignatyev, Dmitry	Cranfield University
Tsourdos, Antonios	Cranfield University

WeC1 — Platon Hall

Linear Systems (Regular Session)

Chair: Piazzi, Aurelio	Università Degli Studi Di Parma
Co-Chair: Koumboulis, Fotis N.	National and Kapodistrian University of Athens

17:30-17:50 WeC1.1

Data-Driven LQR Design for LTI Systems with Exogenous Inputs, pp. 239-244.

Digge, Vijayanand	Indian Institute of Technology Madras
Pasumarthy, Ramkrishna	Indian Institute of Technology Madras

17:50-18:10 WeC1.2

On the Structure of the Multivariable Free Response, pp. 245-250.

Kavaja, Juxhino	Università Degli Studi di Parma
Piazzi, Aurelio	Università Degli Studi di Parma

18:10-18:30 WeC1.3

Time-Delay Estimation with Non-Persistent Input, pp. 251-256.

Medvedev, Alexander V. — Uppsala University

18:30-18:50 — WeC1.4

A Common Noninteracting Control Design for Robot Tracked Vehicles, pp. 257-264.

Koumboulis, Fotis N. — National and Kapodistrian University of Athens

Kouvakas, Nikolaos — National and Kapodistrian University of Athens

18:50-19:10 — WeC1.5

L∞/H∞ Functional Interval Observers Design for Multivariable Systems, pp. 265-270.

Akremi, Rihab — National Engineering School of Gabes

Lamouchi, Rihab — National Engineering School of Gabes

Amairi, Messaoud — National Engineering School of Gabes

WeC2 — Athina A

Robust Control (Regular Session)

Chair: Iles, Sandor — University of Zagreb

Co-Chair: Teofilo Rocha, Kaio Douglas — University of São Paulo

17:30-17:50 — WeC2.1

Robust Kalman Filtering for Systems Subject to Polytopic Uncertainties, pp. 271-276.

Teofilo Rocha, Kaio Douglas — University of São Paulo

Almeida Dias Bueno, Jose Nuno — University of São Paulo

Marcos, Lucas Barbosa — University of São Paulo

Terra, Marco Henrique — University of São Paulo

17:50-18:10 — WeC2.2

Mode-Independent Regulator for Polytopic Markov Jump Linear Systems, pp. 277-282.

Almeida Dias Bueno, Jose Nuno — University of São Paulo

Teofilo Rocha, Kaio Douglas — University of São Paulo

Marcos, Lucas Barbosa — University of São Paulo

Terra, Marco Henrique — University of São Paulo

18:10-18:30 — WeC2.3

Improved Robustness and Performance for Adaptive Control of Non-Linear Plants with Input Saturations, pp. 283-288.

Karez, Ian — University of Rostock

Müller, Thilo — University of Rostock

Jeinsch, Torsten — University of Rostock

18:30-18:50 — WeC2.4

Stabilizing Direct Yaw Moment Control Based on a Flexible Set-Membership Constraint, pp. 289-294.

Iles, Sandor — University of Zagreb

Svec, Marko — University of Zagreb

Makarun, Petar — University of Zagreb

Kir Hromatko, Josip — University of Zagreb

18:50-19:10 — WeC2.5

Quadrotor Control with a Guaranteed Presence of Output Signals under a Prespecified State Bounds, pp. 295-299.

Kuznetsov, Mikhail — ITMO University

Vrazhevsky, Sergey — ITMO University

Khalyamina, Ekaterina — ITMO University

WeC3 — Athina B

Neural Networks (Regular Session)

Chair: Mascolo, Saverio — Politecnico di Bari

Co-Chair: Koutsoukos, Xenofon — Vanderbilt University

17:30-17:50 — WeC3.1

Attack-Resilient Multi-Agent Flocking Control Using Graph Neural Networks, pp. 300-305.

Bhowmick, Chandreyee — Vanderbilt University

Shabbir, Mudassir — Vanderbilt University

Koutsoukos, Xenofon — Vanderbilt University

17:50-18:10	WeC3.2
On Asymptotic Stability of Nonlinear Systems with Deep Reinforcement Learning Controllers, pp. 306-311.	
Manfredi, Gioacchino	Politecnico di Bari
De Cicco, Luca	Politecnico di Bari
Mascolo, Saverio	Politecnico di Bari
18:10-18:30	WeC3.3
Decentralized Federated Learning for Nonintrusive Load Monitoring in Smart Energy Communities, pp. 312-317.	
Giuseppi, Alessandro	Sapienza Università di Roma
Menegatti, Danilo	Sapienza Università di Roma
Manfredi, Sabato	Università Degli Studi di Napoli Federico II
Pietrabissa, Antonio	Consortium for the Research in Automation and Telecommunication
Poli, Cecilia	Institute Superiore di Sanità
18:30-18:50	WeC3.4
Automated Optical Inspection for Printed Circuit Board Assembly Manufacturing with Transfer Learning and Synthetic Data Generation, pp. 318-323.	
Saif, Syed Saad	Sapienza Università di Roma
Aras, Kerem	Token Financial Technologies
Giuseppi, Alessandro	Sapienza Università di Roma
18:50-19:10	WeC3.5
Personalized LSTM Models for Glucose Prediction in Type 1 Diabetes Subjects, pp. 324-329.	
Iacono, Francesca	Università Degli Studi di Pavia
Magni, Lalo	Università Degli Studi di Pavia
Toffanin, Chiara	Università Degli Studi di Pavia

WeC4	Poseidon AB
System Identification (Regular Session)	
Chair: Hure, Nikola	University of Zagreb
Co-Chair: Mohite, Shivaraj	University of Lorraine
17:30-17:50	WeC4.1
Parameter Identification of an Electric Powertrain with Backlash, pp. 330-335.	
Heinz, Melanie	Mercedes-Benz AG
Nelles, Oliver	University of Siegen
17:50-18:10	WeC4.2
Regression-Based Thermodynamic Model Identification of a Zone with a Closed-Access Air Conditioner, pp. 336-342.	
Hure, Nikola	University of Zagreb
Vasak, Mario	University of Zagreb
18:10-18:30	WeC4.3
NARX Models of Two-Phase Microchannels Flow in Comparison, pp. 343-348.	
Stella, Giovanna	Università Degli Studi di Catania
Gagliano, Salvina	Università Degli Studi di Catania
Bucolo, Maide	Università Degli Studi di Catania
18:30-18:50	WeC4.4
Finite Time Convergence Parameter Estimator for Nonlinear MIMO System, pp. 349-354.	
Bazylev, Dmitry	ITMO University
Vrazhevsky, Sergey	ITMO University
18:50-19:10	WeC4.5
Advantages of a Physics-Embedding Kernel for Robot Inverse Dynamics Identification, pp. 355-361.	
Giacomuzzo, Giulio	Università Degli Studi di Padova
Turcato, Niccolò	Università Degli Studi di Padova
Dalla Libera, Alberto	Università Degli Studi di Padova
Carli, Ruggero	Università Degli Studi di Padova

Technical Program for Thursday June 30, 2022

ThA1	Platon Hall
Autonomous Systems I (Regular Session)	
Chair: Freddi, Alessandro	Università Politecnica Delle Marche
Co-Chair: Satpute, Sumeet	Luleå University of Technology
10:30-10:50	ThA1.1
An Adaptive 3D Artificial Potential Field for Fail-Safe UAV Navigation, pp. 362-367.	
Lindqvist, Björn	Luleå University of Technology
Haluska, Jakub	Luleå University of Technology
Kanellakis, Christoforos	Luleå University of Technology
Nikolakopoulos, George	Luleå University of Technology
10:50-11:10	ThA1.2
A Deep Reinforcement Learning Motion Control Strategy of a Multi-Rotor UAV for Payload Transportation with Minimum Swing, pp. 368-374.	
Panetsos, Fotis	National Technical University of Athens
Karras, George	University of Thessaly
Kyriakopoulos, Kostas J.	National Technical University of Athens
11:10-11:30	ThA1.3
A Visual Servoing Strategy for Coastline Tracking Using an Unmanned Aerial Vehicle, pp. 375-381.	
Aspragkathos, Sotiris	National Technical University of Athens
Karras, George	University of Thessaly
Kyriakopoulos, Kostas J.	National Technical University of Athens
11:30-11:50	ThA1.4
A Design and Simulation of a Target Detection, Tracking and Localisation System for UAVs, pp. 382-388.	
Daramouskas, Ioannis	University of Patras
Patrinopoulou, Niki	University of Patras
Meimetis, Dimitrios	University of Patras
Lappas, Vaios	University of Patras
Kostopoulos, Vassilis	University of Patras
11:50-12:10	ThA1.5
A Survey on Control Design Approaches for Remotely Operated UAVs, pp. 389-395.	
Sankaranarayanan, Viswa Narayanan	Luleå University of Technology
Nikolakopoulos, George	Luleå University of Technology
Satpute, Sumeet	Luleå University of Technology
12:10-12:30	ThA1.6
Modeling and Control of a Telescopic Quadrotor Using Disturbance Observer Based Control, pp. 396-402.	
Baldini, Alessandro	Università Politecnica Delle Marche
Felicetti, Riccardo	Università Politecnica Delle Marche
Freddi, Alessandro	Università Politecnica Delle Marche
Longhi, Sauro	Università Politecnica Delle Marche
Monteriù, Andrea	Università Politecnica Delle Marche

ThA2	Athina A
Guidance (Regular Session)	
Chair: Tekin, Raziye	Roketsan Inc
Co-Chair: Lack, Sven	University of Rostock
10:30-10:50	ThA2.1
Three-Dimensional Formation Flight with Impact Vector Guidance, pp. 403-408.	
Alan, Asım Burkay	Roketsan Inc
Tekin, Raziye	Roketsan Inc
10:50-11:10	ThA2.2
Three-Dimensional Impact-Angle Control with Biased Proportional Navigation, pp. 409-413.	
Erer, Koray	Roketsan Inc
Tekin, Raziye	Roketsan Inc

11:10-11:30	ThA2.3
Trajectory Generation for a Quaternion Based 6-DoF ROV Tracking Controller, pp. 414-419.	
Lack, Sven	University of Rostock
Rentzow, Erik	University of Rostock
Jeinsch, Torsten	University of Rostock
11:30-11:50	ThA2.4
Analysis of 2D Impact Angle Control Laws in 3D Kinematics, pp. 420-425.	
Ata, Emre Han	Roketsan Inc
Kaya, Taşkın	Roketsan Inc
Tekin, Raziye	Roketsan Inc
Erer, Koray	Roketsan Inc
11:50-12:10	ThA2.5
RRT-Based Path Planning for Car-Like Vehicles with Nonholonomic Constraints, pp. 426-431.	
Spanogianopoulos, Sotirios	Xi'an Jiaotong-Liverpool University
Sirlantzis, Konstantinos	University of Kent
Ahiska, Kenan	ASELSAN Inc

ThA3	Athina B
Modeling and Flight Control Design for Aerospace Systems (Invited Session)	
Chair: Tzes, Anthony	New York University Abu Dhabi
Co-Chair: Theodoulis, Spilios	French-German Research Institute of Saint-Louis
Organizer: Theodoulis, Spilios	French-German Research Institute of Saint-Louis
Organizer: Tzes, Anthony	New York University Abu Dhabi
10:30-10:50	ThA3.1
Design, Modelling, Localization, and Control for Fire-Fighting Aerial Vehicles (I), pp. 432-437.	
Chaikalis, Dimitris	New York University
Evangeliou, Nikolaos	New York University Abu Dhabi
Tzes, Anthony	New York University Abu Dhabi
Khorrami, Farshad	New York University
10:50-11:10	ThA3.2
Robust Path-Following Control with Anti-Windup for HALE Aircraft (I), pp. 438-443.	
Weiser, Christian	German Aerospace Center (DLR)
Ossmann, Daniel	Munich University of Applied Sciences
Pfifer, Harald	Technische Universität Dresden
11:10-11:30	ThA3.3
Autopilot Design for Dual-Spin Projectiles Using Incremental Nonlinear Dynamic Inversion (I), pp. 444-449.	
Pineau, Sofiane	French-German Research Institute of Saint-Louis
Theodoulis, Spilios	French-German Research Institute of Saint-Louis
Zasadzinski, Michel	University of Lorraine
Boutayeb, Mohamed	University of Lorraine
11:30-11:50	ThA3.4
Smooth Attitude Stabilisation in Prescribed Time of a Rigid Body Despite Uncertainties in Inertia and Additive Disturbances (I), pp. 450-455.	
Sarras, Ioannis	ONERA-The French Aerospace Lab
11:50-12:10	ThA3.5
Altitude and Attitude Quadrotor Control Based on Adaptive Sliding Mode Controller with Input Saturation, pp. 456-461.	
Sidi Brahim, Khelil	Université De Picardie Jules Verne
Terki, Nadjiba	University Mohamed Khider Biskra
El Hajjaji, Ahmed	Université De Picardie Jules Verne
Lara, David	Instituto Tecnologico Superior de Misantla

ThA4	Poseidon AB
Robotics I (Regular Session)	
Chair: Nikolakopoulos, George	Luleå University of Technology

Co-Chair: Lindqvist, Björn	Luleå University of Technology

10:30-10:50 ThA4.1

Embedded GPU Based Autonomous Robot Use Cases, pp. 462-467.

Molnar, Szilard	Technical University of Cluj-Napoca
Lucaci, Adrian	Technical University of Cluj-Napoca
Tamas, Levente	Technical University of Cluj-Napoca

10:50-11:10 ThA4.2

Experimental Evaluation of a Geometry-Aware Aerial Visual Inspection Framework in a Constrained Environment, pp. 468-474.

Kottayam Viswanathan, Vignesh	Luleå University of Technology
Satpute, Sumeet	Lulea University of Technology
Lindqvist, Björn	Luleå University of Technology
Kanellakis, Christoforos	Luleå University of Technology
Nikolakopoulos, George	Luleå University of Technology

11:10-11:30 ThA4.3

Soft Pneumatic Actuated Morphing Quadrotor: Design and Development, pp. 475-480.

Haluska, Jakub	Luleå University of Technology
Västanälv, Jim	Luleå University of Technology
Papadimitriou, Andreas	Luleå University of Technology
Nikolakopoulos, George	Luleå University of Technology

11:30-11:50 ThA4.4

Multi-Robot Task Allocation Framework with Integrated Risk-Aware 3D Path Planning, pp. 481-486.

Bai, Yifan	Luleå University of Technology
Lindqvist, Björn	Luleå University of Technology
Karlsson, Samuel	Luleå University of Technology
Kanellakis, Christoforos	Luleå University of Technology
Nikolakopoulos, George	Luleå University of Technology

11:50-12:10 ThA4.5

Edge Computing Architectures for Enabling the Realisation of the Next Generation Robotic Systems, pp. 487-493.

Seisa, Achilleas Santi	Luleå University of Technology
Damigos, Gerasimos	Luleå University of Technology
Satpute, Sumeet	Luleå University of Technology
Koval, Anton	Luleå University of Technology
Nikolakopoulos, George	Luleå University of Technology

ThB1 Platon Hall

Autonomous Systems II (Regular Session)

Chair: Kyriakopoulos, Kostas J.	National Technical University of Athens
Co-Chair: Schwartz, Howard M.	Carleton University

14:00-14:20 ThB1.1

AROWA: An Autonomous Robot Framework for Warehouse 4.0 Health and Safety Inspection Operations, pp. 494-499.

Konstantinidis, Fotios K.	Democritus University of Thrace
Balaska, Vasiliki	Democritus University of Thrace
Symeonidis, Symeon	Democritus University of Thrace
Mouroutsos, Spyridon G.	Democritus University of Thrace
Gasteratos, Antonios	Democritus University of Thrace

14:20-14:40 ThB1.2

Comparison of Cellular Network Controllers for Quadrotors Experiencing Time Delay, pp. 500-507.

Tayefe Ramezanlou, Mohammad	Carleton University
Schwartz, Howard M.	Carleton University
Lambadaris, Ioannis	Carleton University
Barbeau, Michel	Carleton University

14:40-15:00 ThB1.3

Real-Time Path Planning for Fully Actuated Autonomous Surface Vehicles, pp. 508-513.

Damerius, Robert	University of Rostock

Jeinsch, Torsten	University of Rostock

15:00-15:20 ThB1.4

Hardware-In-The-Loop Testing of a Maritime Autonomous Collision Avoidance System, pp. 514-519.

Tornese, Riccardo	Università Del Salento
Polimeno, Edoardo	Università Del Salento
Pascarelli, Claudio	Università Del Salento
Buccoliero, Stefania	Fincantieri NexTech S.p.A
Carlino, Luca	Fincantieri NexTech S.p.A
Sansebastiano, Emanuele	Fincantieri NexTech S.p.A
Sebastiani, Luca	Fincantieri NexTech S.p.A

15:20-15:40 ThB1.5

Shortest Path Type Classification for Real-Time Three-Points Dubins Problems, pp. 520-525.

De Palma, Daniela	Università Del Salento
Parlangeli, Gianfranco	Università Del Salento

15:20-16:00 ThB1.6

Fixed Time Stability of Discrete Autonomous Systems, pp. 526-531.

Lee, Junsoo	Georgia Institute of Technology
Haddad, Wassim M.	Georgia Institute of Technology

ThB2 Athina A

Navigation (Regular Session)

Chair: Gasteratos, Antonios	Democritus University of Thrace
Co-Chair: Vougioukas, Stavros	University of California Davis

14:00-14:20 ThB2.1

BK Tree Indexing for Active Vision-Based Loop-Closure Detection in Autonomous Navigation, pp. 532-537.

Tsintotas, Konstantinos	Democritus University of Thrace
Sevetlidis, Vasileios	Democritus University of Thrace
Papapetros, Ioannis Tsampikos	Democritus University of Thrace
Balaska, Vasiliki	Democritus University of Thrace
Psomoulis, Athanasios	Democritus University of Thrace
Gasteratos, Antonios	Democritus University of Thrace

14:20-14:40 ThB2.2

Depth Camera Based Row-End Detection and Headland Maneuvering in Orchard Navigation without GNSS, pp. 538-544.

Peng, Chen	University of California Davis
Fei, Zhenghao	University of California Davis
Vougioukas, Stavros	University of California Davis

14:40-15:00 ThB2.3

Fast Planner for MAV Navigation in Unknown Environments Based on Adaptive Search of Safe Lookahead Poses, pp. 545-550.

Patel, Akash	Lulea University of Technology
Lindqvist, Björn	Luleå University of Technology
Kanellakis, Christoforos	Luleå University of Technology
Nikolakopoulos, George	Luleå University of Technology

15:00-15:20 ThB2.4

Visual Control through Narrow Passages for an Omnidirectional Wheeled Robot, pp. 551-556.

Morra, Damiano	Università Degli Studi di Napoli Federico II
Cervera, Enric	Jaume-I University of Castelló De La Plana
Buonocore, Luca Rosario	Università Degli Studi di Napoli Federico II
Cacace, Jonathan	Università Degli Studi di Napoli Federico II
Ruggiero, Fabio	Università Degli Studi di Napoli Federico II
Lippiello, Vincenzo	Università Degli Studi di Napoli Federico II
Di Castro, Mario	CERN

15:20-15:40 ThB2.5

Object Detection and Navigation of a Mobile Robot by Fusing Laser and Camera Information, pp. 557-563.

Syntakas, Spyridon	University of Ioannina

Vlachos, Kostas — University of Ioannina
Likas, Aristidis — University of Ioannina

ThB3 — Athina B
Aerospace Control (Regular Session)
Chair: Henry, David — Université De Bordeaux
Co-Chair: Nikolakopoulos, George — Luleå University of Technology

14:00-14:20 — ThB3.1

Model Predictive Control for Collision-Free Spacecraft Formation with Artificial Potential Functions, pp. 564-570.
Menegatti, Danilo — Sapienza Università di Roma
Giuseppi, Alessandro — Sapienza Università di Roma
Pietrabissa, Antonio — Consortium for the Research in Automation and Telecommunication

14:20-14:40 — ThB3.2

Sliding-Mode Control for On-Orbit Rendezvous with a Fleeing Passive Target on a Circular Capture Trajectory, pp. 571-576.
Henry, David — Université De Bordeaux
Ferreira de Loza, Alejandra — CONACYT - Consejo Nacional De Ciencia Y Tecnologia
Fauré, Martin — Université De Bordeaux
Cieslak, Jérôme — Université De Bordeaux
Punta, Elisabetta — CNR-IEIIT

14:40-15:00 — ThB3.3

On the Design of Coordinated Impedance Control Laws for De-Orbiting and De-Spinning of Cooperative Satellites, pp. 577-582.
Nanos, Kostas — National Technical University of Athens
Papadopoulos, Evangelos — National Technical University of Athens

15:00-15:20 — ThB3.4

A Survey on Drones for Planetary Exploration: Evolution and Challenges, pp. 583-590.
Giacomini, Enrico — Luleå University of Technology
Nikolakopoulos, George — Luleå University of Technology
Westerberg, Lars Göran — Luleå University of Technology

15:20-15:40 — ThB3.5

Linear Quadratic Regulator: A Simple Thrust Vector Control System for Rockets, pp. 591-597.
Sopegno, Laura — Università Degli Studi di Palermo
Livreri, Patrizia — Università Degli Studi di Palermo
Stefanovic, Margareta — University of Denver
Valavanis, Kimon P. — University of Denver

ThB4 — Poseidon AB
Robotics II (Regular Session)
Chair: Novakovic, Branko — University of Zagreb
Co-Chair: Gorjup, Gal — The University of Auckland

14:00-14:20 — ThB4.1

Robust Model-Based Hinf Control for Free-Floating Space Manipulator Cartesian Motions, pp. 598-603.
Anastasiou, Dimitrios — London's Global University
Nanos, Kostas — National Technical University of Athens
Papadopoulos, Evangelos — National Technical University of Athens

14:20-14:40 — ThB4.2

Dynamic Path Planning and Reactive Scheduling for a Robotic Manipulator Using Nonlinear Model Predictive Control, pp. 604-611.
Gafur, Nigora — Technische Universität Kaiserslautern
Weber, Leo — Technische Universität Kaiserslautern
Yfantis, Vassilios — Technische Universität Kaiserslautern
Wagner, Achim — German Research Center for Artificial Intelligence
Ruskowski, Martin — Technische Universität Kaiserslautern

14:40-15:00	ThB4.3
On the Efficiency, Usability, and Intuitiveness of a Wearable, Affordable, Open-Source, Generic Robot Teaching Interface, pp. 612-617.	
Gorjup, Gal	The University of Auckland
Gerez, Lucas	The University of Auckland
Gao, Geng	The University of Auckland
Liarokapis, Minas	The University of Auckland
15:00-15:20	ThB4.4
Nonnegative Saturated Tracking Control for Cable Driven Parallel Robots (CDPRs), pp. 618-623.	
Jabbari, Imed	University of Lorraine
Boutayeb, Mohamed	University of Lorraine
Jammazi, Chaker	Ecole Polytechnique De Tunisie
15:20-15:40	ThB4.5
Handling Vision Noise through Robot Motion Control in a Real-Time Teleoperation System, pp. 624-629.	
Tsitos, Athanasios Christoforos	National Center of Scientific Research Demokritos
Dagioglou, Maria	National Center of Scientific Research Demokritos

ThC1	Platon Hall
Multi-Agent Systems (Regular Session)	
Chair: Siami, Milad	Northeastern University
Co-Chair: Pasumarthy, Ramkrishna	Indian Institute of Technology Madras
16:30-16:50	ThC1.1
Multi-Agent Exploration with Reinforcement Learning, pp. 630-635.	
Sygkounas, Alkis	University of Patras
Tsipianitis, Dimitrios	University of Patras
Nikolakopoulos, George	Luleå University of Technology
Bechlioulis, Charalampos	University of Patras
16:50-17:10	ThC1.2
Time-Delayed Data Transmission in Heterogeneous Multi-Agent Deep Reinforcement Learning System, pp. 636-642.	
Elhami Fard, Neshat	Concordia University
Selmic, Rastko	Concordia University
17:10-17:30	ThC1.3
Role of Agent Update Cycle in Stability and Robustness of Second-Order Consensus Networks, pp. 643-648.	
Huang, Yu-Mei	Northeastern University
Siami, Milad	Northeastern University
17:30-17:50	ThC1.4
Metropolis II: Investigating the Future Shape of Air Traffic Control in Highly Dense Urban Airspace, pp. 649-655.	
Patrinopoulou, Niki	University of Patras
Daramouskas, Ioannis	University of Patras
Lappas, Vaios	University of Patras
Kostopoulos, Vassilis	University of Patras
Morfin Veytia, Andres	Delft University of Technology
Badea, Calin Andrei	Delft University of Technology
Ellerbroek, Joost	Delft University of Technology
Hoekstra, Jacco	TU Delft
de Vries, Vincent	NLR - Royal Netherlands Aerospace Centre
van Ham, Jacomijn	NLR - Royal Netherlands Aerospace Centre
Sunil, Emmanuel	NLR - Royal Netherlands Aerospace Centre
Menéndez-Ponte Alonso, Pablo	NTT DATA Spain
Pedrero Gonzalez, Juan	NTT DATA Spain
Bereziat, Denis	ENAC Université De Toulouse
Vidosavljevic, Andrija	ENAC Université De Toulouse
Sedov, Leonid	Linkoping University
17:50-18:10	ThC1.5
Distributed Least-Squares Over Directed Networks, pp. 656-661.	

Jahvani, Mohammad	Queen's University
Guay, Martin	Queen's University

ThC2	Athina A
Multimodal Sensing for Localization, Planning and Scene Understanding (Invited Session)	
Chair: Lalos, Aris	Athena Research Center
Co-Chair: Mukherjee, Moumita	Luleå University of Technology
Organizer: Lalos, Aris	Athena Research Center
Organizer: Stylios, Chrysostomos	University of Ioannina
Organizer: Nguyen, Duong-Van	Panasonic Automotive Systems Europe
Organizer: Petros Kapsalas, Petros	Panasonic Automotive Systems Europe
Organizer: Moustakas, Konstantinos	University of Patras
16:30-16:50	ThC2.1
A Resilient to Faults Auto-Encoder Enabled Kalman Based Multi-Sensorial Fusion (I), pp. 662-669.	
Mukherjee, Moumita	Luleå University of Technology
Banerjee, Avijit	Luleå University of Technology
Nikolakopoulos, George	Luleå University of Technology
16:50-17:10	ThC2.2
Alternating Optimization for Multimodal Collaborating Odometry Estimation in CAVs (I), pp. 670-675.	
Piperigkos, Nikos	University of Patras
Lalos, Aris	Athena Research Center
Berberidis, Konstantinos	University of Patras
17:10-17:30	ThC2.3
Implementation and Motion Control of a Microrobot Using Laser Sensors, pp. 676-681.	
Karaiskos, Konstantinos	National Technical University of Athens
Lampousis, Charalampos	National Technical University of Athens
Vlachos, Kostas	University of Ioannina
Papadopoulos, Evangelos	National Technical University of Athens
17:30-17:50	ThC2.4
Control Barrier Navigation Functions for STL Motion Planning, pp. 682-687.	
Zehfroosh, Ashkan	University of Delaware
Tanner, Herbert G.	University of Delaware
17:50-18:10	ThC2.5
Vanishing Point Detection Based on the Fusion of Lidar and Image Data (I), pp. 688-692.	
Kloukiniotis, Andreas	University of Patras
Moustakas, Konstantinos	University of Patras

ThC3	Athina B
Marine Control and Identification (Regular Session)	
Chair: Schubert, Agnes Ulrike	University of Rostock
Co-Chair: Wirtensohn, Stefan	University of Applied Sciences Konstanz
16:30-16:50	ThC3.1
Trajectory Tracking of a Fully-Actuated Surface Vessel Using Nonlinear Model Predictive Control: Experimental Results, pp. 693-698.	
Kinjo, Leticia Mayumi	ENSICAEN
Wirtensohn, Stefan	University of Applied Sciences Konstanz
Reuter, Johannes	University of Applied Sciences Konstanz
Ménard, Tomas	ENSICAEN
Gehan, Olivier	ENSICAEN
16:50-17:10	ThC3.2
Model Predictive Control of Vessels with Azimuth Drives in Maneuvering Situations, pp. 699-704.	
Marx, Johannes Richard	University of Rostock
Kurowski, Martin	University of Rostock
Jeinsch, Torsten	University of Rostock

17:10-17:30 ThC3.3

Trajectory Tracking and Fault Detection of Underactuated USVs Based on Nonlinear Model Predictive Control and Moving Horizon Estimation, pp. 705-712.

Rossides, George — Cyprus Marine and Maritime Institute
Constantinou, Christos — Cyprus Marine and Maritime Institute

17:30-17:50 ThC3.4

Adaptive Algorithm for Vessel Roll Prediction Based on the Bayesian Approach, pp. 713-718.

Litvinenko, Yulia — ITMO University
Stepanov, Oleg A. — ITMO University
Zaitsev, Oleg — ITMO University
Antonov, Danila — ITMO University

17:50-18:10 ThC3.5

Adaptation of Parameter Space Model for Automatic Maneuvering with Research Vessel DENEB, pp. 719-724.

Schubert, Agnes Ulrike — University of Rostock
Damerius, Robert — University of Rostock
Rethfeldt, Carsten — University of Rostock
Kurowski, Martin — University of Rostock
Jeinsch, Torsten — University of Rostock

ThC4 Poseidon AB

Robotics III (Regular Session)

Chair: Ruggiero, Fabio — Università Degli Studi Di Napoli Federico II
Co-Chair: El Bou, Cheikh Melainine — Free University of Bolzano

16:30-16:50 ThC4.1

A Homogeneity-Based Path Following Shared Control System for UGVs, pp. 725-730.

El Bou, Cheikh Melainine — Free University of Bolzano

16:50-17:10 ThC4.2

*SLAM and Map Learning Using Hybrid Semantic Graph Optimization**, pp. 731-736.

Agrawal, Ambuj — Indian Institute of Information Technology Allahabad
Agarwal, Dhruv — Indian Institute of Information Technology Allahabad
Arora, Mehul — Indian Institute of Information Technology Allahabad
Mahajan, Ritik — Indian Institute of Information Technology Allahabad
Beohar, Shivansh — Indian Institute of Information Technology Allahabad
Kenye, Lhilo — Indian Institute of Information Technology Allahabad
Kala, Rahul — Indian Institute of Information Technology Allahabad

17:10-17:30 ThC4.3

Motion Planning for Mobile Robots Using the Collidable Velocity Obstacles Method, pp. 737-742.

Gyenes, Zoltan Balint — Budapest University of Technology and Economics
Gincsaine Szadeczky-Kardoss, Emese — Budapest University of Technology and Economics

17:30-17:50 ThC4.4

Disturbance Rejection for Legged Robots through a Hybrid Observer, pp. 743-748.

Morlando, Viviana — Università Degli Studi di Napoli Federico II
Ruggiero, Fabio — Università Degli Studi di Napoli Federico II

17:50-18:10 ThC4.5

Experimental Analysis of Slip Ratio Using the Wheel Walking Locomotion Mode in Reconfigurable Rovers, pp. 749-754.

Dominguez-Durante, Salvador — University of Malaga
Perez-del-Pulgar, Carlos — University of Malaga
Paz-delgado, Gonzalo — University of Malaga
Azkarate, Martin — European Space Agency

Technical Program for Friday July 1, 2022

FrA1	Platon Hall
Fault Diagnosis (Regular Session)	
Chair: Monteriù, Andrea	Università Politecnica Delle Marche
Co-Chair: Somarakis, Christoforos	Palo Alto Research Center

10:30-10:50 FrA1.1

Specific Data Sampling and Filtering Helps to Detect and Isolate Periodic Disturbances, pp. 755-760.

Ettler, Pavel	Compureg Plzeň S.r.o
Puchr, Ivan	Compureg Plzeň S.r.o

10:50-11:10 FrA1.2

Learning-Based Diagnostics for Fault Detection and Isolation in Linear Stochastic Systems, pp. 761-766.

Noorani, Erfaun	University of Maryland College Park
Somarakis, Christoforos	Palo Alto Research Center
Goyal, Raman	Palo Alto Research Center
Feldman, Alexander	Palo Alto Research Center
Rane, Shantanu	Palo Alto Research Center

11:10-11:30 FrA1.3

Actuator Fault Diagnosis of Nonlinear Systems Based on Unknown Input Root-Mean-Square Cubature Kalman Filter, pp. 767-772.

Qian, Huaming	Harbin Engineering University
Yan, Shuya	Harbin Engineering University
Ding, Peng	Harbin Engineering University
Chu, Shuai	Harbin Engineering University

11:30-11:50 FrA1.4

Robust Fault Detection Based on Zonotopic Observers for Linear Parameter Varying Systems, pp. 773-778.

Lamouchi, Rihab	National Engineering School of Gabes
Amairi, Messaoud	National Engineering School of Gabes
Raïssi, Tarek	Conservatoire National Des Arts Et Métiers
Aoun, Mohamed	National Engineering School of Gabes

11:50-12:10 FrA1.5

A Comparison of Feature Extraction Methods for Crack and Ice Monitoring in Wind Turbine Blades: System Identification and Matrix Decomposition, pp. 779-784.

Calderano, Pedro	Pontifical Catholic University of Rio De Janeiro
Marins, Daniel	Pontifical Catholic University of Rio De Janeiro
Hultmann Ayala, Helon Vicente	Pontifical Catholic University of Rio De Janeiro

FrA2	Athina A
Networked Systems (Regular Session)	
Chair: Konstantopoulos, George	University of Patras
Co-Chair: Zorzi, Mattia	Universita Degli Studi Di Padova

10:30-10:50 FrA2.1

Distributed Kalman Filtering with Event-Triggered Communication: A Robust Approach, pp. 785-790.

Ghion, Davide	Serenissima Informatica Spa
Zorzi, Mattia	Università Degli Studi Di Padova

10:50-11:10 FrA2.2

Centrality Measure Based on the Laplacian Matrix Spectral Radius Eigenvector Application to the Identification of a Leader, pp. 791-796.

Bateman, Francois	Ecole De l'Air Et De L'Espace
Niel, Fabien	Centre De Recherche De l'Ecole De L'air

11:10-11:30 FrA2.3

Distributed Bounded Integral Control for Multimachine Power Systems, pp. 797-802.

Perantonis, Ioannis	University of Patras
Alexakis, Zaint	University of Patras
Konstantopoulos, George	University of Patras

Alexandridis, Antonio	University of Patras

11:30-11:50 FrA2.4

A Generalized Distributed Analysis and Control Synthesis Approach for Networked Systems with Arbitrary Interconnections, pp. 803-808.

Welikala, Shirantha	University of Notre Dame
Lin, Hai	University of Notre Dame
Antsaklis, Panos J.	University of Notre Dame

11:50-12:10 FrA2.5

Finite and Fixed Time Semistability and Consensus for Nonlinear Discrete-Time Network Systems, pp. 809-814.

Lee, Junsoo	Georgia Institute of Technology
Haddad, Wassim M.	Georgia Institute of Technology

FrA3 Athina B

Cyber-Physical Systems (Regular Session)

Chair: Giuseppi, Alessandro	Sapienza Università di Roma
Co-Chair: Oliva, Gabriele	Università Campus Bio-Medico di Roma

10:30-10:50 FrA3.1

Distributed and Asynchronous Secure State Reconstruction for Cyber-Physical Systems, pp. 815-820.

Fioravanti, Camilla	Università Campus Bio-Medico di Roma
Oliva, Gabriele	Università Campus Bio-Medico di Roma
Panzieri, Stefano	Università Degli Studi Roma Tre

10:50-11:10 FrA3.2

Optimal Energy Storage System Placement for Robust Stabilization of Power Systems against Dynamic Load Altering Attacks, pp. 821-828.

Germanà, Roberto	Sapienza Università di Roma
Giuseppi, Alessandro	Sapienza Università di Roma
Pietrabissa, Antonio	Consortium for the Research in Automation and Telecommunication
Di Giorgio, Alessandro	Sapienza Università Di Roma

11:10-11:30 FrA3.3

A Digital Twin Infrastructure for Designing an Underwater Survey with a Professional DPV, pp. 829-834.

Bartolucci, Veronica	Università Politecnica Delle Marche
Ciuccoli, Nicolò	Università Politecnica Delle Marche
Prendi, Fatjon	Università Politecnica Delle Marche
Screpanti, Laura	Università Politecnica Delle Marche
Scaradozzi, David	Università Politecnica Delle Marche

11:30-11:50 FrA3.4

Control and Measurement of Nonlinear Dynamic Systems Over AWGN Channel with Application in Tele-Operation of Autonomous Vehicles, pp. 835-840.

Dolatkhah Takloo, Somayeh	K. N. Toosi University of Technology
Farhadi, Alireza	Sharif University of Technology
Khaki Sedigh, Ali	K. N. Toosi University of Technology

11:50-12:10 FrA3.5

Automated Detection of Maize Leaf Diseases in Agricultural Cyber-Physical Systems, pp. 841-846.

Verma, Anil	National Institute of Technology Karnataka
Bhowmik, Biswajit	National Institute of Technology Karnataka

FrA4 Poseidon AB

Robotics IV (Regular Session)

Chair: Moustris, George	National Technical University of Athens
Co-Chair: Tarantos, Spyridon	Sapienza Università Di Roma

10:30-10:50 FrA4.1

Model-Based/Model Predictive Control Design for Free Floating Space Manipulator Systems, pp. 847-852.

Psomiadis, Evangelos	National Technical University of Athens
Papadopoulos, Evangelos	National Technical University of Athens

10:50-11:10 FrA4.2

Real-Time Motion Generation for Mobile Manipulators Via NMPC with Balance Constraints, pp. 853-860.

Tarantos, Spyridon — Sapienza Università di Roma
Oriolo, Giuseppe — Sapienza Università di Roma

11:10-11:30 FrA4.3

Modelling and Analysis of a Parallel Double Delta Mechanism for Robotic Surgery, pp. 861-866.

Moustris, George — National Technical University of Athens
Tzafestas, Costas — National Technical University of Athens

11:30-11:50 FrA4.4

A Framework for Active Vision-Based Robot Planning Using Spiking Neural Networks, pp. 867-871.

Oikonomou, Katerina Maria — Democritus University of Thrace
Kansizoglou, Ioannis — Democritus University of Thrace
Gasteratos, Antonios — Democritus University of Thrace

11:50-12:10 FrA4.5

Towards Quasi-Static Kinematic Calibration of Serial Articulated Industrial Manipulators, pp. 872-877.

Theissen, Nikolas Alexander — KTH Royal Institute of Technology
Monetti, Fabio Marco — KTH Royal Institute of Technology
Gonzalez, Monica Katherine — KTH Royal Institute of Technology
Maffei, Antonio — KTH Royal Institute of Technology

FrB1 Platon Hall

Fault Tolerant Control (Regular Session)

Chair: Papadopoulos, Evangelos — National Technical University of Athens
Co-Chair: Monteriù, Andrea — Università Politecnica Delle Marche

14:00-14:20 FrB1.1

An Integrated Design of PI Interval Observer-Based FTC for LTI Systems, pp. 878-883.

Nguyen, Duc To — University of Évry-Val d'Essonne - University of Paris-Saclay
Mammar, Said — University of Paris-Saclay
Ichalal, Dalil — University of Paris-Saclay
Smaili, Mohand — University of Paris-Saclay

14:20-14:40 FrB1.2

Economic Reliability-Aware MPC for Operational Management of Flow-Based Networks Using Bayesian Networks, pp. 884-889.

Pedrosa, Javier — Universitat Politecnica De Catalunya
Puig, Vicenç — Universitat Politecnica De Catalunya
Nejjari, Fatiha — Universitat Politecnica De Catalunya

14:40-15:00 FrB1.3

Simulation-Based Debugging of Formal Environment Models, pp. 890-895.

Meywerk, Tim — University of Bremen
Niedzwiecki, Arthur — University of Bremen
Herdt, Vladimir — University of Bremen, DFKI GmbH
Drechsler, Rolf — University of Bremen, DFKI GmbH

15:00-15:20 FrB1.4

Optimization-Based Attack against Control Systems with CUSUM-Based Anomaly Detection, pp. 896-901.

Gualandi, Gabriele — Mälardalens University
Maggio, Martina — Lund University
Papadopoulos, Alessandro Vittorio — Mälardalens University

FrB2 Athina A

Distributed Systems (Regular Session)

Chair: Gasparri, Andrea — Università Degli Studi Roma Tre
Co-Chair: Eser, Steffen — RWTH Aachen University

14:00-14:20 FrB2.1

Distributed Model Predictive Control of a Nonlinear Building Energy System Using Consensus ADMM, pp. 902-907.

Eser, Steffen	RWTH Aachen University
Stoffel, Phillip	RWTH Aachen University
Kümpel, Alexander	RWTH Aachen University
Müller, Dirk	RWTH Aachen University

14:20-14:40 FrB2.2

Finite-Time Distributed Protocol for Tracking the Upper (Lower) Bound for a Set of Time-Varying Reference Signals, pp. 908-913.

Lippi, Martina	Università Degli Studi Roma Tre
Furchi', Antonio	Università Degli Studi Roma Tre
Marino, Alessandro	Università Degli Studi di Cassino
Gasparri, Andrea	Università Degli Studi Roma Tre

14:40-15:00 FrB2.3

Hierarchical Distributed Model Predictive Control Based on Dual Decomposition and Quadratic Approximation, pp. 914-919.

Yfantis, Vassilios	Technische Universität Kaiserslautern
Gafur, Nigora	Technische Universität Kaiserslautern
Wagner, Achim	German Research Center for Artificial Intelligence
Ruskowski, Martin	Technische Universität Kaiserslautern

15:00-15:20 FrB2.4

Optimal Load Control and Scheduling through Distributed Mixed-Integer Linear Programming, pp. 920-926.

Yfantis, Vassilios	Technische Universität Kaiserslautern
Motsch, William	Technologie-Initiative SmartFactory KL E.V
Bach, Nico	Technische Universität Kaiserslautern
Wagner, Achim	German Research Center for Artificial Intelligence
Ruskowski, Martin	Technische Universität Kaiserslautern

15:20-15:40 FrB2.5

Private Consensus Using Chaotic Oscillator-Based Encryption, pp. 927-932.

Fioravanti, Camilla	Università Campus Bio-Medico di Roma
Oliva, Gabriele	Università Campus Bio-Medico di Roma
Panzieri, Stefano	Università Degli Studi Roma Tre
Hadjicostis, Christoforos	University of Cyprus

FrB3 Athina B

Automotive Control (Regular Session)

Chair: Sename, Olivier	Grenoble INP / GIPSA-Lab
Co-Chair: Basargan, Hakan	Budapest University of Technology and Economics

14:00-14:20 FrB3.1

Integrated Adaptive Velocity and Semi-Active Suspension Control for Different Road Profiles, pp. 933-938.

Basargan, Hakan	Budapest University of Technology and Economics
Mihaly, Andras	SZTAKI - Institute for Computer Science and Control
Gaspar, Peter	SZTAKI - Institute for Computer Science and Control
Sename, Olivier	Grenoble INP / GIPSA-Lab

14:20-14:40 FrB3.2

MPC Control Strategy for Autonomous Vehicles Driving in Roundabouts, pp. 939-944.

Farkas, Zsofia	Budapest University of Technology and Economics
Mihaly, Andras	SZTAKI - Institute for Computer Science and Control
Gaspar, Peter	SZTAKI - Institute for Computer Science and Control

14:40-15:00 FrB3.3

Integrated Control of Steering and Braking for Effective Collision Avoidance with Autonomous Emergency Braking in Automated Driving, pp. 945-950.

Wang, Dekun	KTH Royal Institute of Technology
Nazem Tahmasebi, Kaveh	KTH Royal Institute of Technology
Chen, Dejiu	KTH Royal Institute of Technology

15:00-15:20 FrB3.4

MPC-Based Optimal Parameter Scheduling of LPV Controllers: Application to Lateral ADAS Control, pp. 951-956.

Medero, Ariel	Grenoble INP / GIPSA-Lab
Menezes Morato, Marcelo	Universidade Federal De Santa Catarina
Sename, Olivier	Grenoble INP / GIPSA-Lab
Puig, Vicenç	CSIC-UPC

15:20-15:40 FrB3.5

Communication Topologies Evaluation for Vehicle Platoon Moving on Highway, pp. 957-962.

Pauca, Ovidiu	Gheorghe Asachi Technical University of Iasi
Maxim, Anca	Gheorghe Asachi Technical University of Iasi
Caruntu, Constantin-Florin	Gheorghe Asachi Technical University of Iasi

FrB4 Poseidon AB

Robotics V (Regular Session)

Chair: Fabian, Martin	Chalmers University of Technology
Co-Chair: Artemiadis, Panagiotis	University of Delaware

14:00-14:20 FrB4.1

Precise Motion Control of Autonomous Robots, pp. 963-968.

Novakovic, Branko	University of Zagreb
Majetic, Dubravko	University of Zagreb
Kasac, Josip	University of Zagreb
Brezak, Danko	University of Zagreb

14:20-14:40 FrB4.2

Robust Dynamic Walking for a 3D Dual-SLIP Model under One-Step Unilateral Stiffness Perturbations: Towards Bipedal Locomotion Over Compliant Terrain, pp. 969-975.

Karakasis, Chrysostomos	University of Delaware
Poulakakis, Ioannis	University of Delaware
Artemiadis, Panagiotis	University of Delaware

14:40-15:00 FrB4.3

Analyzing Interoperability and Security Overhead of ROS2 DDS Middleware, pp. 976-981.

Aartsen, Max	The Hague University of Applied Sciences
Banga, Kanta	The Hague University of Applied Sciences
Talko, Konrad	The Hague University of Applied Sciences
Touw, Dustin	The Hague University of Applied Sciences
Wisman, Bertus	The Hague University of Applied Sciences
Meinsma, Daniel	The Hague University of Applied Sciences
Björkqvist, Mathias	DFINITY Foundation

15:00-15:20 FrB4.4

Formal Verification of Deadlock Avoidance Rules for AGV Systems, pp. 982-987.

Riazi, Sarmad	AGVE AB
Falk, Jonathan	Chalmers University of Technology
Greger, Alexander	Chalmers University of Technology
Pettersson, Anton	Chalmers University of Technology
Fabian, Martin	Chalmers University of Technology

15:20-15:40 FrB4.5

Towards Dynamic Quadruped Locomotion: Development of a CPG-Driven Foot Trajectory Generator, pp. 988-993.

Teixeira de Paula, Daniel	São Paulo State University
Godoy, Eduardo Paciencia	São Paulo State University
Becerra-Vargas, Mauricio	São Paulo State University

FrC1 Platon Hall

Discrete-Event and Hybrid Systems (Regular Session)

Chair: Iacono, Francesca	Università Degli Studi di Pavia
Co-Chair: Motta, Carlo	Università Degli Studi Di Napoli Federico II

16:30-16:50 FrC1.1

Assessment of Initial-State-Opacity in Live Bounded and Reversible Discrete Event Systems Via Integer Linear Programming, pp. 994-999.

Basile, Francesco	Università Degli Studi di Salerno
De Tommasi, Gianmaria	Università Degli Studi di Napoli Federico II
Motta, Carlo	Università Degli Studi di Napoli Federico II
Santini, Stefania	Università Degli Studi di Napoli Federico II
Petrillo, Alberto	Università Degli Studi di Napoli Federico II

16:50-17:10 FrC1.2

Disturbance Decoupling by Dynamic Output Feedback for Linear Impulsive Systems with Periodic Jumps, pp. 1000-1005.

Zattoni, Elena	Alma Mater Studiorum Università di Bologna
Otsuka, Naohisa	Tokyo Denki University
Perdon, Anna Maria	Accademia Marchigiana Di Scienze Lettere Ed Arti
Conte, Giuseppe	Università Politecnica Delle Marche

17:10-17:30 FrC1.3

Interval State Estimation of Switched Takagi-Sugeno Systems with Metzler-Lipschitz Features, pp. 1006-1011.

Krokavec, Dusan	Technical University of Kosice
Filasova, Anna	Technical University of Kosice

17:30-17:50 FrC1.4

Output Feedback Control of Nondeterministic Finite–State Systems with Reach–Avoid Specifications, pp. 1012-1017.

Ajeleye, Daniel Ajedamola	Università Degli Studi Dell'Aquila
Tommaso, Masciulli	Università Degli Studi Dell'Aquila
Pola, Giordano	Università Degli Studi Dell'Aquila

17:50-18:10 FrC1.5

Power Management Strategies of Hybrid Storage System Suppling Electric Vehicle, pp. 1018-1023.

Degas, Laid	Ecole Supérieure Des Techniques Aéronautiques Et De Construction
Jarraya, Imen	National Engineering School of Sfax
Rizoug Nassim, Pr.rizoug	Ecole Supérieure Des Techniques Aéronautiques Et De Construction
Daas, Sara	Badji Mokhtar University
Larouci, Cherif	Ecole Supérieure Des Techniques Aéronautiques Et De Construction
Telmoudi, Achraf Jabeur	University of Tunis

FrC2 Athina A

Power Systems and Smart Grid (Regular Session)

Chair: Braitor, Andrei-Constantin	The University of Sheffield
Co-Chair: Michos, Grigoris	The University of Sheffield

16:30-16:50 FrC2.1

Direct MPP Tracking of PV by Estimating the Virtual Optimal Resistance, pp. 1024-1029.

Alexakis, Zaint	University of Patras
Alexandridis, Antonio	University of Patras
Konstantopoulos, George	University of Patras

16:50-17:10 FrC2.2

On the Existence and Uniqueness of Equilibria in Meshed DC Microgrids with CPLs, pp. 1030-1035.

Braitor, Andrei-Constantin	The University of Sheffield
Konstantopoulos, George	University of Patras

17:10-17:30 FrC2.3

Robust Distributed Control for DC Microgrids with System Constraints, pp. 1036-1041.

Michos, Grigoris	The University of Sheffield
Baldivieso Monasterios, Pablo	The University of Sheffield
Konstantopoulos, George	University of Patras

17:30-17:50 FrC2.4

Sensitivity Analysis of Impedance Measurement Algorithms Implemented in Intelligent Electronic Devices, pp. 1042-1046.

Rohadi, Nanang	Universitas Padjadjaran
Zivanovic, Rastko	University of Applied Sciences Upper Austria

17:50-18:10 FrC2.5

Dominant Modes Estimation Using SCUSUM Method Along with SSI, pp. 1047-1052.

Verma, Shashank Shekhar — Veermata Jijabai Technological Institute
Raphel, Mariya — Veermata Jijabai Technological Institute
Maran, Mamta — Veermata Jijabai Technological Institute

FrC3 Athina B

Control, Optimization, and Learning Methods for Emerging Mobility Systems in Smart Cities (Invited Session)

Chair: Malikopoulos, Andreas — University of Delaware
Co-Chair: Fényes, Dániel — SZTAKI - Institute for Computer Science and Control
Organizer: Malikopoulos, Andreas — University of Delaware
Organizer: Siri, Silvia — Università Degli Studi Di Genova

16:30-16:50 FrC3.1

Performance Analysis of Optimally Coordinated Connected and Automated Vehicles in a Mixed Traffic Environment (I), pp. 1053-1058.

Valencia, Alejandra — University of Delaware
Mahbub, A.M. Ishtiaque — University of Delaware
Malikopoulos, Andreas — University of Delaware

16:50-17:10 FrC3.2

PWA-CTM: An Extended Cell-Transmission Model Based on Piecewise Affine Approximation of the Fundamental Diagram (I), pp. 1059-1065.

Alimardani, Fatemeh — University of Maryland College Park
Baras, John S. — University of Maryland College Park

17:10-17:30 FrC3.3

Overlapping Internal Boundary Control of Lane-Free Automated Vehicle Traffic with State and Input Inclusion (I), pp. 1066-1073.

Malekzadeh, Milad — Technical University of Crete
Papamichail, Ioannis — Technical University of Crete
Papageorgiou, Markos — Technical University of Crete

17:30-17:50 FrC3.4

Combined Observer Design for Road Vehicles Using LPV-Based and Learning-Based Methods, pp. 1074-1079.

Fényes, Dániel — SZTAKI - Institute for Computer Science and Control
Hegedus, Tamas — Budapest University of Technology and Economics
Nemeth, Balazs — SZTAKI - Institute for Computer Science and Control

17:50-18:10 FrC3.5

Cooperative Multi-Lane Shock Wave Detection and Dissipation Via Local Communication (I), pp. 1080-1086.

Suriyarachchi, Nilesh — University of Maryland College Park
Mavridis, Christos — University of Maryland College Park
Baras, John S. — University of Maryland College Park

FrC4 Poseidon AB

Applications (Regular Session)

Chair: Doitsidis, Lefteris — Technical University of Crete
Co-Chair: Ivanjko, Edouard — University of Zagreb

16:30-16:50 FrC4.1

Automated Generation of PLC Code for Implementing Mode-Based Control Algorithms in Buildings, pp. 1087-1092.

Cai, Xiaoye — RWTH Aachen University
Shi, Ruochen — RWTH Aachen University
Kümpel, Alexander — RWTH Aachen University
Müller, Dirk — RWTH Aachen University

16:50-17:10 FrC4.2

Reinforcement Learning Based Variable Speed Limit Control for Mixed Traffic Flows Using Speed Transition Matrices for State Estimation, pp. 1093-1098.

Vrbanić, Filip — University of Zagreb
Tisljaric, Leo — University of Zagreb

Majstorović, Željko	University of Zagreb
Ivanjko, Edouard	University of Zagreb

17:10-17:30 FrC4.3

HYDRA 2.0: Towards Developing a Holistic Tool for STEM Education, pp. 1099-1104.

Kakaras, George	Technical University of Crete
Goumenakis, Epaminodas	Technical University of Crete
Glynos, Evangelos	Technical University of Crete
Spanoudakis, Polychronis	Technical University of Crete
Tsinarakis, George	Technical University of Crete
Tsourveloudis, Nikos	Technical University of Crete
Doitsidis, Lefteris	Technical University of Crete

17:30-17:50 FrC4.4

A Multipole Expansion Method for PDE Constrained Problems, pp. 1105-1110.

Zivanovic, Rastko	University of Applied Sciences Upper Austria

17:50-18:10 FrC4.5

EMG Onset and Offset Detection Via a Modified Threshold Crossings Algorithm, pp. 1111-1116.

Nikolaidi, Vasiliki Theofili	University of Patras
Andrikopoulos, George	KTH Royal Institute of Technology
Tsipianitis, Dimitrios	University of Patras
Kazakos, Dimosthenis	University of Patras

BOOK OF ABSTRACTS

Technical Program for Wednesday June 29, 2022

WeA1 Platon Hall

Predictive Control I (Regular Session)

Chair: Sename, Olivier — Grenoble INP / GIPSA-Lab

Co-Chair: Piccinelli, Nicola — Università Degli Studi Di Verona

10:30-10:50 WeA1.1

Fast Nonlinear Model Predictive Control Using LSTM Networks: A Model Linearisation Approach, pp. 1-6

Zarzycki, Krzysztof — Warsaw University of Technology

Lawrynczuk, Maciej — Warsaw University of Technology

This work describes a fast Model Predictive Control (MPC) algorithm in which Long Short-Term Memory (LSTM) networks are used to model dynamical processes. To obtain a computationally simple quadratic optimisation MPC task, a linear approximation of the model is repeatedly determined on-line using an original linearisation method that is specially tailored for the LSTM model. For a benchmark polymerisation process, it is shown that the described approach results in more precise prediction and better control quality than the classical model linearisation method. It is also shown that the described algorithm gives very similar control quality to that observed in MPC with nonlinear optimisation.

10:50-11:10 WeA1.2

Swinging up and Stabilization Control of the Furuta Pendulum Using Model Predictive Path Integral Control, pp. 7-12

Homburger, Hannes — University of Applied Sciences Konstanz

Wirtensohn, Stefan — University of Applied Sciences Konstanz

Reuter, Johannes — University of Applied Sciences Konstanz

This paper presents the swinging up and stabilization control of a Furuta pendulum using the recently published nonlinear Model Predictive Path Integral (MPPI) approach. This algorithm is based on a path integral over stochastic trajectories and can be parallelized easily. The controller parameters are tuned offline regarding the nonlinear system dynamics and simulations. Constraints in terms of state and input are considered in the cost function. The presented approach sequentially computes an optimal control sequence that minimizes this optimal control problem online. The control strategy has been tested in full-scale experiments using a pendulum prototype. The investigated MPPI controller has demonstrated excellent performance in simulation for the swinging up and stabilizing task. To also achieve outstanding performance in a real-world experiment using a controller with limited computing power, a linear quadratic controller (LQR) is designed for the stabilization task. In this paper, the determination of the controller parameters for the MPPI algorithm is described in detail. Further, a discussion treats the advantages of the nonlinear MPPI control. Videos are available under https://www.htwg-konstanz.de/en/research-and-transfer/ institutes-and-laboratories/isd/control-engineering/videos/

11:10-11:30 WeA1.3

Fast Nonlinear Model Predictive Control Using a Custom Cost-Function: Preliminary Results, pp. 13-18

Nebeluk, Robert — Warsaw University of Technology

Lawrynczuk, Maciej — Warsaw University of Technology

Typically, in Model Predictive Control (MPC) algorithms, the squared sum of predicted control errors (the L2 norm) is minimised on-line. This work discusses an alternative approach in which a custom, user-defined cost-function is used; it may be defined analytically or in a graphical form. To obtain a computationally fast procedure, a differentiable neural approximation of the custom cost-function is used, and the predicted trajectory of the controlled variable is linearised on-line. As a result, a quadratic optimisation MPC task is derived. Efficiency of the described approach is discussed for a simulated polymerisation reactor. It is shown that the discussed algorithm gives better results in terms of the custom cost-function than the classical L2 approach. Moreover, it is shown that the algorithm gives similar results to those possible in MPC with full nonlinear optimisation repeated at each sampling instant.

11:30-11:50 WeA1.4

NMPC Via qLPV Models and Taylor-Based Scheduling Parameter Extrapolation: A Cartesian Robot Case Study, pp. 19-24

Menezes Morato, Marcelo — Universidade Federal De Santa Catarina

Naspolini, Amir — Universidade Federal De Santa Catarina

Normey-Rico, Julio Elias — Universidade Federal De Santa Catarina

Sename, Olivier — Grenoble INP / GIPSA-Lab

In this brief paper, we present an overview of recent advances on Model Predictive Control (MPC) synthesis for nonlinear systems using quasi-Linear Parameter Varying (qLPV) embeddings. For such, we consider a highly nonlinear Cartesian robot benchmark as a case study. Specifically, we advocate for the use of recursive Taylor-based extrapolation maps to generate accurate estimates for the future trajectories of the qLPV scheduling parameters as shown in recent findings. We show how these estimates can be used to enhance and fasten the corresponding MPC algorithms, offering comparable performances to state-of-the-art techniques, while maintaining relieved numerical burden during the implementation. Through realistic simulations of the Cartesian robot, we demonstrate the effectiveness and the real-time capabilities of the discussed method, which is tested against widely acknowledged techniques (the SQP qLPV MPC framework and CasADi).

11:50-12:10 WeA1.5

Passivity-Based Teleoperation with Interaction Force Constraints Using Hybrid Linear Model Predictive Control, pp. 25-30

Piccinelli, Nicola — Università Degli Studi di Verona
Muradore, Riccardo — Università Degli Studi di Verona

The bilateral teleoperation technique allows a human operator to interact with a remote environment and is generally applied in safety-critical scenarios. In such scenarios, even if the force feedback allows to feel the interaction with the environment, communication delay can lead to damages or side effects. For instance, in a critical scenario like surgery, different tissues tolerate different maximum forces, and their manipulation often requires force control. Model Predictive Control (MPC) could be a solution to such situations thanks to its capability of embedding constraints in the optimization problem. Linear MPC is usually employed in real-time control since it allows to have high control frequency. In this paper, we propose a hybrid-MPC based bilateral teleoperation. The hybrid system allows to explicitly handle the switching behaviour of the interaction force. Such methodology minimizes the number of switches between free motion and contact states. This reduced chattering provides smooth behaviour of the manipulator both in soft and hard contact scenarios.

WeA2 — Athina A

Optimisation I (Regular Session)

Chair: El Hajjaji, Ahmed — University of Picardie Jules Verne
Co-Chair: Yfantis, Vassilios — Technische Universität Kaiserslautern

10:30-10:50 — WeA2.1

A Hierarchical Dual Decomposition-Based Distributed Optimization Algorithm Combining Quasi-Newton Steps and Bundle Methods, pp. 31-36

Yfantis, Vassilios — Technische Universität Kaiserslautern
Ruskowski, Martin — Technische Universität Kaiserslautern

This paper presents a hierarchical distributed optimization algorithm based on quasi-Newton update steps. Separable convex optimization problems are decoupled through dual decomposition and solved in a distributed fashion by coordinating the solutions of the subproblems through dual variables. The proposed algorithm updates the dual variables by approximating the Hessian of the dual function through collected sub-gradient information, analogously to quasi-Newton methods. As the dual maximization problem is generally non-smooth, a smooth approximation might show poor performance. To this end cutting planes, analogous to bundle methods, are constructed that take the non-smoothness of the dual function into account and lead to a better convergence behaviour near the optimum. The proposed algorithm is evaluated on a large set of benchmark problems and compared to the sub-gradient method and to the bundle trust method for non-smooth optimization.

10:50-11:10 — WeA2.2

Distributed Asynchronous Projection Onto the Intersection of Convex Sets, pp. 37-42

Fioravanti, Camilla — Università Campus Bio-Medico Di Roma
Oliva, Gabriele — Università Campus Bio-Medico Di Roma
Panzieri, Stefano — Università Degli Studi Roma Tre

In this paper, we consider a distributed computation setting where agents are interconnected by a directed and strongly connected graph and the opinion of each agent is characterized by a convex set in a metric space. Given an initial point and under the assumption that the convex sets have a nonempty intersection, the aim of the agents is to compute the orthogonal projection onto the intersection of the convex sets. However, we assume each agent can compute the projection onto just its own convex set. Specifically, we consider an asynchronous token passing approach that extends traditional Dysktra's algorithm to the case where iterated projections onto the single convex sets are constrained by a network topology, considering two different token transmission policies: round-robin (e.g., a deterministic, cyclic ordering) and random (e.g., according to a Markov chain). The main strength points of the algorithm are the small memory and bandwidth requirements as well as the simplicity of implementation.

11:10-11:30 — WeA2.3

The Influence of Driving Cycle Characteristics on Motor Optimisation for Electric Vehicles, pp. 43-48

Meddour, Aissam Riad — Ecole Supérieure Des Techniques Aéronautiques Et De Construction
Rizoug Nassim, Pr.rizoug — Ecole Supérieure Des Techniques Aéronautiques Et De Construction
Babin Anthony, Anthony — Ecole Supérieure Des Techniques Aéronautiques Et De Construction
Vagg, Christopher — University of Bath
Burke, Richard — University of Bath

Under regulated conditions, a driving cycle forecasts the electric vehicle's range and different driving cycles can substantially impact the vehicle's performance. By evaluating a suggested compact electric car, the impacts of several driving cycle types on battery sizing and motor optimisation convergence are investigated in this article. Matlab and Ansys Electronics are used to conduct the simulations. The energy consumption of four driving cycles is estimated using a vehicle dynamic model to estimate the required autonomy, on which is based on the storage system sizing. The Motor model is constructed using the finite element software Ansys electronics. Its geometrical parameters will be determined using an optimisation algorithm while considering the new power and torque demands, including the storage system weight. The genetic algorithm is used for the optimisation process to minimise the motor's losses

11:30-11:50 — WeA2.4

Optimal Control of a Grid-Connected Service Area for Plug-In Electric Vehicles Fast Charging under Uncertain Power Demand, pp. 49-55

De Santis, Emanuele — Sapienza Università di Roma
Liberati, Francesco — Consortium for the Research in Automation and Telecommunication
Di Giorgio, Alessandro — Sapienza Università di Roma

In this paper we consider the problem of controlling a service area hosting stations for the provisioning of the electric vehicles fast charging service, having the support of an electric energy storage system and local power production from renewables. Key aspects motivating the work are the hard temporal constraint imposed by drivers requiring the fast charging service and the impact high aggregated power withdrawal has on the economic viability of the investment for the service area operator; consequently key control requirements include a congestion level driven tracking of the charging power demand and the flattening of power flow at the point of connection of the service area to the electricity grid, while keeping stable ESS operation. These opposing control objectives, together with the uncertain nature of the power demand and production, brings to the formulation of a stochastic model predictive control problem, based on a continuous/finite-time optimal control problem, for which the explicit form of solution is determined. Simulations are presented to validate the proposed approach.

11:50-12:10 WeA2.5

Reinforcement Learning Based Multi-Objective Optimization for Broadband Newtonian Noise Cancellation in GW Detectors, pp. 56-61

Jose, Roselyn — Indian Institute of Technology Madras
Kalaimani, Rachel Kalpana — Indian Institute of Technology Madras

The sensitivity of terrestrial Gravitational-Wave detectors can be improved in the low-frequency region by subtracting Newtonian Noise at the mirrors of the interferometer. An estimate of the Newtonian Noise is obtained by gathering information from an array of sensors monitoring the sources of noise. Efficient and maximal subtraction of Newtonian Noise is possible when the position of the sensors is optimized for a wide range of frequencies. This constitutes a multi-objective optimization problem which is solved by generating a Pareto optimal solution. Generally, multiple Pareto optimal solutions are generated, and further analysis is done to select the most suitable Pareto point for implementation. This paper proposes a method to obtain a smart Pareto optimal point by modifying the Normal Boundary Intersection method using reinforcement learning techniques. The proposed method will directly generate the smart Pareto point to be implemented in the Newtonian Noise cancellation system. The performance of our algorithm is compared with existing literature.

WeA3 — Athina B

Decentralized Control (Regular Session)

Chair: Iftar, Altug — Eskisehir Technical University
Co-Chair: Dotoli, Mariagrazia — Politecnico Di Bari

10:30-10:50 WeA3.1

Overlapping Decompositions and Decentralized Robust Controller Design for Neutral Time-Delay Systems, pp. 62-66

Iftar, Altug — Eskisehir Technical University

Decentralized robust controller design for neutral time-delay systems which have an overlapping structure is considered. Overlapping decompositions and expansions are used to derive a robustness bound which accounts for both the uncertainties (both in the time-delays and in the matrices of the model) and the neglected interactions among the subsystems. An approach to design decentralized robust controllers is then proposed. Apart from the derivation of the aforementioned bound, the approach is completely based on local nominal models and is decoupled for each subsystem.

10:50-11:10 WeA3.2

Multi-Block ADMM Approach for Decentralized Demand Response of Energy Communities with Flexible Loads and Shared Energy Storage System, pp. 67-72

Hosseini, Seyed Mohsen — Free University of Bolzano
Carli, Raffaele — Politecnico di Bari
Jantzen, Jan — Politecnico di Bari
Dotoli, Mariagrazia — Politecnico di Bari

This paper proposes a novel decentralized energy scheduling framework for demand response of energy communities in the case of limited overall capacity of distribution networks. A combined energy scheduling of heating, ventilation, and air conditioning systems and a community energy storage system (CESS) for multiple smart residential users is presented. The proposed approach aims at minimizing the total expected energy costs while ensuring the occupants' thermal comfort. The optimization problem is first formulated as a mixed-integer linear programming problem, which is converted into a linear programming problem using a tractable approximation method based on a non-complementary charging/discharging strategy of the CESS. The decentralized resolution process is based on multi-block proximal Jacobian alternating direction method of multipliers, ensuring efficient computation and protecting users' privacy. We assess the effectiveness of the proposed approach through numerical experiments on a realistic case study.

11:10-11:30 WeA3.3

Group and Socially Aware Multi-Agent Reinforcement Learning, pp. 73-78

Vallecha, Manav — Indian Institute of Information Technology Allahabad
Kala, Rahul — Indian Institute of Information Technology Allahabad

Much research in the field of robot navigation shows the effectiveness of Deep Reinforcement Learning and Reward Function Modeling for Crowd Navigation and Multi-Agent Reinforcement Learning. The notion of groups has not yet been studied in the context of Reinforcement Learning. A robot using the current approaches is likely to walk in between a group of people, while a robot moving alongside with a group of people is unlikely to make an extra effort to avoid group splitting when avoiding other people. We learn the behavior of multiple-robots to be group-aware to avoid breaking of the groups, while also being-socially aware to leave comforting personal space from the other people. The work uses Imitation Learning on a dataset produced by using the Social Potential Field algorithm to kick start the learning of the Reinforcement Learning policy. The learning is facilitated by the reward function that is specifically modelled to learn the desired behaviours. The proposed work is compared against the Artificial Potential Field Algorithm, Social Potential Field Algorithm, Optimal Reciprocal Collision Avoidance and Reinforcement Learning baselines and found to be the best among all these approaches.

11:30-11:50 WeA3.4

Coordinated Navigation of Holonomic Robot Swarms in Complex Workspaces Via Dynamic Formation Tracking Control, pp. 79-84

Trakas, Panagiotis — University of Patras
Bechlioulis, Charalampos — University of Patras
Rovithakis, George A. — Aristotle University of Thessaloniki

This paper deals with the planar navigation problem of a swarm of robotic agents within an obstacle cluttered workspace, under time varying formation specifications. The robots are considered homogeneous and achieve the desired formation by operating inside a moving and shape-varying region. The complexity of the cluttered workspace is confronted by the transformation of the original planar world into a punctured unit disk. The navigation of the swarm is accomplished by a simultaneous path and motion planning strategy with regards to the centroid of the desired region. Towards this direction, a motion planner based on artificial potential fields successfully drives the centroid to the desired position while avoiding collisions with the workspace. Additionally, the formation orientation is aligned with the linear velocity of its centroid. The robots are also equipped with a distributed controller to avoid collisions with each other. Finally, simulation results validate the efficiency of our method and illustrate the ability of the algorithm to appropriately adapt the formation in situations of narrow path crossing.

11:50-12:10 WeA3.5

Extension Principle and Controller Design for Neutral Time-Delay Systems, pp. 85-90

Iftar, Altug — Eskisehir Technical University

Extension principle, which is a special case of inclusion, is defined for neutral point-wise time-delay systems. Necessary and sufficient conditions for the extension principle to hold for such systems are then presented. Next, controller design for such systems is discussed and it is shown that when the expanded system is an extension of the original system, then any controller designed for the expanded system is contractible for implementation on the original system. This result enables controller design using overlapping decompositions for a large-scale neutral time-delay system which has an overlapping structure, which is also presented.

WeA4 — Poseidon AB

Nonlinear Systems (Regular Session)

Chair: Ailon, Amit — Ben Gurion University of the Negev
Co-Chair: Theodosis, Dionysios — Technical University of Crete

10:30-10:50 WeA4.1

A New Matrix Multiplier-Based LMI Approach for Nonlinear Observers, pp. 91-96

Mohite, Shivaraj — University of Lorraine
Alma, Marouane — University of Lorraine
Zemouche, Ali — University of Lorraine

This paper addresses the problem of LMI based observer design for Lipschitz nonlinear systems. A new observer design technique is proposed which is based on the introduction of a newly defined positive definite matrix multiplier in the LMI formulation. A numerical example along with a flexible link robot model are investigated in MATLAB/Simulink to show the effectiveness of the proposed method.

10:50-11:10 WeA4.2

Achieving Prescribed Performance for Euler-Lagrange Systems with Impulsive Behaviour, pp. 97-102

Kechagias, Andreas — Aristotle University of Thessaloniki
Rovithakis, George A. — Aristotle University of Thessaloniki

We consider the problem of controlling, with prescribed performance, uncertain Euler-Lagrange systems in the presence of aperiodic impulses affecting the system state. Between any two consecutive impulse time instants, we guarantee that the output tracking error converges to a predefined and arbitrarily small region of interest, within a prespecified fixed time. Furthermore, all signals in the closed loop are bounded. The magnitude of the impulses and their time of appearance are unknown in advance. Yet a known minimum time interval is required to elapse, before the appearance of a new impulse. Simulation results clarify and verify the theoretical findings.

11:10-11:30 WeA4.3

Sampled-Data Controllers for Autonomous Vehicles on Lane-Free Roads, pp. 103-108

Theodosis, Dionysios — Technical University of Crete
Tzortzoglou, Filippos N. — Technical University of Crete
Karafyllis, Iasson — National Technical University of Athens

Papamichail, Ioannis — Technical University of Crete
Papageorgiou, Markos — Technical University of Crete

In this paper, we design decentralized control strategies (per vehicle) for the two-dimensional movement of autonomous vehicles on lane-free roads, where each vehicle determines its control input based on its own state and the relative speeds and distances from adjacent vehicles and from the boundaries of the road. It is shown that the vehicles do not collide with each other or with the road boundaries, and all vehicle speeds converge to a given longitudinal speed set-point. Moreover, we present sufficient conditions for the emulated (sampled data) controllers that ensure collision avoidance between vehicles and with the road boundaries, as well as speed positivity, bounded speed and bounded orientation of the vehicles. Finally, we numerically investigate the maximum allowable sampling period and present periodic and non-periodic sampling algorithms where each vehicle has its own sampling period.

11:30-11:50 WeA4.4

Point-To-Point Control and Set-Point Regulation by Steering in a Two-Wheeled Tilting Dynamic Model, pp. 109-114

Ailon, Amit — Ben-Gurion University of the Negev

The article considers two fundamental problems in two-wheeled vehicle controls. First, we deal with the problem of how to change a current state to a final one in the state space of the dynamic model. Then, we suggest a control algorithm for tilt set-point regulation. The suggested control algorithms are obtained by using an augmented model which combines the vehicle dynamics with a steering generator model in which the steering is displayed as a state variable. The considered control algorithms for the highly nonlinear nonminimum phase system are accompanied by relevant examples.

11:50-12:10 WeA4.5

Finite Frequency H∞ Control of 2-D Continuous Takagi-Sugeno Systems, pp. 115-120

Er-rachid, Ismail — University Sultan Moulay Slimane
Zoulagh, Taha — University of Santiago De Chile
Tadeo, Fernando — University of Valladolid
Merzouki, Hassnae — University Sultan Moulay Slimane
Tissir, El Houssaine — Université Sidi Mohamed Ben Abdellah

This paper solves a state feedback H∞ control problem for two dimensional continuous Takagi-Sugeno fuzzy systems, using a finite frequency (FF) approach. In particular, the application to Roesser systems is investigated via the use of the Generalized Kalman Yakubovich Popov lemma. New design conditions guaranteeing the FF H∞ control are established in terms of Linear Matrix Inequalities. These conditions provide less conservative results in terms of H∞ norm when compared with the entire frequency designs. To demonstrate the efficiency of the proposed method, the application to a simulated system is also presented.

WeB1 Platon Hall

Predictive Control II (Regular Session)

Chair: Menezes Morato, Marcelo — Universidade Federal De Santa Catarina
Co-Chair: Stoffel, Phillip — RWTH Aachen University

15:30-15:50 WeB1.1

Combining Data-Driven and Physics-Based Process Models for Hybrid Model Predictive Control of Building Energy Systems, pp. 121-126

Stoffel, Phillip — RWTH Aachen University
Löffler, Charlotte — RWTH Aachen University
Eser, Steffen — RWTH Aachen University
Kümpel, Alexander — RWTH Aachen University
Müller, Dirk — RWTH Aachen University

Model predictive control is well suited to control building energy systems efficiently. However, it still lacks commercial relevance due to the high modeling effort. This article presents a methodology to reduce the modeling effort by combining data-driven and physics-based process models in a hybrid MPC scheme. Data-driven models like artificial neural networks are generally nonconvex and nonlinear. Thus, using such models results in a nonlinear, nonconvex optimization problem. We present a workflow to efficiently solve the resulting optimization problem with gradient-based solvers using the algorithmic differentiation tool CasADi. The developed workflow is applied to an exemplary building energy system to implement an economic, hybrid model predictive controller. Simulation results confirm the high potential of the proposed methodology by realizing a cost-effective operation of the controlled system.

15:50-16:10 WeB1.2

Switching Predictive Controller for Building Optimal Thermal Comfort, pp. 127-132

Rajaoarisoa, Lala Herimanjaka — Institut Mines Télécom Nord Europe
Benzaama, Mohammed Hichem — Ecole Supérieure d'Ingénieurs Des Travaux De La Construct
M'Sirdi, Kouider Nacer — Laboratoire d'Informatique Et Systèmes UMR 7020
Clavier, Laurent — Institut Mines Télécom Nord Europe
Sayed-mouchaweh, Moamar — Institut Mines Télécom Nord Europe

To make buildings more energy efficient, building owners or managers are looking for ways to reduce the energy consumption of equipment such as heating, ventilation and air conditioning (HVAC). In this context, this paper deals with the synthesis and design of switching predictive HVAC controllers exploiting a data-driven output feedback controller for a class of complex nonlinear systems. The

system is approximated by a set of linear polynomial models, which is reduced to an auto regressive with exogenous terms model. Data from the internet of things devices are used to feed the controller. It will also be used for partitioning the output space into different operating regions and interpolation regions. Based on this partition, a novel piecewise optimal predictive controller (pw-OPC) with affine terms via optimal output feedback is designed. We give some conditions to verify the feasibility of the technique and the stabilizability of this class of controller. We then check its effectiveness experimentally by applying it to control the heating systems of a student residence. We will compare it with other existing controllers such as an optimal output-feedback controller and an optimal predictive controller to determine its performance. The results prove that the pw-OPC gives good results in terms of thermal comfort and energy savings.

16:30-16:50 WeB1.3

Effective Inventory Control in Supply Chains with Large Uncertain Decay Factor Using Robust Model Predictive Control, pp. 133-138

Orsini, Valentina — Università Politecnica Delle Marche
Letto, Beatrice — Università Politecnica Delle Marche

This paper deals with the inventory control in supply chains under the following assumptions: 1) highly perishable goods with uncertain decay factor, 2) a future customer demand belonging to a known compact uncertainty set. The problem is to define a control policy keeping the on-hand stock level as close as possible to a desired level despite the above uncertainties. The contribution of this paper focuses on a Robust Model Predictive Control (RMPC) approach. This implies solving a min-max optimization problem with hard constraints on some physical variables. To drastically reduce the numerical complexity of this problem, the control signal (i.e., the sequence of replenishment orders) is sought in the space of B-spline functions, which are known to be universal approximators admitting a parsimonious parametric representation. This allows us: 1) to reduce the number of both decision variables and constraints involved in the optimization procedure, 2) to reformulate the numerically involved minimization of the worst case cost functional as a Weighted Constrained Robust Least Squares (WCRLS) estimation problem. The WCRLS algorithm can be efficiently implemented using second order cone programming. A rigorous analysis of stability and feasibility conditions is provided.

16:10-16:30 WeB1.4

Self Triggered Controller Co-Design Using LASSO Regression, pp. 139-144

Etienne, Lucien — Institut Mines Télécom Nord Europe
Langueh, Kokou Anani — Institut Mines Télécom Nord Europe
Rajaoarisoa, Lala Herimanjaka — Institut Mines Télécom Nord Europe

In this work, we consider the control of a linear time-invariant system with self-triggered sampling. This study leads us to the resolution of the co-design problem. We address it by jointly computing the controller and the future sampling scheduled as a sparse optimization problem. Accordingly, we show that a relaxation of the optimal self-trigger co-design can be formulated as a LASSO (Least Absolute Shrinkage and Selection Operator) regression. Thus, we give some results on the possibility to obtain a controller ensuring practical or asymptotic stability while reducing sampling of the control action, by using the properties of the solutions of the LASSO regression.

16:50-17:10 WeB1.5

An Observer Based Field Oriented Economic Model Predictive Control Approach for Permanent Magnet Synchronous Motors, pp. 145-151

Geweth, Daniel — Bosch GmbH
Vollmer, Ulrich — Bosch GmbH
Diehl, Moritz — Albert-Ludwigs-Universität Freiburg

This paper proposes an observer based nonlinear model predictive control approach for permanent magnet synchronous motors (PMSM), for high performance torque control applications in standard automotive electronic control units (ECUs). The optimisation problem is formulated as a field-oriented economic model predictive control (FO-EMPC) problem that takes into account the dq-model of the PMSM with spherical voltage constraint. A terminal set and a terminal penalty are used to improve stability and convergence with a short prediction horizon in order to reduce the calculation effort. The associated observer is designed to estimate harmonic disturbances as well as disturbances caused by parameter deviations in real systems. Furthermore, the proposed observer is based on a predictor-corrector scheme to cope with the additional time delay, typically arising in discrete-time control systems. The proposed observer based model predictive control approach is demonstrated in simulation and in an experiment on a motor test bench. In comparison to a state-of-the-art control, the observer-based FO-EMPC shows a superior control performance.

WeB2 — Athina A

Optimisation II (Regular Session)

Chair: Stylios, Chrysostomos — Athena Research Center
Co-Chair: Manzoni, Eleonora — Università Degli Studi Di Padova

15:30-15:50 WeB2.1

Optimal MmWave Sensor Selection for Bearing-Only Localization in Smart Environments, pp. 152-157

Vlachos, Evangelos — Athena Research Center
Spyrou, Evangelos — University of Ioannina
Stylios, Chrysostomos — Athena Research Center
Berberidis, Konstantinos — University of Patras

Nowadays, millimetre wave (mmWave) direction sensors are being used increasingly as general-purpose radars, since they can provide high-level of accuracy for a variety of situations at low-cost. Via multiple mmWave sensors, bearing estimation can be derived to track the position of a target, while in smart environments several sensors can be deployed. In this work, we provide an optimal sensor

selection technique, for choosing which sensors to activate for bearing estimation and which not. The proposed approach is decomposed into training phase, where sensor selection is performed, and operational phase, where bearing estimation is obtained. Via simulation results we evaluate the proposed approach compared with the conventional methodology of utilizing all available data streams.

15:50-16:10 WeB2.2

Robust Finite-Frequency H∞ Model Reduction for Uncertain 2D Discrete Systems, pp. 158-163

El-Amrani, Abderrahim — Université Sidi Mohamed Ben Abdellah
El Hajjaji, Ahmed — University of Picardie Jules Verne
Bosche, Jerome — University of Picardie Jules Verne
Aitouche, Abdel — CRISTAL/JUNIA

In this work, robustness, and convergence properties of model reduction are investigated for discrete two-dimensional (2D) systems in the Fornasini-Marchesini (F-M) model with polytopic uncertainties. The goal is to design a reduced order model minimizing H∞ performance in a known finite-frequency (FF) area of the noises able to reproduce the behaviour of the uncertain 2D original system. Using Lyapunov function and generalized Kalman Yakubovich Popov (gKYP) lemma, sufficient conditions for the existence of the FF reduced order design approach are formulated as feasibility of a set of Linear Matrix Inequalities (LMIs). Numerical simulations are given to illustrate the validity and feasibility of the designed reduced-order model.

16:30-16:50 WeB2.3

Reinforcement Q-Learning for Closed-Loop Hypnosis Depth Control in Anesthesia, pp. 164-169

Calvi, Giulia — Università Degli Studi di Padova
Manzoni, Eleonora — Università Degli Studi di Padova
Rampazzo, Mirco — Università Degli Studi di Padova

The management of anesthesia is one of the most critical challenges since millions of subjects undergo surgeries every day. For instance, providing an inaccurate drug dose to the patient may entail adverse effects and postoperative complications. In this context, the use of computer-controlled drug dosing systems nowadays available provides significant advantages to effectively regulate anesthesia. This paper presents the control of the depth of hypnosis in anesthesia through a Machine Learning approach, i.e., a Q-learning, that enables an agent to learn in an interactive environment by trial and error using feedback from its own actions and experiences. The design and performance evaluation of the proposed solution are done in silico by exploiting an Open-source Patient Simulator, that can describe the main relevant system characteristics.

16:10-16:30 WeB2.4

Feedback Strategies for Threshold Crossing of Protein Levels at a Prescribed Time, pp. 170-175

Nieto, Cesar — University of Delaware
Ghusinga, Khem Raj — University of North Carolina at Chapel Hill
Singh, Abhyudai — University of Delaware

The timing of diverse cellular processes is based on the instant when the concentration of regulatory proteins crosses a critical threshold level. Hence, noise mechanisms inherent to these protein synthesis pathways drive statistical fluctuations in such events' timing. How to express proteins ensuring both the threshold crossing at a prescribed time and minimal timing fluctuations? To find this optimal strategy, we formulate a model where protein molecules are synthesized in random bursts of gene activity. The burst frequency depends on the protein level, creating a feedback loop. Between consecutive bursts, cellular growth dilutes protein concentration. Counterintuitively, our analysis shows that positive feedback in protein production is best for minimizing variability in threshold-crossing times. We analytically predict the optimal feedback strength in terms of the dilution rate and show that it depends on how noise is incorporated in the model. As a corollary to our result, a no-feedback strategy emerges as the optimal strategy in the absence of dilution.

16:50-17:10 WeB2.5

The Refined Optimal Control Problem and Synthesized Control Methods for Its Solution, pp. 176-181

Diveev, Askhat — Federal Research Center

A new statement of the optimal control problem is presented. A goal of reformulation for the well-known problem consists of that its solution can be used in a real object directly. The refined optimal control problem includes one additional requirement to the optimal trajectory, that it had an attractive neighbourhood. To this target a control function must depend on not only time but on the state space vector. It is proposed to solve the new optimal control problem by a machine learning with a symbolic regression for providing a movement stabilization along to the optimal trajectory. The example of solving the refined optimal control problem for mobile robot moving on the plane with obstacles is presented.

WeB3 — Athina B

Intelligent Data Processing from Sensors in Control and Decision Support Systems (Invited Session)

Chair: Popescu, Dan	Politehnica University of Bucharest
Co-Chair: Mavridis, Christos	University of Maryland College Park
Organizer: Popescu, Dan	Politehnica University of Bucharest
Organizer: Lazar, Corneliu	Gheorghe Asachi Technical University of Iasi
Organizer: Ichim, Loretta	Politehnica University of Bucharest
Organizer: Stamatescu, Grigore	Politehnica University of Bucharest

15:30-15:50 WeB3.1

Comparative Study of Neural Networks Used in Halyomorpha Halys Detection (I), pp. 182-187

Popescu, Dan — Politehnica University of Bucharest
Ichim, Loretta — Politehnica University of Bucharest
Dimoiu, Mihai — Politehnica University of Bucharest
Trufelea, Raluca — Politehnica University of Bucharest

The paper's purpose was to investigate some methods based on neural networks for the detection and classification of harmful insects for agriculture as the Halyomorpha Halys. The implementation of different object detection networks for image categorization was analysed. Images from the Maryland Biodiversity database were used for neural network training and testing. Rotation, scaling, blurring, mirroring, and other techniques were employed for data augmentation. For the detection and classification of Halyomorpha Halys, some neural networks that include multiple smaller networks were implemented and investigated. The networks used are the following: YOLOv5s, SSD with different backbones such as MobileNet V1, MobileNet V2, and ResNet-50, Faster R-CNN with ResNet-50 backbone, and EfficientDet-D0. Moreover, neural networks were evaluated and compared based on performance metrics such as accuracy and time. Performances like accuracy between 0.49 – 0.86 and time between 36 ms – 55 ms were obtained. The best results were obtained for YOLOv5s, in terms of accuracy, and EfficientDet-D0, in terms of time.

15:50-16:10 WeB3.2

Detection of Early Pregnancy in Ultrasound Images Using YOLOv3 (I), pp. 188-193

Teodor, Oana Mihaela — Politehnica University of Bucharest
Cirstoiu, Monica Mihaela — Carol Davila University of Medicine and Pharmacy
Ichim, Loretta — Politehnica University of Bucharest
Popescu, Dan — Politehnica University of Bucharest

Automatic interpretation of morphological metrics recently gained great interest in medical imaging applications. For ultrasound image analysis various artificial intelligence algorithms emerged with the aim to overcome drawbacks related to measurement variability and image quality. Advanced methods of automatic analysis can meet the need to centralize a large amount of information from these images, to accurately interpret the medical data, and to minimize the rate of human error. In the current paper, we propose a solution designed for automating the detection of early pregnancy from endovaginal ultrasound scans. A YOLOv3 convolutional neural network was configured to detect the gestational sac, the yolk sac, and the embryo given the potential to facilitate ultrasound diagnostic in obstetrics by automating the detection of these early pregnancy elements. The database created for this research included 349 images evaluating incipient pregnancies with gestational age ranging from 40 to 70 days. The results obtained support the use of YOLOv3 for the precise detection of ultrasound elements specific to an incipient pregnancy.

16:30-16:50 WeB3.3

Risk Sensitivity and Entropy Regularization in Prototype-Based Learning, pp. 194-199

Mavridis, Christos — University of Maryland College Park
Noorani, Erfaun — University of Maryland College Park
Baras, John S. — University of Maryland College Park

Prototype-based learning methods have been extensively studied as fast, recursive, data-driven, interpretable, and robust learning algorithms. We study the effect of entropy regularization in prototype-based learning regarding (i) robustness with respect to the dataset and the initial conditions, and (ii) the generalization properties of the learned representation. A duality relationship, with respect to a Legendre-type transform, between free energy and Kulback-Leibler divergence measures, is used to show that entropy-regularized prototype-based learning is connected to exponential objectives associated with risk-sensitive learning. We use these results to incentivize the development of entropy-regularized prototype-based learning algorithms by highlighting its properties, including (i) memory and computational efficiency, (ii) gradient-free training rules, and (iii) the ability to simulate an annealing optimization process that results in progressively growing competitive-learning neural network architectures.

16:10-16:30 WeB3.4

Single Image Dehazing Using Local Detail Enhancement, pp. 200-204

Ok, Jiheon — Yonsei University
Jeong, Taeuk — Yonsei University
Lee, Chulhee — Yonsei University

Most existing single image dehazing algorithms require the estimation of atmospheric light using simple procedures based on error-prone assumptions. In this letter, a new dehazing method based on local detail enhancement is proposed to estimate atmospheric light and transmission map by considering local detail enhanced images as quasi-haze-free images. The proposed method is based on the decomposition model that interprets the transmission map as a base layer and the haze-free image as a detail-like layer. From a hazy image, local detail information is extracted using the local detail enhancement approach based on an edge preserving filter. Then, atmospheric lights and transmission maps for each colour channel are estimated using Koschmieder's law. The transmission map is refined using the dark channel prior and a guided filter. The experimental results show the proposed method can remove the layer of haze effectively and produce better performance than existing dehazing methods.

16:50-17:10 WeB3.5

Model-Free iPI Controller Design and Application to a Thermal Plant (I), pp. 205-210

Baciu, Andrei — Gheorghe Asachi Technical University of Iasi
Lazar, Corneliu — Gheorghe Asachi Technical University of Iasi
Caruntu, Constantin-Florin — Gheorghe Asachi Technical University of Iasi

The automatic controllers with multiple integral components represent a special category. Although they are not so widely used for

standard applications, there is a class of processes that require this type of controller. Thus, in this paper, the intelligent PI (iPI) controllers designed in the Model-Free Control paradigm are presented and compared with a PI controller. Two tuning methods are proposed for the iPI controllers, one based on a pole-placement technique and the other one based on the Iterative Feedback Tuning (IFT) strategy. The IFT algorithm hinges on an iterative data-driven approach that starts from a predesigned set of parameters for the controller and leads to an optimal set of parameters that should improve the system's performance. To test the capabilities of the proposed design methods, a comparison between the three controllers was performed on a thermal plant used to heat-treat Mg-Li-Al based alloys, and their performances were evaluated based on a numerical analysis.

WeB4	Poseidon AB
Nonlinear Control (Regular Session)	
Chair: Dritsas, Leonidas	ASPETE
Co-Chair: Heshmati Alamdari, Shahab	Aalborg University

15:30-15:50 WeB4.1

Revisiting the Derivation of Stage Costs in Infinite Horizon Discrete-Time Optimal Control, pp. 211-216

Fiedler, Christian — RWTH Aachen University
Trimpe, Sebastian — RWTH Aachen University

In many applications of optimal control, the stage cost is not fixed, but rather a design choice with considerable impact on the control performance. In infinite horizon optimal control, the choice of stage cost is often restricted by the requirement of uniform cost controllability, which is nontrivial to satisfy. Here we revisit a previously proposed constructive technique for stage cost design. We generalize its setting, weaken the required assumptions and add additional flexibility. Furthermore, we show that the required assumptions essentially cannot be weakened anymore. By providing improved design options for stage costs, this work contributes to expanding the applicability of optimization based control methodologies, in particular, model predictive control.

15:50-16:10 WeB4.2

State Feedback Control with Providing Inputs and Outputs in Given Sets, pp. 217-220

Furtat, Igor — Russian Academy of Sciences
Gushchin, Pavel — Gubkin Russian State University of Oil and Gas
Nguyen, Ba Huy — Russian Academy of Sciences
Vrazhevsky, Sergey — ITMO University

A novel method for control of dynamical systems providing the plant input and outputs in a given sets is proposed. The obtained method includes two kind of coordinate changes. The first one reduces the output variable to a new one which dimension does not exceed the dimension of the control. The second coordinate change makes it possible to pass from a constrained control problem to an unconstrained one. Examples illustrate the efficiency of the proposed method.

16:30-16:50 WeB4.3

An Aperiodic Prescribed Performance Control Scheme for Uncertain Nonlinear Systems, pp. 221-226

Nikou, Alexandros — Ericsson AB
Verginis, Christos — Uppsala University
Heshmati Alamdari, Shahab — Aalborg University

This paper proposes a low-complexity feedback control law that is updated aperiodically, in an event-triggered manner, and guarantees prescribed transient and steady state performance for uncertain nonlinear systems affine in the control. By prescribed performance, we mean that the closed-loop error trajectory converges to a predefined arbitrarily small residual set, with convergence rate no less than a certain prespecified value, having maximum overshoot less than a preassigned level. The proposed novel control design is performed in the transformed normalized error, and the triggering mechanism is extracted by guaranteed that these errors always lead to bounded closed loop signals. Moreover, the approach provides a scheme of designing and tuning the control parameters in order to achieve stabilization in a desire state in a pre-defined time $T > 0$. The efficiency of the proposed approach is verified with numerical simulations in MATLAB.

16:10-16:30 WeB4.4

Robust Tracking Control for a Class of Uncertain Systems with Matched and Unmatched Nonlinearities, pp. 227-232

Dritsas, Leonidas — ASPETE

This article is concerned with the systematic design of robust nonlinear tracking controllers for a certain class of uncertain systems i.e., systems which are nominally linear, suffering from matched model uncertainties and disturbances and uncertain matched and unmatched nonlinearities. The proposed composite state feedback tracking controller consists of two parts: a linear and a nonlinear one. The LMI--based design of the linear part of the composite controller is based on the nominal linear system and is formulated as a multi--objective H-infinity minimization problem for stabilization, disturbance rejection, tracking, performance, and minimization of the 2-norm of the state feedback gains. The design of the nonlinear part is based on Lyapunov redesign methodologies, and a continuous nonlinear state feedback guarantees Uniform Ultimate Boundedness (UUB) of the closed--loop system. Explicit formulae for the size of the UUB region and the Radius of the Attracting Ball (RAB) are derived, indicating a trade-off between robustness, tracking performance and control chattering. The efficacy of the proposed methodology is demonstrated via a numerical example on a single input system.

16:50-17:10 WeB4.5

Incremental Nonlinear Dynamic Inversion with Sparse Online Gaussian Processes Adaptation for Partially Unknown Systems, pp. 233-238

Ignatyev, Dmitry — Cranfield University

Tsourdos, Antonios — Cranfield University

Sensor-based Incremental control is a recently developed family of techniques with a reduced dependency on a plant model. This approach uses measurements or estimates of current state derivatives and actuator states to linearize the dynamics with respect to the previous time moment. However, in such a formulation, the control system is sensitive to the quality of measurements or estimations. The presence of uncertainties caused by unforeseen malfunctions in measurement and/or actuation systems could provoke drastic performance degradation. The paper proposes a sensor-based Incremental Nonlinear Dynamic Inversion (INDI) control algorithm augmented with Budgeted Sparse Online Gaussian Processes Adaptation for the compensation of unknown system behaviour. INDI performs quite efficiently under design conditions. Meanwhile, GP-based direct adaptation provides not only long-term dependency learning but also noise signal filtering. The efficiency of the proposed approach is demonstrated with a longitudinal motion of a missile.

WeC1 — Platon Hall

Linear Systems (Regular Session)

Chair: Piazzi, Aurelio — Università Degli Studi Di Parma

Co-Chair: Koumboulis, Fotis N. — National and Kapodistrian University of Athens

17:30-17:50 — WeC1.1

Data-Driven LQR Design for LTI Systems with Exogenous Inputs, pp. 239-244

Digge, Vijayanand — Indian Institute of Technology Madras

Pasumarthy, Ramkrishna — Indian Institute of Technology Madras

This paper presents a data-driven state feedback control law, based on a linear quadratic regulator (LQR) design, for systems with exogenous inputs. In general, this framework is referred to as a data-driven min-max controller and is more robust to disturbances than the standard LQR controllers. Instead of relying on system models, in this work, the state feedback control law is computed directly from the knowledge of the inputs and the states. The LQR gain is parametrized with matrices that are directly estimated using open-loop experiment data of the system. We experimentally validate our results by implementing the data driven controller for performance management of a webserver hosted on a private cloud.

17:50-18:10 — WeC1.2

On the Structure of the Multivariable Free Response, pp. 245-250

Kavaja, Juxhino — Università Degli Studi Di Parma

Piazzi, Aurelio — Università Degli Studi Di Parma

The structure of the free (or zero-input) response of multivariable (MIMO) linear time-invariant systems is investigated. In a behavioral setting, the free response is an autonomous behaviour, solution of a homogeneous differential equation. A new closed-form expression of this solution is presented. It is a linear (real) combination of modes associated to the system's pole minimal polynomial. The vector coefficients of the modes belong to the output mode subspaces. These are characterized by a chain of subspace inclusions for each distinct pole. In the special, but relevant case of the pole minimal polynomial having simple roots the closed-form expression simplifies and admits a phasor interpretation. Examples are included to highlight the paper's findings.

18:10-18:30 — WeC1.3

Time-Delay Estimation with Non-Persistent Input, pp. 251-256

Medvedev, Alexander V. — Uppsala University

The problem of analytically calculating the value of a pure discrete time delay from input-output measurements is considered for the case of square-summable input, i.e., in l_2. This is a class of input signals that are often encountered in applications but do not possess persistent excitation property as they vanish at infinity. By expressing the input and output signals in terms of Laguerre series, i.e., being considered in Laguerre domain, it can be turned into a parameter estimation problem that has a closed-form solution. Several delay value estimates, both for a general and pre-defined input sequence, are proposed and evaluated in simulation.

18:30-18:50 — WeC1.4

A Common Noninteracting Control Design for Robot Tracked Vehicles, pp. 257-264

Koumboulis, Fotis N. — National and Kapodistrian University of Athens

Kouvakas, Nikolaos — National and Kapodistrian University of Athens

Motivated by the control problem of a robot tracked vehicle, the problem of common noninteracting control with simultaneous partial output zeroing is introduced and solved for the case of multi model normal linear time invariant systems, using a regular and static measurement output feedback controller. The necessary and sufficient conditions for the solvability of the problem are established, and the general solution of the controllers is derived. The present design results are successfully applied to the two-model description of the robot tracked vehicle, through a common controller, using only measurements of the motor currents and the orientation of the vehicle. Additionally, approximate asymptotic command following is achieved. Finally, using a metaheuristic algorithm the transient behavior of the independently controlled outputs, is improved.

18:50-19:10 — WeC1.5

L_infty/H_infty Functional Interval Observers Design for Multivariable Systems, pp. 265-270

Akremi, Rihab — National Engineering School of Gabes

Lamouchi, Rihab — National Engineering School of Gabes

Amairi, Messaoud — National Engineering School of Gabes

This work presents a functional interval observer synthesis for Linear Time Invariant (LTI) multivariable systems subject to unknown but

bounded disturbances. Two approaches, respectively based on H_∞ and L_∞ performances, are developed to attenuate the effects of uncertainties. Sufficient conditions are given in terms of Linear Matrix Inequalities (LMIs). The performances of the proposed methods are illustrated through numerical simulations.

WeC2	Athina A
Robust Control (Regular Session)	
Chair: Iles, Sandor	University of Zagreb
Co-Chair: Teofilo Rocha, Kaio Douglas	University of São Paulo

17:30-17:50 WeC2.1

Robust Kalman Filtering for Systems Subject to Polytopic Uncertainties, pp. 271-276

Teofilo Rocha, Kaio Douglas — University of São Paulo
Almeida Dias Bueno, Jose Nuno — University of São Paulo
Marcos, Lucas Barbosa — University of São Paulo
Terra, Marco Henrique — University of São Paulo

Measuring the entire state vector of a dynamic system in practical applications is often infeasible due to various factors. State estimation is usually adopted to overcome this issue. However, the system model inevitably undergoes the degrading effects of parametric uncertainties. Hence, it is crucial to estimate the state irrespective of such unknown parameter variations. In this paper, we address the robust filtering problem regarding linear discrete-time systems subject to polytopic uncertainties. We formulate a min-max optimization problem whose cost function weights the polytope vertices altogether. The solution yields a robust recursive filter as a Kalman-like correction-prediction algorithm, suitable for real-time applications. We further provide stability conditions for the steady-state filter. Furthermore, we validate our approach with a numerical example, comparing the results with other methods from the literature on robust filtering.

17:50-18:10 WeC2.2

Mode-Independent Regulator for Polytopic Markov Jump Linear Systems, pp. 277-282

Almeida Dias Bueno, Jose Nuno — University of São Paulo
Teofilo Rocha, Kaio Douglas — University of São Paulo
Marcos, Lucas Barbosa — University of São Paulo
Terra, Marco Henrique — University of São Paulo

We propose a mode-independent recursive regulator for discrete-time Markov jump linear systems with polytopic uncertainties. Based on an indicator function, we define an augmented system which encompasses all possible Markov modes. The use of a penalty parameter allows us to formulate the control problem as a special case of least-squares optimization with uncertain data. The recursive solution is robust and yields the mode-independent feedback gains to stabilize the augmented system. We recover, thereafter, the states and inputs of the original system from the augmented variables. We also provide a numerical example to validate the proposed method and compare it to an alternative technique.

18:10-18:30 WeC2.3

Improved Robustness and Performance for Adaptive Control of Non-Linear Plants with Input Saturations, pp. 283-288

Karez, Ian — University of Rostock
Müller, Thilo — University of Rostock
Jeinsch, Torsten — University of Rostock

In this paper a robust state feedback adaptive control scheme for non-linear plants with input saturations, such as unmanned underwater vehicles, is proposed. For the performance during input saturation the adaptive model recovery anti-windup method is used. To increase robustness, the control law is divided into a nominal and an adaptive one. High adaptation gains are usually needed to reach good tracking performance. Since high adaptation gains decrease the robustness of adaptive controllers, the control scheme is extended by a command governor. The command governor adjusts the trajectory of the given command signal to improve the transient performance at low adaptation gains.

18:30-18:50 WeC2.4

Stabilizing Direct Yaw Moment Control Based on a Flexible Set-Membership Constraint, pp. 289-294

Iles, Sandor — University of Zagreb
Svec, Marko — University of Zagreb
Makarun, Petar — University of Zagreb
Kir Hromatko, Josip — University of Zagreb

Direct yaw moment control (DYC) can improve a vehicle's cornering performance by controlling the torque applied to each wheel. However, an important aspect of DYC is dealing with constraints to ensure that torque can be achieved, and the force is transferred from the tire to the road without losing traction. An effective way to deal with constraints is to use model predictive control (MPC). This type of control predicts the future behaviour of a system based on its model and optimizes its performance over a finite horizon. It is possible to use a velocity-dependent linear time-varying (LTV) vehicle model for prediction. However, when using such a model, it is difficult to guarantee recursive feasibility and stability. In this work, these guarantees are provided using the tensor product model transformation to transform the LTV model into a polytopic linear parameter-varying (LPV) model. Such a model is used to obtain a robust controller and a corresponding rho-contractive set, and to compute a sequence of nested one-step controllable sets. Online LTV-MPC optimization problem is solved subject to a flexible set membership constraint on the first predicted state that guarantees robust stability.

18:50-19:10 WeC2.5

Quadrotor Control with a Guaranteed Presence of Output Signals under a Prespecified State Bounds, pp. 295-299

Kuznetsov, Mikhail ITMO University
Vrazhevsky, Sergey ITMO University
Khalyamina, Ekaterina ITMO University

The article proposes a new robust tracking control method for UAV systems in roll and pitch angular planes. The main achievement of the obtained controller is a guarantee that the output signal is confined in a sufficiently small prespecified bounded set formed by arbitrary continuously differentiable functions. The method is applied to a multiple-input multiple-output quadrotor model under external bounded disturbances and parametrical uncertainties influence. Results and achieved performance are verified via representative computer simulation results.

WeC3 Athina B

Neural Networks (Regular Session)

Chair: Mascolo, Saverio Politecnico Di Bari
Co-Chair: Koutsoukos, Xenofon Vanderbilt University

17:30-17:50 WeC3.1

Attack-Resilient Multi-Agent Flocking Control Using Graph Neural Networks, pp. 300-305

Bhowmick, Chandreyee Vanderbilt University
Shabbir, Mudassir Vanderbilt University
Koutsoukos, Xenofon Vanderbilt University

Flocking control of a group of mobile agents has been recently investigated using Graph Convolution Networks (GCNs). The design relies on training using a centralized controller, but the resulting GCN controller is based on communication between the agents. The agents receive sensor measurements which are incorporated into the states and shared between the neighbours. However, the paradigm is prone to adversarial attacks. In this paper, we consider the problem of designing GCN-based distributed flocking control that is resilient to attacks on the communicated information. We consider an attack model that is used to compromise the inter-agent communication and may inject arbitrary signals. Our control design uses a coordinate-wise median-based aggregation function. It is shown that the GCN-based controller using the proposed aggregation method is resilient against attacks on the communication between the agents, whereas the typical average-based aggregation fails to maintain the flock structure. Robustness analysis is performed to show that the proposed method is resilient whenever most of the agents in the neighbourhood can be trusted. Simulation results and analysis are presented that validate the merits of the proposed approach.

17:50-18:10 WeC3.2

On Asymptotic Stability of Nonlinear Systems with Deep Reinforcement Learning Controllers, pp. 306-311

Manfredi, Gioacchino Politecnico Di Bari
De Cicco, Luca Politecnico Di Bari
Mascolo, Saverio Politecnico Di Bari

Controlling systems with learning-based control strategies is attracting the interest of the research community due to the advantages that machine learning offers, such as the possibility of controlling nonlinear systems that would be hard to control with conventional techniques, the possibility of controlling systems whose model is not available and so on. Reinforcement Learning (RL) and Deep Neural Networks (DNN) can be merged to obtain Deep Reinforcement Learning (DRL) control strategies. Yet, such new approaches are implemented only in few real-world applications since classical DRL control policies cannot guarantee asymptotic stability, which is a key requirement to guarantee safety. In this work, we propose a framework that, after extracting the DRL control policy, tries to synthesise a Lyapunov function that certifies the asymptotic stability of the system controlled with such a policy. We also show that our framework paves the way for safety guarantees that are often necessary when deriving a control policy. Results show that Lyapunov functions can be synthesised for the considered benchmark systems, thus ensuring asymptotic stability. Furthermore, the corresponding regions of attraction prove the quality of DRL control policies wrt other state-of-the-art learning-based controls.

18:10-18:30 WeC3.3

Decentralized Federated Learning for Nonintrusive Load Monitoring in Smart Energy Communities, pp. 312-317

Giuseppi, Alessandro Sapienza Università di Roma
Menegatti, Danilo Sapienza Università di Roma
Manfredi, Sabato Università Degli Studi di Napoli Federico II
Pietrabissa, Antonio Consortium for the Research in Automation and Telecommunication
Poli, Cecilia Istituto Superiore di Sanità

Federated Learning is a distributed learning solution for machine learning problems without the need of collecting the available data in a single centralized data centre. With the standard FL approaches, model training is performed locally, and a centralized server collects and elaborates the trainable parameters of the local models: even if data are not shared, the presence of the centralized server still rises trust and security issues. In this work, we introduce the Decentralized Federated Learning (DecFedAvg) algorithm, which aims at achieving complete decentralization by the lack of a coordination server, and compare its performance against the original federated learning algorithm Federated Averaging (FedAvg) over the Nonintrusive Load

18:30-18:50 WeC3.4

Automated Optical Inspection for Printed Circuit Board Assembly Manufacturing with Transfer Learning and Synthetic Data Generation, pp. 318-323

Saif, Syed Saad — Sapienza Università di Roma
Aras, Kerem — Token Financial Technologies
Giuseppi, Alessandro — Sapienza Università di Roma

Automated Optical Inspection (AOI) is among the most common and effective quality checks employed in production lines. This paper details the design of a Deep Learning solution that was developed for addressing a specific quality control in a Printed Circuit Board Assembly (PCBA) manufacturing process. The developed Deep Neural Network exploits transfer learning and a synthetic data generation process to be trained even if the quantity of the data samples available is low. The overall AOI system was designed to be deployed on low-cost hardware with limited computing capabilities to ease its deployment in industrial settings.

18:50-19:10 WeC3.5

Personalized LSTM Models for Glucose Prediction in Type 1 Diabetes Subjects, pp. 324-329

Iacono, Francesca — Università Degli Studi di Pavia
Magni, Lalo — Università Degli Studi di Pavia
Toffanin, Chiara — Università Degli Studi di Pavia

Blood Glucose (BG) regulation is the main challenge of Type 1 diabetes patients, that need exogenous insulin treatments to keep BG levels under control. The Artificial Pancreas (AP) is a closed-loop system developed to automatically regulate BG, using continuous glucose monitoring data to compute and directly inject the optimal insulin quantity. The AP includes controllers, like the Model Predictive Control, and alarm systems that need patients models to predict BG levels. In recent years, thanks to a growing availability of both in silico and in vivo data, neural network techniques have been investigated for glucose prediction, showing a good capability to understand the non-linearities of the system. In this work, personalized LSTM models are proposed for the 100 patients of the UVAslash Padova simulator. BG levels are predicted with a prediction horizon of 40 minutes, considering meals, insulin and past BG values as input. The proposed LSTMs with a simple architecture obtained satisfactory results with respect to the literature (RMSE=7.67, FIT=75.86%).

WeC4 — Poseidon AB

System Identification (Regular Session)

Chair: Hure, Nikola — University of Zagreb
Co-Chair: Mohite, Shivaraj — University of Lorraine

17:30-17:50 WeC4.1

Parameter Identification of an Electric Powertrain with Backlash, pp. 330-335

Heinz, Melanie — Mercedes-Benz AG
Nelles, Oliver — University of Siegen

To determine the main characteristics and analyze an electric powertrain at an early stage of vehicle development, a simple and easy-to-parameterize model is needed. Simulations of an electric powertrain can also be used for the design of a feed-forward control, a control system, or for an observer during the further development process. For this purpose, a simplified nonlinear two-mass oscillator with backlash can be used. To parameterize this model, an optimization method is needed. In this paper, the differential evolution algorithm is used to identify the parameters of the powertrain. To reduce the time required for parameter identification, an additional termination condition is introduced. To define suitable parameters for the purpose of the application, an appropriate choice of the loss function is important. Therefore, different loss functions are compared, and multi-objective optimization is applied. The additional influence of the excitation signal on the parameter identification is discussed. A validation of the parameterized model based on measurements indicates that the simplified model is fully sufficient and that the proposed parameter determination is suitable for the mentioned applications and requires low computational resources.

17:50-18:10 WeC4.2

Regression-Based Thermodynamic Model Identification of a Zone with a Closed-Access Air Conditioner, pp. 336-342

Hure, Nikola — University of Zagreb
Vasak, Mario — University of Zagreb

Smart buildings have a great potential in the energy regulation market. One of the levers that are used for the flexibility provision of buildings are the thermal comfort systems. This paper deals with a thermodynamic model identification for a comfort-regulated zone of a smart home with an installed air conditioner. The intended end-use of the model is model predictive control of comfort with electricity demand response over a collection of objects with such similar configuration. Typical commercial setups of closed-access air conditioners found in residential objects are considered, where there is no possibility of any data communication from the air conditioner and where the sensory equipment is quite limited due to an intended large-scale deployment. This drives the specific input-output model form where the air conditioner electricity consumption is the selected model input. The performance of different mathematical models for temperature prediction in the smart home in the heating season is analysed and the results with quantitative measures are provided. The complete analysis is based on measurement data collected on a smart home experimental setup.

18:10-18:30 WeC4.3

NARX Models of Two-Phase Microchannels Flow in Comparison, pp. 343-348

Stella, Giovanna — Università Degli Studi Di Catania
Gagliano, Salvina — Università Degli Studi Di Catania
Bucolo, Maide — Università Degli Studi Di Catania

In this work, two structures of data-driven models have been optimized and compared for the identification and tracking of fast two-phase flows in microchannels. Two-phase flow, consisted of an interlaced sequence of two fluids, as water and air, traveling in a microchannel is defined slug flow and it can be generated by their interaction at a junction. An extensive experimental campaign was performed to collect data and the processes was optically monitored. Two structures of Nonlinear AutoRegressive with eXogenous (NARX) input models, by using Neural Networks (NN) and Wavelet Networks (WN), were compared for modeling the slug flow passage. Two types of patterns were chosen to train and test the networks: single-flow pattern, one per experiment, and multi-flow patterns containing more experimental conditions. The test on single flow patterns highlights the robustness of the models in tracking the slug flow passage and the test on multiple flows patterns confirms the possibility to have one model for different experimental conditions. To underline the potential of these models, some indices were considered to evaluate their performance. The proposed models can represent an important step towards the development of predictive control for real-time System-on-Chip applications.

18:30-18:50 WeC4.4

Finite Time Convergence Parameter Estimator for Nonlinear MIMO System, pp. 349-354

Bazylev, Dmitry ITMO University

Vrazhevsky, Sergey ITMO University

In this paper, we present a finite time convergence (FTC) parameter estimator for a class of non-linear MIMO systems. The designed FTC estimator is based on a continuous-time parameter identification algorithm that was recently proposed by the authors. Compared to the previous solution the new modified estimator doesn't require the unobvious to achieve in practice assumptions imposed on regression functions to ensure guaranteed convergence. As a practical example, we use a ”Twin Rotor MIMO System” laboratory bench which model is given by a nonlinear multi-channel system with cross-couplings. Significant improvement of the transient behaviour for the new parameter estimator is demonstrated via representative simulation results.

18:50-19:10 WeC4.5

Advantages of a Physics-Embedding Kernel for Robot Inverse Dynamics Identification, pp. 355-361

Giacomuzzo, Giulio Università Degli Studi di Padova

Turcato, Niccolò Università Degli Studi di Padova

Dalla Libera, Alberto Università Degli Studi di Padova

Carli, Ruggero Università Degli Studi di Padova

The Geometrically Inspired Polynomial Kernel (GIP) has been recently proposed in the context of black box inverse dynamics estimation based on Gaussian Processes, driven by the fact that the inverse dynamics map derived from the Lagrangian equations is a polynomial function in a suitable feature space. In this paper, we further investigate the advantages of the GIP kernel comparing it with the state-of-the-art Radial Basis Function Kernel (RBF). We extend the analysis of the generalization properties, by comparing estimation accuracy and reliability of the confidence intervals returned. Moreover, we evaluate the structural properties induced by the two kernels considering their ability to estimate inertial, Coriolis and gravitational components of the inverse dynamics map. Numerical experiments confirm that the GIP kernel has better generalization properties and returns more reliable estimates of the prediction variance. Moreover, its superior ability to estimate inertial, Coriolis and gravitational torques components, suggests that it better encodes the underlying structural properties of the unknown inverse dynamics map.

Technical Program for Thursday June 30, 2022

ThA1 Platon Hall

Autonomous Systems I (Regular Session)

Chair: Freddi, Alessandro Università Politecnica Delle Marche

Co-Chair: Satpute, Sumeet Luleå University of Technology

10:30-10:50 ThA1.1

An Adaptive 3D Artificial Potential Field for Fail-Safe UAV Navigation, pp. 362-367

Lindqvist, Björn Luleå University of Technology

Haluska, Jakub Luleå University of Technology

Kanellakis, Christoforos Luleå University of Technology

Nikolakopoulos, George Luleå University of Technology

This article presents an obstacle avoidance framework for unmanned aerial vehicles (UAVs), with a focus on providing safe and stable local navigation in critical scenarios. The framework is based on enhanced artificial potential field (APF) concepts and is paired with a nonlinear model predictive controller (NMPC) for complete local reactive navigation. This paper will consider a series of additions to the classical artificial potential field that addresses UAV-specific challenges, allows for smooth navigation in tightly constrained environments, and ensures safe human-robot interactions. The APF formulation is fundamentally based on using raw LiDAR pointcloud data as input to decouple the safe robot navigation problem from the reliance on any map or obstacle detection software, resulting in a very resilient and fail-safe framework that can be used as an additional safety layer for any 3D-LiDAR equipped UAV in any environment or mission scenario. We evaluate the scheme in both laboratory experiments and field trials, and also place a large emphasis on realistic scenarios for safe human-robot interactions.

10:50-11:10 ThA1.2

A Deep Reinforcement Learning Motion Control Strategy of a Multi-Rotor UAV for Payload Transportation with Minimum Swing, pp. 368-374

Panetsos, Fotis National Technical University of Athens

Karras, George — University of Thessaly
Kyriakopoulos, Kostas J. — National Technical University of Athens

This paper addresses the problem of controlling a multirotor UAV with a cable-suspended load. To ensure the safe transportation of the load, the swinging motion, induced by the strongly coupled dynamics, has to be minimized. Specifically, using the Twin Delayed Deep Deterministic Policy Gradient (TD3) Reinforcement Learning algorithm, a policy Neural Network is trained in a model-free manner which navigates the vehicle to the desired waypoints while, simultaneously, compensating for the load oscillations. The learned policy network is incorporated into the cascaded control architecture of the autopilot by replacing the common PID position controller and, thus, communicating directly with the inner attitude one. The performance of the proposed policy is demonstrated through a comparative simulation and experimental study while using an octorotor UAV.

11:10-11:30 ThA1.3

A Visual Servoing Strategy for Coastline Tracking Using an Unmanned Aerial Vehicle, pp. 375-381

Aspragkathos, Sotiris — National Technical University of Athens
Karras, George — University of Thessaly
Kyriakopoulos, Kostas J. — National Technical University of Athens

In this paper, an Image-based Visual Servo (IBVS) Control strategy for the autonomous surveillance of coastlines using an octocopter aerial vehicle is proposed. The implemented strategy is focused on the vision-based detection and tracking of dynamic coastlines and in the presence of waves while flying in low altitudes. For this purpose, a Deep Neural Network (DNN) for the detection of the coastline is employed. The DNN is accompanied by an analytical formulation of an Extended Kalman Filter (EKF), which considers an approximate periodical wave motion model to provide an online estimate of the coastline motion directly in image space. The estimated feedback is provided to an appropriately formulated IBVS tracking controller for the autonomous guidance of the octocopter along the coastline, ensuring the latter is always kept inside the camera's field of view. The efficacy of the proposed scheme is demonstrated via a set of comparative outdoor experiments using an octocopter flying along the coastline on various weather and beach settings.

11:30-11:50 ThA1.4

A Design and Simulation of a Target Detection, Tracking and Localisation System for UAVs, pp. 382-388

Daramouskas, Ioannis — University of Patras
Patrinopoulou, Niki — University of Patras
Meimetis, Dimitrios — University of Patras
Lappas, Vaios — University of Patras
Kostopoulos, Vassilis — University of Patras

In computer vision multiple-object detection has gain significant interest by the researchers the last decade through the evolution in the field of deep learning. Nowadays, there are many architectures achieving great accuracy in detecting multiple objects in an image. On the other hand, tracking the detecting objects remains a very difficult task and still a lot of effort is provided in that field. In general, multiple-object detection, recognition and tracking are quite desired in many domains and applications. This paper presents a target detection, tracking and localisation solution for UAVs using optical cameras. A custom object detection model, based on YOLOv4-tiny, was developed based on YOLOv4-tiny and its performance was compared against YOLOv4-tiny and YOLOv4-608. While the target track algorithm in use is base on Deep SORT, providing state of the art tracking. The presented localisation method can determine the position of ground targets, detected from the custom object detection model, with great accuracy. Finally, a guidance methodology is presented, responsible for creating real-time movement commands for the UAV to follow a selected target and provide coverage over him. The overall system was tested using Software-In-The-Loop (SITL) simulation in Gazebo with up to four UAVs.

11:50-12:10 ThA1.5

A Survey on Control Design Approaches for Remotely Operated UAVs, pp. 389-395

Sankaranarayanan, Viswa Narayanan — Luleå University of Technology
Nikolakopoulos, George — Luleå University of Technology
Satpute, Sumeet — Luleå University of Technology

Quadrotors find their roles in various sectors ranging from remote surveillance to autonomous delivery due to their capabilities of hovering, Vertical Take Off and Landing (VTOL) and rapid manoeuvring. They are a viable asset to humans in safety-critical and hazardous operations such as remote inspection and manipulation of tunnels and windmills. These applications induce external disturbances and noises along with the modelling uncertainties in the dynamics. Applications such as aerial manipulation require control from a ground station autonomously or semi-autonomously, which leads to unpredictable delays and lags. In this context, the quadrotor has to perform its goals of following the desired trajectory with minimal deviation and holding its position without any deviation while operating in the environment. So, this article analyses the existing control techniques for the quadrotor tracking problem, which also tackle parametric uncertainties, unknown time-varying delays and ensure safety.

12:10-12:30 ThA1.6

Modeling and Control of a Telescopic Quadrotor Using Disturbance Observer Based Control, pp. 396-402

Baldini, Alessandro — Università Politecnica Delle Marche
Felicetti, Riccardo — Università Politecnica Delle Marche
Freddi, Alessandro — Università Politecnica Delle Marche
Longhi, Sauro — Università Politecnica Delle Marche
Monteriù, Andrea — Università Politecnica Delle Marche

Morphing multirotors are characterized by the capability to modify their shape during the flight, to negotiate narrow gaps without the need for miniaturization, thus preserving flight time and payload. In this paper, we propose a mathematical model for a morphing quadrotor

characterized by telescopic arms: as extendable arms move, the centre of mass position changes, as well as the inertia of the vehicle. Then, we address the tracking control problem of the telescopic quadrotor under external additive disturbances (e.g., wind), following the disturbance observer-based control approach. The control scheme consists in an inner/outer loop structure, where both loops interact with a nonlinear disturbance observer. Closed loop performances are analyzed and the control scheme is validated through a realistic numerical simulation.

ThA2	Athina A
Guidance (Regular Session)	
Chair: Tekin, Raziye	Roketsan Inc
Co-Chair: Lack, Sven	University of Rostock

10:30-10:50 ThA2.1

Three-Dimensional Formation Flight with Impact Vector Guidance, pp. 403-408

Alan, Asım Burkay — Roketsan Inc
Tekin, Raziye — Roketsan Inc

In this study, a guidance approach is developed for the formation flight phenomenon. This method is successful to determine any desired formation shape which is achieved by engaging in tail-chase scenarios with virtual leaders. The solution is given in two parts: kinematics of formation flight and guidance design. Impact Vector Guidance method, which is originally used to set a desired impact angle for the engagement, is modified in a way to accomplish tail-chase scenarios. The modifications on the guidance law is explained in details and their effects are given with simulation results. Lastly, an air strike is simulated using the proposed guidance law with a leader missile and its followers.

10:50-11:10 ThA2.2

Three-Dimensional Impact-Angle Control with Biased Proportional Navigation, pp. 409-413

Erer, Koray — Roketsan Inc
Tekin, Raziye — Roketsan Inc

An impact-angle guidance law for three-dimensional engagements is presented in this paper. The guidance law is derived without linearization, takes the cross-coupling effects into account, and does not require the time-to-go information. The approach is based on plane pursuit, which aims to bring the velocity vector of the missile into a rotating impact plane, and biased proportional navigation, in which the bias applied only over the initial part of the engagement. The proposed guidance law is in stand-alone vector form and straightforward to implement. The performance is demonstrated with simulation runs.

11:10-11:30 ThA2.3

Trajectory Generation for a Quaternion Based 6-DoF ROV Tracking Controller, pp. 414-419

Lack, Sven — University of Rostock
Rentzow, Erik — University of Rostock
Jeinsch, Torsten — University of Rostock

Quaternion based 6-DoF tracking controllers for underwater vehicles have been described in the literature since the early 90's. However, the spread of this control concept in practical applications is very low because quaternions for describing the attitude are not so common. In this paper, a variety of mathematical properties and calculation rules for quaternion are collected and their use for the calculation of quaternion-based trajectories are described. Furthermore, the use of scaling functions for the generation of different velocity-profiles (polynomial and cycloidal) is presented. The generated trajectories are tested in a simulation study for a 6-DoF tracking controller on a simple ROV model.

11:30-11:50 ThA2.4

Analysis of 2D Impact Angle Control Laws in 3D Kinematics, pp. 420-425

Ata, Emre Han — Roketsan Inc
Kaya, Taşkın — Roketsan Inc
Tekin, Raziye — Roketsan Inc
Erer, Koray — Roketsan Inc

Impact-angle control is utilized to shape the planar trajectory of a missile to obtain a desired terminal direction. When the engagement is not contained in a plane, the mechanization of a guidance law designed for this purpose will be ambiguous. There might be a number of alternative approaches to implement an impact-angle guidance law in a three-dimensional environment. This paper evaluates two of them. In the first approach, which is probably the conventional one, the pursuit angles are calculated with respect to the inertial frame and in the second, they are calculated with respect to the velocity frame. The performance of these methods is illustrated by simulations, which also include a reference impact-vector guidance law, in a comparative manner. Whereas the results imply that the one based on the velocity frame might be the better choice, both methods will enable the guidance designer to leverage two-dimensional guidance laws to shape the trajectory in three dimensions.

11:50-12:10 ThA2.5

RRT-Based Path Planning for Car-Like Vehicles with Nonholonomic Constraints, pp. 426-431

Spanogianopoulos, Sotirios — Xi'an Jiaotong-Liverpool University
Sirlantzis, Konstantinos — University of Kent
Ahiska, Kenan — ASELSAN Inc

In this paper, for car-like mobile robots, a novel path planning algorithm is proposed. The algorithm is based on rapidly exploring random trees (RRT) with fixed nodes (RRT*FN). An improvement on the RRT*FN is proposed to abide by the non-holonomic motion constraints and RRT*FN nonholonomic (RRT*FN-NH) is introduced. The new path planning algorithm handles the non-holonomic constraints as well as the constraints on the velocity and acceleration of the vehicle. The performance of the proposed algorithm RRT*FN-NH is tested on two maps obtained from Google images at three different speed profiles.

ThA3	Athina B
Modeling and Flight Control Design for Aerospace Systems (Invited Session)	
Chair: Tzes, Anthony	New York University Abu Dhabi
Co-Chair: Theodoulis, Spilios	French-German Research Institute of Saint-Louis
Organizer: Theodoulis, Spilios	French-German Research Institute of Saint-Louis
Organizer: Tzes, Anthony	New York University Abu Dhabi

10:30-10:50 ThA3.1

Design, Modelling, Localization, and Control for Fire-Fighting Aerial Vehicles (I), pp. 432-437

Chaikalis, Dimitris — New York University
Evangeliou, Nikolaos — New York University Abu Dhabi
Tzes, Anthony — New York University Abu Dhabi
Khorrami, Farshad — New York University

A firefighting aerial system is considered in this article. Such a system is comprised of a tethered hose, a high-pressure water pump, and a multirotor aerial vehicle. In this paper, the overall dynamic model of this system is developed, taking into account the behaviour of the hose and the recoil force of the exiting waterjet. The aerial vehicle is designed with vertical and lateral rotors, offering an additional actuation input to aid in compensation of the effects of the hose and the waterjet. A model-based controller is developed to guarantee stable flight of the aerial vehicle. A localization method is proposed, where the aerial vehicle's relative position with respect to its base is computed by including a force sensor on the vehicle and solving the inverse of the hose curvature equations. Simulations are used to investigate the effectiveness of the overall developed model, the controller efficiency, and the accuracy of the force-based localization method.

10:50-11:10 ThA3.2

Robust Path-Following Control with Anti-Windup for HALE Aircraft (I), pp. 438-443

Weiser, Christian — German Aerospace Center (DLR)
Ossmann, Daniel — Munich University of Applied Sciences
Pfifer, Harald — Technische Universität Dresden

In this paper, a robust path-tracking controller for a High-Altitude Long Endurance (HALE) aircraft is presented. The main control paradigm for operating a HALE aircraft consists of a basic path following control, i.e., tracking a reference flight path and airspeed while dealing with very limited thrust. The priority lies in keeping airspeed inside the small flight envelope of HALE aircraft even during saturated thrust. For the basic path following objective, a mixed sensitivity approach is proposed which can easily deal with decoupled tracking and robustness requirements. To deal with saturated control inputs, an anti-windup scheme is incorporated in the control design. A novel observer-based mixed sensitivity design is used which allows directly using classical anti-windup methods based on back-calculation. The control design is verified in nonlinear simulation and compared to a classical total energy control-based controller.

11:10-11:30 ThA3.3

Autopilot Design for Dual-Spin Projectiles Using Incremental Nonlinear Dynamic Inversion (I), pp. 444-449

Pineau, Sofiane — French-German Research Institute of Saint-Louis
Theodoulis, Spilios — French-German Research Institute of Saint-Louis
Zasadzinski, Michel — University of Lorraine
Boutayeb, Mohamed — University of Lorraine

This article addresses the design of a nonlinear autopilot using Incremental Nonlinear Dynamic Inversion for a 155mm dual-spin projectile equipped with a course correction fuze. The aim of the autopilot is to control the lateral accelerations of the projectile following the embedded guidance law desired load factors to keep the projectile on the proper trajectory. Designed with a practical and straightforward methodology, a two-stage cascaded INDI structure based on time-scale separation between fast lateral rate dynamics and slow acceleration dynamics was used to linearize and control each channel. Fixed-structure robust linear controllers were designed to impose closed-loop behaviour of lateral accelerations throughout the whole flight envelope by decoupling and controlling the aerodynamic angles. Full trajectory nonlinear simulations confirm the successful implementation of the law reducing ballistic dispersion under nominal conditions.

11:30-11:50 ThA3.4

Smooth Attitude Stabilisation in Prescribed Time of a Rigid Body Despite Uncertainties in Inertia and Additive Disturbances (I), pp. 450-455

Sarras, Ioannis — ONERA-The French Aerospace Lab

We consider the problem of stabilisation in predefined, finite time of the attitude of a rigid body. Inspired by classical laws in misisle guidance, the proposed control law is time-varying but smooth as opposed to classical sliding-mode-based laws that are generally discontinuous, or continuous at best, and suffer from robustness issues. Through a backstepping design, and the explicit construction of a strict Lyapunov function, we are able to ensure stabilisation to a desired attitude even in the presence of uncertainties in the inertia

matrix and under the effect of additive disturbances. Numerical simulations show the efficiency of the proposed controller.

11:50-12:10 ThA3.5

Altitude and Attitude Quadrotor Control Based on Adaptive Sliding Mode Controller with Input Saturation, pp. 456-461

Sidi Brahim, Khelil — Université De Picardie Jules Verne
Terki, Nadjiba — University Mohamed Khider Biskra
El Hajjaji, Ahmed — Université De Picardie Jules Verne
Lara, David — Instituto Tecnologico Superior De Misantla

This paper deals with the adaptive robust tracking control problem of a quadrotor under parametric uncertainties, actuator saturation and external wind disturbances. An adaptive robust control strategy is proposed to deal with this tracking problem. To solve the actuator saturation problem, an auxiliary system with adaptation law is considered. Global stability of the resulting closed loop system is analysed using the sliding mode approach and the Lyapunov theory. The proposed control strategy is developed to control the altitude system and attitude system representing the rotation angles in the presence of external perturbations, uncertainties, and input saturation. The proposed control scheme is finally verified through various tests of simulation, also an experimental validation is carried on Parrot Mambo minidrone proving its effectiveness.

ThA4 — Poseidon AB

Robotics I (Regular Session)

Chair: Nikolakopoulos, George — Luleå University of Technology
Co-Chair: Lindqvist, Björn — Luleå University of Technology

10:30-10:50 ThA4.1

Embedded GPU Based Autonomous Robot Use Cases, pp. 462-467

Molnar, Szilard — Technical University of Cluj-Napoca
Lucaci, Adrian — Technical University of Cluj-Napoca
Tamas, Levente — Technical University of Cluj-Napoca

The recent advances in embedded GPU solutions allow the use of these devices for onboard mobile robotics applications. The focus of this paper is on the implementation and validation of navigation tasks for various autonomous mobile robot platforms. These platforms include ground, aerial vehicles as well as mobile manipulators. The main challenge for these implementations was the feasibility of the adopted solutions on embedded platforms with dedicated GPUs. As each of our solutions contains deep neural networks, the existence of embedded GPU is a must. We evaluated several different boards for our solutions with various experimental setups. The code and the datasets for these demos are available on the author GitHub page.

10:50-11:10 ThA4.2

Experimental Evaluation of a Geometry-Aware Aerial Visual Inspection Framework in a Constrained Environment, pp. 468-474

Kottayam Viswanathan, Vignesh — Luleå University of Technology
Satpute, Sumeet — Lulea University of Technology
Lindqvist, Björn — Luleå University of Technology
Kanellakis, Christoforos — Luleå University of Technology
Nikolakopoulos, George — Luleå University of Technology

This article aims to present an experimental evaluation of an offline, geometry-aware aerial visual inspection framework, specifically in constrained environment, established for geometrically fractured objects, by employing an autonomous unmanned aerial vehicle (UAV), equipped with on-board sensors. Based on a model-centric approach, the proposed inspection framework, generates inspection viewpoints around the geometrically fractured object, subject to the augmented static bounds to prevent collisions. The novel framework of visual inspection, presented in this article, aims to mitigate challenges arising due to the spatially constrained environment, such as limited configuration space and collision with the object under inspection, by accounting for the geometrical information of the vehicle to be inspected. The efficacy of the proposed scheme is experimentally evaluated through large scale field trials with a mining machine.

11:10-11:30 ThA4.3

Soft Pneumatic Actuated Morphing Quadrotor: Design and Development, pp. 475-480

Haluska, Jakub — Luleå University of Technology
Västanälv, Jim — Luleå University of Technology
Papadimitriou, Andreas — Luleå University of Technology
Nikolakopoulos, George — Luleå University of Technology

The majority of the aerial robots scientific literature investigates methods to create fully automated solutions using fixed-frame multi-rotors. However, the ability of the Micro Aerial Vehicles (MAVs) to alter their structure and adapt to various constraints posed by the environment remains unexplored. Aerial robotic platforms that can alter their shape in-flight can increase their potential value and extend the range of applications. It is essential to develop and deploy such platforms which can effectively address the missing elements for exploring previously unreachable locations. This article deals with a novel reconfigurable quadrotor whose arms are based on Soft Pneumatic Actuators (SPA) from a design, analysis, and development point of view. Simulation analysis and experimental results are provided to showcase the potential of such designs that integrate soft actuators with the traditional fixed-frame MAVs designs.

11:30-11:50 ThA4.4

Multi-Robot Task Allocation Framework with Integrated Risk-Aware 3D Path Planning, pp. 481-486

Bai, Yifan	Luleå University of Technology
Lindqvist, Björn	Luleå University of Technology
Karlsson, Samuel	Luleå University of Technology
Kanellakis, Christoforos	Luleå University of Technology
Nikolakopoulos, George	Luleå University of Technology

This article presents an overall system architecture for multi-robot coordination in a known environment. The proposed framework is structured around a task allocation mechanism that performs unlabelled multi-robot path assignment informed by 3D path planning, while using a nonlinear model predictive control (NMPC) for each unmanned aerial vehicle (UAV) to navigate along its assigned path. More specifically, at first a risk aware 3D path planner D∗+ is applied to calculate cost between each UAV agent and each target point. Then the cost matrix related to the computed trajectories to each goal is fed into the Hungarian Algorithm that solves the assignment problem and generates the minimum total cost. NMPC is implemented to control the UAV while satisfying path following and input constraints. We evaluate the proposed architecture in Gazebo simulation framework and the result indicates UAVs can approach their assigned target whilst avoiding collisions.

11:50-12:10 ThA4.5

Edge Computing Architectures for Enabling the Realisation of the Next Generation Robotic Systems, pp. 487-493

Seisa, Achilleas Santi	Luleå University of Technology
Damigos, Gerasimos	Luleå University of Technology
Satpute, Sumeet	Luleå University of Technology
Koval, Anton	Luleå University of Technology
Nikolakopoulos, George	Luleå University of Technology

Edge Computing is a promising technology to provide new capabilities in technological fields that require instantaneous data processing. Researchers in areas such as machine and deep learning use extensively edge and cloud computing for their applications, mainly due to the significant computational and storage resources that they provide. Currently, Robotics is seeking to take advantage of these capabilities as well, and with the development of 5G networks, some existing limitations in the field can be overcome. In this context, it is important to know how to utilize the emerging edge architectures, what types of edge architectures and platforms exist today and which of them can and should be used based on each robotic application. In general, Edge platforms can be implemented and used differently, especially since there are several providers offering more or less the same set of services with some essential differences. Thus, this study addresses these discussions for those who work in the development of the next generation robotic systems and will help to understand the advantages and disadvantages of each edge computing architecture in order to choose wisely the right one for each application.

ThB1 — Platon Hall

Autonomous Systems II (Regular Session)

Chair: Kyriakopoulos, Kostas J.	National Technical University of Athens
Co-Chair: Schwartz, Howard M.	Carleton University

14:00-14:20 ThB1.1

AROWA: An Autonomous Robot Framework for Warehouse 4.0 Health and Safety Inspection Operations, pp. 494-499

Konstantinidis, Fotios K.	Democritus University of Thrace
Balaska, Vasiliki	Democritus University of Thrace
Symeonidis, Symeon	Democritus University of Thrace
Mouroutsos, Spyridon G.	Democritus University of Thrace
Gasteratos, Antonios	Democritus University of Thrace

Over the previous two decades, a tremendous impact has been created on each stage of the production value chain, through digitization of the traditional industrial processes and procedures. Since warehouses are at the heart of distributed supply chain networks, it is critical to leverage modern automation tools and through-engineering solutions to increase their efficiency and continuously meet the demanding standards. Towards this end, we describe the design of a health and safety (H&S) inspection robot capable of autonomously detecting hazard events without human intervention in ware- houses. It makes use of computer vision (CV) techniques, edge computing (EC) and artificial intelligence (AI) to identify critical occurrences that have a detrimental impact on H&S. while counting available resources using inventory tracking methodologies. Furthermore, action-based modules are activated in response to the recognised event, informing warehouse workers about it and notifying other systems, operators and stakeholders, where appropriate, as foreseen by the protocol. Lastly, the conceptual architecture of the proposed autonomous robot is presented, which classifies the needed vision-based and action-based modules.

14:20-14:40 ThB1.2

Comparison of Cellular Network Controllers for Quadrotors Experiencing Time Delay, pp. 500-507

Tayefe Ramezanlou, Mohammad	Carleton University
Schwartz, Howard M.	Carleton University
Lambadaris, Ioannis	Carleton University
Barbeau, Michel	Carleton University

This paper presents a control framework including delay estimator, state estimator, and controller to compensate for random time delays

in cellular networks. The effect of network delay on the control of a quadrotor is investigated. A comparative study is done between a linear-based PD and nonlinear Backstepping controller. A time delay estimator based on the Markov stochastic model is developed. The combination of the time delay estimator and the state estimator is used to compute the control signal. Results show that the performance of both controllers in low-variation delays is approximately equivalent. According to the results, the linear-based PD controller is a good choice since it satisfies the problem conditions with a more straightforward design process.

14:40-15:00 ThB1.3

Real-Time Path Planning for Fully Actuated Autonomous Surface Vehicles, pp. 508-513

Damerius, Robert — University of Rostock
Jeinsch, Torsten — University of Rostock

This paper presents a method for real-time path planning for fully actuated autonomous surface vehicles in confined waters. The goal is to continuously generate a collision-free path from a given initial pose to a given final pose. Both the own vehicle and static obstacles are represented as convex polygons. As soon as the environment changes, or other initial or final poses are specified, a warm start is performed, in which the results of previous solutions are reused. An optimal sampling-based approach is used to explore the search space. In a cost function, the length of the path is weighted together with the distance to all obstacles. Some parts of the cost function are calculated in advance and stored in look-up tables to reduce the computation time. The result is an optimal path from an initial pose to a final pose that avoids collisions of the vehicle with static obstacles. The proposed warm start procedure is tested by real-time experiments using different scenarios.

15:00-15:20 ThB1.4

Hardware-In-The-Loop Testing of a Maritime Autonomous Collision Avoidance System, pp. 514-519

Tornese, Riccardo — Università Del Salento
Polimeno, Edoardo — Università Del Salento
Pascarelli, Claudio — Università Del Salento
Buccoliero, Stefania — Fincantieri NexTech S.p.A
Carlino, Luca — Fincantieri NexTech S.p.A
Sansebastiano, Emanuele — Fincantieri NexTech S.p.A
Sebastiani, Luca — Fincantieri NexTech S.p.A

Real-time simulators are useful tools for the development and validation of complex systems such as naval ships, aircraft, or land vehicles, requiring over time more rigorous testing and integration as these systems become more and more complex. Hardware-in-the-loop simulation (HILS) is a well-established technique used for a rapid and economical validation of both hardware and software sections of the developed architecture. This paper describes the design and execution of a hardware-in-the-loop simulator developed to test a maritime autonomous collision avoidance system (CAS) as well as some notable test cases to study the behaviour of the model. The HILS system is composed by a programmable logic controller (PLC) linked to two personal computers, one responsible for hosting the Linux system running the ROS Path Planner, the other for simulating the current scenario and the ship model.

15:20-15:40 ThB1.5

Shortest Path Type Classification for Real-Time Three-Points Dubins Problems, pp. 520-525

De Palma, Daniela — Università Del Salento
Parlangeli, Gianfranco — Università Del Salento

This paper addresses the three-point Dubins problem using a classification approach, namely by only evaluating the relative initial and final configurations with the via point position using a suitable partition of the Cartesian plane. This allows to promptly choose the path type among the eight possible thus making the path planning for three points Dubins problems much faster and more suitable for real-time applications. Some examples are provided to show the efficiency of the proposed strategy.

15:20-16:00 ThB1.6

Fixed Time Stability of Discrete Autonomous Systems, pp. 526-531

Lee, Junsoo — Georgia Institute of Technology
Haddad, Wassim M. — Georgia Institute of Technology

Unlike finite time stability, wherein the upper bound of the settling-time function capturing the finite settling time behaviour of the dynamical system depends on the system initial conditions, fixed time stability involves finite time stable systems for which the minimum bound of the settling-time function is guaranteed to be independent of the system initial conditions and can a priori be adjusted. In this paper, we develop several fixed time stability results for discrete autonomous systems including a fixed-time Lyapunov theorem that involves a Lyapunov difference that satisfies an exponential inequality of the Lyapunov function giving rise to a minimum bound on the settling-time function characterized by the principal and secondary branches of the Lambert W function.

ThB2 Athina A

Navigation (Regular Session)

Chair: Gasteratos, Antonios — Democritus University of Thrace
Co-Chair: Vougioukas, Stavros — University of California Davis

14:00-14:20 ThB2.1

BK Tree Indexing for Active Vision-Based Loop-Closure Detection in Autonomous Navigation, pp. 532-537

Tsintotas, Konstantinos — Democritus University of Thrace

Sevetlidis, Vasileios — Democritus University of Thrace
Papapetros, Ioannis Tsampikos — Democritus University of Thrace
Balaska, Vasiliki — Democritus University of Thrace
Psomoulis, Athanasios — Democritus University of Thrace
Gasteratos, Antonios — Democritus University of Thrace

Aiming to recognize familiar places through the camera measurements during a robot's autonomous mission, visual loop-closure pipelines are developed for navigation frameworks. This is because the main objective for any simultaneous localization and mapping (SLAM) system is its consistent map generation. However, methods based on active vision tend to attract the researchers' attention mainly due to their offered possibilities. This paper proposes a BK-tree structure for a visual loop-closure pipeline's generated database when active vision is adopted. This way, we address the drawback of scalability in terms of timing occurring when querying the map for similar locations while high performances and the online nature of the system are maintained. The proposed method is built upon our previous work for visual place recognition, that is, the incremental bag-of-tracked-words. The proposed technique is evaluated on two publicly available image-sequences. The one is recorded via an unmanned aerial vehicle (UAV) and selected due to its active vision characteristics, while the second is registered via a car; still, it is chosen as it is among the most extended datasets in visual loop-closure detection. Our experiments on an entry-level system show high recall scores for each evaluated environment and response time that satisfies real-time constraints.

14:20-14:40 ThB2.2

Depth Camera Based Row-End Detection and Headland Maneuvering in Orchard Navigation without GNSS, pp. 538-544

Peng, Chen — University of California Davis
Fei, Zhenghao — University of California Davis
Vougioukas, Stavros — University of California Davis

A robust navigation system is a prerequisite for a mobile robot to carry out precision agriculture tasks in modern orchards. In contrast to open fields, navigation based solely on the Global Navigation Satellite System (GNSS) is not stable in many orchards, where tree canopies may block the GNSS signal or introduce multi-path error. Research has been done to localize a robot while it travels inside a row but navigating to the next row on the headland still relies on a reference map or artificial landmarks. In this work, we developed a row-end detection method by exploiting drastic changes in the statistical distribution of points sensed by a depth camera compared to the points inside the row. Also, a robust row entry method is implemented by building a local environment map and a reactive path tracker. The whole navigation system is tested and evaluated on a mobile robot in a vineyard. The experimental results show that the robot can detect the tree row-end accurately and maneuver a U-turn to the next row.

14:40-15:00 ThB2.3

Fast Planner for MAV Navigation in Unknown Environments Based on Adaptive Search of Safe Lookahead Poses, pp. 545-550

Patel, Akash — Lulea University of Technology
Lindqvist, Björn — Luleå University of Technology
Kanellakis, Christoforos — Luleå University of Technology
Nikolakopoulos, George — Luleå University of Technology

Autonomous navigation capability is a crucial part for deploying robots in an unknown environment. In this article a reactive local planner for autonomous and safe navigation in subterranean environment is presented. The proposed planning framework navigates the MAV forward in a tunnel such that the MAV gains more information about the environment while avoiding obstacles. The proposed planning architecture works solely based on the information of local surrounding of the MAV thus, making navigation simple yet fast. One of the biggest novelties of the article comes from solving the combined problem of autonomous navigation and obstacle avoidance. The proposed algorithm for selecting the next way point of interest also accounts in the safety margin for traversing to such way point. The approach presented in this article is also different from classical map based global planning algorithms because it favours the next way point away from obstacles in selection process and thus providing a safe path for incremental forward navigation. The approach is validated by simulating a MAV equipped with the proposed reactive local planner in order for the MAV to navigate in a subterranean cave environment.

15:00-15:20 ThB2.4

Visual Control through Narrow Passages for an Omnidirectional Wheeled Robot, pp. 551-556

Morra, Damiano — Università Degli Studi Di Napoli Federico II
Cervera, Enric — Jaume-I University of Castelló De La Plana
Buonocore, Luca Rosario — Università Degli Studi Di Napoli Federico II
Cacace, Jonathan — Università Degli Studi Di Napoli Federico II
Ruggiero, Fabio — Università Degli Studi Di Napoli Federico II
Lippiello, Vincenzo — Università Degli Studi Di Napoli Federico II
Di Castro, Mario — CERN

Robotic systems are gradually replacing human intervention in dangerous facilities to improve human safety and prevent risky situations. In this domain, our work addresses the problem of autonomous crossing narrow passages in a semi-structured (i.e., partially known) environment. We focus on the CERN's Super Proton Synchrotron particle accelerator, where a mobile robot platform is equipped with a lightweight arm to perform measurements, inspection, and maintenance operations. The proposed approach leverages an image-based visual servoing strategy that exploits computer vision to detect and track known geometries defining narrow passage gates. The effectiveness of the proposed approach has been demonstrated in a realistic mock-up.

15:20-15:40 ThB2.5

Object Detection and Navigation of a Mobile Robot by Fusing Laser and Camera Information, pp. 557-563

Syntakas, Spyridon — University of Ioannina
Vlachos, Kostas — University of Ioannina
Likas, Aristidis — University of Ioannina

While state-of-the-art YOLO approaches have revolutionized real time object detection in mobile robotics, most of the publicly available models are trained on datasets with a small number of available classes. In addition, the difficulty in creating large datasets with many available classes for 2D object detection sets limitations to real world robotic applications and specialized use cases. This paper presents a solution that tackles these limitations by approaching object detection via fusion of 2D laser and RGB camera information resulting to a detector with 1000 learned classes. Object localization is performed in the 3D world by clustering the point cloud provided by the 2D laser scanner using the DBSCAN algorithm. The clusters are projected onto the image plane providing Regions of Interest (ROI), where proposed object bounding boxes are obtained, that are labelled with distance information. Object recognition is achieved using a pretrained, on the ImageNet dataset, ResNet and a voting schema among proposed bounding boxes, that also estimates the objects height. The detection system is used in combination with a navigation system that employs artificial potential field. The combination of the two, makes the robot's perception easily adaptable to specialized applications and the robot's behaviour adjustable to the complexity and variability of unstructured and unknown workspaces. The method has been implemented in ROS and tested both in simulation as well as in real case scenarios using the mobile robot Pioneer 3-DX. The work is aimed at robots with limited hardware and sensor capabilities and tries to enable detection via fusion, despite the limitations.

ThB3 — Athina B

Aerospace Control (Regular Session)

Chair: Henry, David — Université De Bordeaux
Co-Chair: Nikolakopoulos, George — Luleå University of Technology

14:00-14:20 — ThB3.1

Model Predictive Control for Collision-Free Spacecraft Formation with Artificial Potential Functions, pp. 564-570

Menegatti, Danilo — Sapienza Università Di Roma
Giuseppi, Alessandro — Sapienza Università Di Roma
Pietrabissa, Antonio — Consortium for the Research in Automation and Telecommunication

A collision-free formation control strategy for spacecrafts flying in formation is presented. A linear control law is developed by means of Model Predictive Control (MPC) via the dual-mode paradigm. Collision avoidance is dealt with by using Artificial Potential Functions (APFs) to keep a desired safe distance from the obstacles. The main innovation in the proposed approach is that each spacecraft independently performs the collision avoidance manoeuvres and, consequently, the APFs-based collision avoidance control is in charge also of the collision avoidance between spacecrafts. The optimality of the solution is discussed, and numerical simulations show the effectiveness of the proposed method.

14:20-14:40 — ThB3.2

Sliding-Mode Control for On-Orbit Rendezvous with a Fleeing Passive Target on a Circular Capture Trajectory, pp. 571-576

Henry, David — Université De Bordeaux
Ferreira de Loza, Alejandra — CONACYT - Consejo Nacional De Ciencia Y Tecnologia
Fauré, Martin — Université De Bordeaux
Cieslak, Jérôme — Université De Bordeaux
Punta, Elisabetta — CNR-IEIIT

This paper deals with the design of finite-time controllers for on-orbit rendezvous and capture missions. The objective is to assess the capacity of sliding–mode controllers to control a chaser spacecraft during a capture manoeuvre of a fleeing passive spacecraft. The control solution is based on a variable structure approach that relies on the sliding mode control theory. More precisely, the general super-twisting algorithm is used to control the chaser's attitude, whereas the control of the relative position between the two spacecraft is based on the simplex-based sliding mode control theory. The method is tested in a full-scaled benchmark that accurately simulates the capture mission.

14:40-15:00 — ThB3.3

On the Design of Coordinated Impedance Control Laws for De-Orbiting and De-Spinning of Cooperative Satellites, pp. 577-582

Nanos, Kostas — National Technical University of Athens
Papadopoulos, Evangelos — National Technical University of Athens

In several on-orbit applications, such as de-orbiting, continuous contact between a servicing robot (chaser) and a serviced satellite (target) is needed. The task includes chaser free-space motion and subsequent contact interaction with a floating target. To achieve this, usually grasping of the satellite is proposed. However, most of the existing satellites on orbit have no dedicated grapple fixtures. In this paper, a coordinated impedance control law is proposed for the de-orbiting of a target via continuous contact and without grasping between the chaser end-effector and the target. Since both the manipulator's end-effector and the spacecraft base are controlled, the developed controller guarantees singularity avoidance in addition to maintaining continuous contact between the two bodies. Also, this controller is adapted to be employed in the de-spinning of a rotating satellite with known angular velocity via continuous contact. The developed control laws apply to spatial systems and are illustrated by planar examples.

15:00-15:20 ThB3.4

A Survey on Drones for Planetary Exploration: Evolution and Challenges, pp. 583-590

Giacomini, Enrico — Luleå University of Technology
Nikolakopoulos, George — Luleå University of Technology
Westerberg, Lars Göran — Luleå University of Technology

During the last decade, the efforts in space exploration have increased massively and led to a need for new ways to examine planets and other celestial bodies. The modern tendency is to create spacecraft able to scout the surface from a higher point of view, where drones have shown to be most helpful. Even if the benefits brought by this type of technology are considerable, the challenges are still difficult to overcome. This article presents a comprehensive literature review on drone technologies for planetary exploration, focusing mainly on the difficulties encountered. Considerable complications derive from the unknown environment, affecting most of the design, the mathematical model of the body, its controllability, and overall levels of autonomy. Various solutions to these challenges are proposed based on past and future missions. Furthermore, a look into the future gives an idea of possible technological developments and ways to provide the most efficient aerial exploration of other planets.

15:20-15:40 ThB3.5

Linear Quadratic Regulator: A Simple Thrust Vector Control System for Rockets, pp. 591-597

Sopegno, Laura — Università Degli Studi Di Palermo
Livreri, Patrizia — Università Degli Studi Di Palermo
Stefanovic, Margareta — University of Denver
Valavanis, Kimon P. — University of Denver

The paper focuses on developing, tuning, and testing a controller for a two-stage finless rocket during its boost phase that is based on the Linear Quadratic Regulator (LQR) optimal control method. This is accomplished by deriving and adopting a rocket simplified rigid body model that represents accurately its physical properties and the corresponding aerodynamic forces acting on the rocket system during the flight phase. The launcher is commanded through the control input thrust gimbal angle to the desired altitude using the implemented LQR-based controller. Emphasis is given to the Thrust Vector Control (TVC) system, and to the minimization of the drift caused by wind gust disturbance phenomena, which may result in a sideway motion of the rocket, and, consequently, in deviating from its desired trajectory; this is addressed, and it is overcome by considering the output parameters expressed in terms of the pitch angle, pitch rate (or angular body rate) and drift. The linearized state-space model is validated for analysis and design compensation of the pitch control logic of the ascent flight control system. The derived algorithm is, then, implemented in a Matlab/Simulink setting to demonstrate that the LQR controller provides closed-loop dynamic tracking, while the tuning of the LQR controller through the weighting matrices Q and R allows for simulating and testing how the variation of the gain directly impacts the performance of the closed-loop system and, in turn, the controller.

ThB4 — Poseidon AB

Robotics II (Regular Session)

Chair: Novakovic, Branko — University of Zagreb
Co-Chair: Gorjup, Gal — The University of Auckland

14:00-14:20 ThB4.1

Robust Model-Based Hinf Control for Free-Floating Space Manipulator Cartesian Motions, pp. 598-603

Anastasiou, Dimitrios — London's Global University
Nanos, Kostas — National Technical University of Athens
Papadopoulos, Evangelos — National Technical University of Athens

During on-orbit tasks, when space manipulator systems (SMS) need to handle captured unknown objects accurately, robust control for compensation of uncertainties and disturbances is required. To avoid fuel consumption and/or sudden end-effector impacts with the object, the SMS is in free-floating mode, i.e., the base is not actuated. In this work, a robust Cartesian-space controller is developed for a free-floating SMS during object capture. The controller consists of a model-based part, which linearizes the dynamics globally and guarantees specific performance, and of a linear H_∞ part, that assists by adding robustness in the presence of parametric uncertainties and/or disturbances. It is shown that the developed controller minimizes tracking errors and attenuates sensor noise. The sensitivity of the developed controller to uncertainties is studied by Monte Carlo simulations; the resulting tracking errors are an order of magnitude smaller than those obtained without H_∞ compensation. The control method applies to spatial systems and is demonstrated by a planar example.

14:20-14:40 ThB4.2

Dynamic Path Planning and Reactive Scheduling for a Robotic Manipulator Using Nonlinear Model Predictive Control, pp. 604-611

Gafur, Nigora — Technische Universität Kaiserslautern
Weber, Leo — Technische Universität Kaiserslautern
Yfantis, Vassilios — Technische Universität Kaiserslautern
Wagner, Achim — German Research Center for Artificial Intelligence
Ruskowski, Martin — Technische Universität Kaiserslautern

Operation of robotic manipulators is limited to structured environments and well-defined tasks due to an offline path planning. However, flexible production processes and human-robot collaboration necessitates a real time path planning to allow for replanning a path in changing environments. In this work, we investigate established planning algorithms for their applicability to dynamic path planning

problems. We further compare these methods with our approach based on model predictive control. We consider a single manipulator with six degrees of freedom in static and dynamic environments. We investigate three experimental setups and show the advantages of the proposed MPC-ELS approach over more traditional path planning algorithms in terms of several metrics, such as pathlength, execution time or trajectory smoothness. In addition, we propose a scheduling algorithm for object allocation to determine an optimal sequence for pick and place tasks with regard to minimum execution time.

14:40-15:00 ThB4.3

On the Efficiency, Usability, and Intuitiveness of a Wearable, Affordable, Open-Source, Generic Robot Teaching Interface, pp. 612-617

Gorjup, Gal — The University of Auckland
Gerez, Lucas — The University of Auckland
Gao, Geng — The University of Auckland
Liarokapis, Minas — The University of Auckland

Modern collaborative and industrial robots are typically accompanied by proprietary control interfaces, which may also offer basic teaching functionality. However, many such interfaces are not suited for frequent reconfiguration of the robot system, which is essential in agile manufacturing and research. To flatten the learning curve between different interface variants and efficiently integrate external components into the process, generic robot teaching interfaces can be utilized. This paper proposes a new wearable, open-source, robot teaching interface and focuses on evaluating and comparing it with other affordable generic robot teaching interfaces in assembly task programming. Wireless input devices, including a standard keyboard, a gaming console controller, and a 6D mouse have been considered. The devices are compared in terms of perceived usability, subjective workload, and time efficiency when programming insertion tasks through a waypoint-based teaching scheme.

15:00-15:20 ThB4.4

Nonnegative Saturated Tracking Control for Cable Driven Parallel Robots (CDPRs), pp. 618-623

Jabbari, Imed — University of Lorraine
Boutayeb, Mohamed — University of Lorraine
Jammazi, Chaker — Ecole Polytechnique De Tunisie

In this note, we propose a bounded time-varying nonnegative global tracking control law for the cable driven parallel robots (CDPR) in 3D. The goal of this control law is that the robot end-effector tracks a reference trajectory with exponential convergence. Thanks to judicious transformations of the control variables and to a particular time varying Lyapunov function we propose positive and bounded control laws guaranteeing an exponential convergence. The numerical simulations carried out show the high potential of this approach.

15:20-15:40 ThB4.5

Handling Vision Noise through Robot Motion Control in a Real-Time Teleoperation System, pp. 624-629

Tsitos, Athanasios Christoforos — National Center of Scientific Research Demokritos
Dagioglou, Maria — National Center of Scientific Research Demokritos

Teleoperation allows robots to perform complex actions in tasks and environments where robot cognition and motion capabilities cannot support autonomy or where cooperation with humans is necessary. In this work, we present a teleoperation system for controlling the motion of a non-anthropomorphic robot arm through a natural user interface that tracks human movements through a single RGB-D visual sensor. A proportional-derivative (PD) controller is formulated to regulate robot end-effector commanded accelerations and to deal with the noisy and low-frequency human information. The system is integrated in the robot operating system (ROS) and a Universal Robots UR3 cobot is used for the evaluation. The results show that the PD controller achieves a superior performance in terms of both tracking accuracy and robot motion smoothness compared to using a proportional controller which regulates the commanded velocities. Furthermore, the same gains of the PD controller can be used to handle a wider range of human speeds. Finally, we provide real-time demonstrations of the system and the ROS pipeline.

ThC1 Platon Hall

Multi-Agent Systems (Regular Session)

Chair: Siami, Milad — Northeastern University
Co-Chair: Pasumarthy, Ramkrishna — Indian Institute of Technology Madras

16:30-16:50 ThC1.1

Multi-Agent Exploration with Reinforcement Learning, pp. 630-635

Sygkounas, Alkis — University of Patras
Tsipianitis, Dimitrios — University of Patras
Nikolakopoulos, George — Luleå University of Technology
Bechlioulis, Charalampos — University of Patras

Modern robots are used in many exploration, search and rescue applications nowadays. They are essentially coordinated by human operators and collaborate with inspection or rescue teams. Over time, robots (agents) have become more sophisticated with more autonomy, operating in complex environments. Therefore, the purpose of this paper is to present an approach for autonomous multi-agent coordination for exploring and covering unknown environments. The method we suggest combines reinforcement learning with multiple neural networks (Deep Learning) to plan the path for each agent separately and achieve collaborative behaviour amongst them. Specifically, we have applied two recent techniques, namely the target neural network and the prioritized experience replay, which have been proven to stabilize and accelerate the training process. Agents should also avoid obstacles (walls, objects, etc.) throughout the exploration without prior information/knowledge about the environment; thus we use only local information available at any time instant

to make the decision of each agent. Furthermore, two neural networks are used for generating actions, accompanied by an extra neural network with a switching logic that chooses one of them. The exploration of the unknown environment is conducted in a two-dimensional model (2D) using multiple agents for various maps, ranging from small to large size. Finally, the efficiency of the exploration is investigated for a different number of agents and various types of neural networks.

16:50-17:10 ThC1.2

Time-Delayed Data Transmission in Heterogeneous Multi-Agent Deep Reinforcement Learning System, pp. 636-642

Elhami Fard, Neshat — Concordia University
Selmic, Rastko — Concordia University

This paper studies the data transmission between agents of a multi-agent, deep reinforcement learning (MADRL) system (leaderless and leader-follower) using the deep Q-network (DQN) algorithm. The structure of the MADRL system consists of various clusters of agents. The agents in a cluster have the same architectures. The DQN architecture is used to present the first cluster's agents structure. The other clusters, including various architectures, are considered as the environment of the first cluster's deep reinforcement learning (DRL) agent. The goal of each static agent is to transfer data with the maximum average reward. We consider two novel observations in data transmission termed on-time and time-delay. The two proposed observations are considered when the data transmission channel is idle, and the data is transmitted on-time or time-delayed. Moreover, by considering the distance between the neighbouring agents, we present a novel immediate reward function by appending a distance-based reward to the previously utilized reward. We have rigorously shown which system (on-time or time-delayed) has a superior performance based on the DQN loss and team reward for the entire team of agents. The claims have been proven theoretically, and the simulation confirms theoretical findings.

17:10-17:30 ThC1.3

Role of Agent Update Cycle in Stability and Robustness of Second-Order Consensus Networks, pp. 643-648

Huang, Yu-Mei — Northeastern University
Siami, Milad — Northeastern University

We consider the problems of asymptotic stability and robustness in large-scale second-order consensus networks and vehicle platoons in the discrete-time domain. First, we develop a graph-theoretic methodology to design the state feedback law for the second-order consensus networks and vehicle platoons in a discrete-time framework. We analyse the stability of such networks based on algebraic properties of the Laplacian matrices of underlying graphs and each vehicle's update cycle (also known as the time step). We further provide a necessary and sufficient condition of stability of a linear second-order consensus network in the discrete-time domain. Moreover, we evaluate the robustness of the consensus networks by employing the expected value of the steady-state dispersion of the state of the entire network, also known as squared H_2-norm, as a performance measure. We show the connection between performance measures with respect to network size, connectivity, and the update cycle. The main contribution of this work is that we provide a formal framework to quantify the relation between scaling performance measures and restrictions of the vehicles' update cycles. Specifically, we show that denser networks (i.e., networks with more communications/edges) require faster agents (i.e., smaller update cycles) to outperform or achieve the same level of robustness as sparse networks (i.e., networks with fewer communications/edges).

17:30-17:50 ThC1.4

Metropolis II: Investigating the Future Shape of Air Traffic Control in Highly Dense Urban Airspace, pp. 649-655

Patrinopoulou, Niki — University of Patras
Daramouskas, Ioannis — University of Patras
Lappas, Vaios — University of Patras
Kostopoulos, Vassilis — University of Patras
Morfin Veytia, Andres — Delft University of Technology
Badea, Calin Andrei — Delft University of Technology
Ellerbroek, Joost — Delft University of Technology
Hoekstra, Jacco — TU Delft
de Vries, Vincent — NLR - Royal Netherlands Aerospace Centre
van Ham, Jacomijn — NLR - Royal Netherlands Aerospace Centre
Sunil, Emmanuel — NLR - Royal Netherlands Aerospace Centre
Menéndez-Ponte Alonso, Pablo — NTT DATA Spain
Pedrero Gonzalez, Juan — NTT DATA Spain
Bereziat, Denis — ENAC Université De Toulouse
Vidosavljevic, Andrija — ENAC Université De Toulouse
Sedov, Leonid — Linkoping University

Metropolis II aims to provide insights in what is needed to enable high-density urban air operations. It does this by investigating the foundation for U-space U3/U4 services. The final goal is to provide a unified approach for strategic deconfliction, tactical deconfliction, and dynamic capacity management. Highly dense operations in constrained urban airspace will likely require a degree of complexity that does not exist in modern-day air traffic management. The expected high traffic demand will require a shared use of the airspace instead of assigning exclusive use of blocks of the airspace to some flights. A unified approach for traffic management is needed because at high-densities, airspace design, flight planning, and separation management become increasingly interdependent. Metropolis II builds upon the results of the first Metropolis project. Three concepts with a varying degree of centralisation will be compared using simulations. (1) The centralised concept will take a global approach for separation management. (2) The decentralised concept aims to give the individual agents separation responsibility. (3) The hybrid concept tries to combine a centralised strategic planning agent with a robust tactical separation strategy.

17:50-18:10 ThC1.5

Distributed Least-Squares Over Directed Networks, pp. 656-661

Jahvani, Mohammad — Queen's University
Guay, Martin — Queen's University

This paper proposes a distributed dynamics that solves the least-squares problem associated with a network system of linear algebraic equations. We consider static directed multi-agent networks. Each agent in the network has access to a private subset of the linear equations. Furthermore, we assume that agents cannot acquire any information about their "out- degrees" at any time. Under the strong connectivity condition on the underlying communication network, we show that the local estimated solution of each agent converges exponentially to the exact least-squares solution of the associated network system of linear algebraic equations.

ThC2 — Athina A

Multimodal Sensing for Localization, Planning and Scene Understanding (Invited Session)

Chair: Lalos, Aris — Athena Research Center
Co-Chair: Mukherjee, Moumita — Luleå University of Technology
Organizer: Lalos, Aris — Athena Research Center
Organizer: Stylios, Chrysostomos — University of Ioannina
Organizer: Nguyen, Duong-Van — Panasonic Automotive Systems Europe
Organizer: Petros Kapsalas, Petros — Panasonic Automotive Systems Europe
Organizer: Moustakas, Konstantinos — University of Patras

16:30-16:50 — ThC2.1

A Resilient to Faults Auto-Encoder Enabled Kalman Based Multi-Sensorial Fusion (I), pp. 662-669

Mukherjee, Moumita — Luleå University of Technology
Banerjee, Avijit — Luleå University of Technology
Nikolakopoulos, George — Luleå University of Technology

This article presents a novel Auto-encoder-enabled fault resilient multi-sensor fusion architecture while incorporating an extended Kalman filter framework. The auto-encoder facilitate reconstruction of the faulty measurements from multiple onboard sensors, while the centralized extended Kalman filter enables an accurate fusion architecture. Moreover, the process is capable of successfully eliminating the additive noise appearing from the raw sensor data. The proposed method provides a robust reconstruction mechanism in the presence of time-dependent anomalies and faulty sensor measurement. The efficacy of the proposed scheme is extensively evaluated in the context of pose estimation for a micro aerial vehicle equipped with multiple onboard sensors. In addition, the evaluation process incorporates various realistic failure scenarios with artificially introduced inaccurate measurements. The superiority of the proposed Auto-encoder enabled centralized Kalman filter (AEKF) fusion is demonstrated through an extensive comparison with a recently developed Fault Resilient Optimal Information Filter (FROIF) method.

16:50-17:10 — ThC2.2

Alternating Optimization for Multimodal Collaborating Odometry Estimation in CAVs (I), pp. 670-675

Piperigkos, Nikos — University of Patras
Lalos, Aris — Athena Research Center
Berberidis, Konstantinos — University of Patras

Cooperative, Connected and Automated Mobility will enable the close coordination of actions between vehicles, road users and traffic infrastructures, resulting in profound socioeconomic impacts. In this context, location and yaw angle of vehicles is considered vital for safe, secured, and efficient driving. Motivated by this fact, we formulated a multimodal sensor fusion problem which provides more accurate localization and yaw information than the original sources. Simultaneously estimating location and yaw parameters of vehicles can be treated as the task of cooperative odometry or awareness. To do so, V2V communication as well as multimodal self and intervehicular measurements from various sensors are considered for the problem formulation. The solution strategy is based on the maximum likelihood criterion as well as a novel alternating gradient descent approach. To simulate realistic traffic conditions, CARLA autonomous driving simulator has been used. The detailed evaluation study has shown that each vehicle, relying only on its neighbourhood, is able to accurately re-estimate both its own and neighbouring states (comprised of locations and yaws), effectively realising the vision of 360◦ awareness.

17:10-17:30 — ThC2.3

Implementation and Motion Control of a Microrobot Using Laser Sensors, pp. 676-681

Karaiskos, Konstantinos — National Technical University of Athens
Lampousis, Charalampos — National Technical University of Athens
Vlachos, Kostas — University of Ioannina
Papadopoulos, Evangelos — National Technical University of Athens

In this paper an improved implementation of a microrobotic platform, including position feedback provided by two laser sensors, and the development of a rule-based closed-loop motion controller are presented. The microrobot employs a novel driving principle, using centrifugal forces generated by two vibration motors that give the platform the ability to make motions with micrometre resolution. In this implementation, a pair of laser sensors are integrated at the bottom of the platform and calibrated through a custom procedure. The high-rate output of the laser sensors is fed to an algorithm that provides the position and orientation of the microrobot required for closed-loop motion control. Compared to using an overhead camera, this implementation, results in up to five times higher closed-loop control bandwidth, improved autonomy, and modularity. Experimental closed-loop results demonstrate the ability of the motion controller in driving the microrobot to a desired target under a microscope.

17:30-17:50 ThC2.4

Control Barrier Navigation Functions for STL Motion Planning, pp. 682-687

Zehfroosh, Ashkan — University of Delaware
Tanner, Herbert G. — University of Delaware

This paper describes an approach to constructing control barrier functions that realize planning and control objectives that are expressed in a fragment of signal temporal logic. The particular construction is based on the navigation function method for robot motion planning and is attractive because it offers a straightforward way to design the robot control law that implements the signal temporal logic specification. The efficacy of the reported method is illustrated through simulation examples.

17:50-18:10 ThC2.5

Vanishing Point Detection Based on the Fusion of Lidar and Image Data (I), pp. 688-692

Kloukiniotis, Andreas — University of Patras
Moustakas, Konstantinos — University of Patras

Despite the great progress that has been done in vanishing point-based methods for road detection using visual information the results are still vulnerable to external light conditions. For that reason, the fusion of LIDAR data, alongside images can be used for a more reliable result. LIDAR data may lack illumination information but are less susceptible to light conditions. The main contribution of this paper is the use of LIDAR data to create a mask that will restrict the area of the image that could eventually be the road. More specifically, we are using LIDAR data to detect the points of the ground. By contracting an Octree, we find the best-fitting plane of each leaf and by performing clustering we estimate the ground. Next, we are mapping the points of the road to the image to create a mask for the image processing step. We extract the texture orientation using Gabor Filter and thereinafter the vanishing point. The proposed approach has been implemented and tested with over 1000 images of different road scenes in the KITTI dataset. The experimental results demonstrate that this training-free approach can detect horizon and vanishing point very accurately and robustly, while achieving promising performance.

ThC3 — Athina B

Marine Control and Identification (Regular Session)

Chair: Schubert, Agnes Ulrike — University of Rostock
Co-Chair: Wirtensohn, Stefan — University of Applied Sciences Konstanz

16:30-16:50 ThC3.1

Trajectory Tracking of a Fully-Actuated Surface Vessel Using Nonlinear Model Predictive Control: Experimental Results, pp. 693-698

Kinjo, Leticia Mayumi — ENSICAEN
Wirtensohn, Stefan — University of Applied Sciences Konstanz
Reuter, Johannes — University of Applied Sciences Konstanz
Ménard, Tomas — ENSICAEN
Gehan, Olivier — ENSICAEN

The trajectory tracking problem for a real-scaled fully actuated surface vessel is addressed in this paper. A nonlinear model predictive control (NMPC) scheme was designed to track a reference trajectory, considering state and input constraints, and environmental disturbances, which were assumed to be constant over the prediction horizon. The controller was tested by performing docking manoeuvres using the real-scaled research vessel from the University of Applied Sciences Konstanz at the Rhine river in Germany. A comparison between the experimental results and the simulated ones was analyzed to validate the NMPC controller.

16:50-17:10 ThC3.2

Model Predictive Control of Vessels with Azimuth Drives in Maneuvering Situations, pp. 699-704

Marx, Johannes Richard — University of Rostock
Kurowski, Martin — University of Rostock
Jeinsch, Torsten — University of Rostock

Due to the worldwide increase in shipping traffic, the effort put in automation of ship motion control is also increasing. Despite great success in this area during the last decades, the maneuvering of ships with azimuth drives continues to be one of the most challenging tasks in ship motion control. To tackle this challenge, this paper presents a MPC (Model Predictive Control) based concept for controlling body-fixed velocities. To do so, a mathematical model is designed to describe the dynamics of a ship in a standardized form. Thereafter, a model predictive controller to control body-fixed velocities is developed. To deal with non-linearities resulting from the physical properties of the ships and their actuators, especially the azimuth drives, two configurations containing different restrictions are proposed. Thus, linear MPC techniques can be applied and input constraints are explicitly taken into account. Subsequently the controller is validated with simulations of different scenarios leaned on real maneuvers. The results obtained from the simulations show, that the designed concept leads to a functioning MPC approach for controlling body-fixed velocities. They also indicate that there are still some changes that have to be applied and research that has to be done before going about a real-life implementation.

17:10-17:30 ThC3.3

Trajectory Tracking and Fault Detection of Underactuated USVs Based on Nonlinear Model Predictive Control and Moving Horizon Estimation, pp. 705-712

Rossides, George — Cyprus Marine and Maritime Institute
Constantinou, Christos — Cyprus Marine and Maritime Institute

This paper brings together the concepts of Nonlinear Model Predictive Control (NMPC) and Moving Horizon Estimation (MHE) for the adaptive control of an underactuated Unmanned Surface Vehicle (USV) equipped with two azimuth thrusters for trajectory tracking applications. The proposed methodology achieves fault detection based on the estimation of thrusters' efficiencies allowing the completion of the mission in the case of single thruster failure. Simulation studies that are based on a real USV "Kerkouros" are presented to verify the effectiveness of the proposed methodology.

17:30-17:50 ThC3.4

Adaptive Algorithm for Vessel Roll Prediction Based on the Bayesian Approach, pp. 713-718

Litvinenko, Yulia — ITMO University
Stepanov, Oleg A. — ITMO University
Zaitsev, Oleg — ITMO University
Antonov, Danila — ITMO University

The problem of vessel roll prediction is considered in this paper within the framework of the Bayesian approach; the proposed adaptive algorithm for its solution is described. The obtained algorithm is compared with the one based on neural networks. The advantages of the proposed algorithm are discussed.

17:50-18:10 ThC3.5

Adaptation of Parameter Space Model for Automatic Maneuvering with Research Vessel DENEB, pp. 719-724

Schubert, Agnes Ulrike — University of Rostock
Damerius, Robert — University of Rostock
Rethfeldt, Carsten — University of Rostock
Kurowski, Martin — University of Rostock
Jeinsch, Torsten — University of Rostock

This paper focuses on the development of a parameter space model, which is applied for automatic berthing maneuvers of the German research vessel DENEB in Rostock Port. The holistic modeling approach for the entire operating range of a watercraft is characterized by a first-order structure with nonlinear parameters represented in look-up tables. The model on force level is divided in static and dynamic module, where the structure of the static part depends on the vessel specific actuator configuration. Simulation results of a highly complex hydrodynamic motion model from a ship handling simulator are used as the data basis since such models are not directly suitable for controller design. Derived from the parameter space model, allocation and feed-forward systems are designed. Successful automatic berthing maneuvers in the port show the suitability of the model approach especially for robust maneuvering automation of vessels at low velocities.

ThC4 Poseidon AB

Robotics III (Regular Session)

Chair: Ruggiero, Fabio — Università Degli Studi di Napoli Federico II
Co-Chair: El Bou, Cheikh Melainine — Free University of Bolzano

16:30-16:50 ThC4.1

A Homogeneity-Based Path Following Shared Control System for UGVs, pp. 725-730

El Bou, Cheikh Melainine — Free University of Bolzano

Human-robot shared control is used to permit an unmanned ground vehicle (UGV) to semi-automatically follow a path at a constant forward speed. The control inputs from the human and from an automatic controller are blended using a mixed initiative blending law. A passive measure of human intent governs the blending law, permitting a rapid and smooth transition between human- and robot-control. The robot's automatic controller is formulated using a kinematic model of the UGV, which is based on Ackermann steering. The resulting automatic control law is mathematically homogeneous. The homogeneity is used to dynamically rescale the automatic control input so that it always respects the magnitude constraints of the steering actuator. The stability of the closed-loop human-robot shared control system is proved. Illustrative simulations of the proposed control law, in which a human operator imposes steering commands on the UGV through a joystick, are presented.

16:50-17:10 ThC4.2

*SLAM and Map Learning Using Hybrid Semantic Graph Optimization**, pp. 731-736

Agrawal, Ambuj — Indian Institute of Information Technology Allahabad
Agarwal, Dhruv — Indian Institute of Information Technology Allahabad
Arora, Mehul — Indian Institute of Information Technology Allahabad
Mahajan, Ritik — Indian Institute of Information Technology Allahabad
Beohar, Shivansh — Indian Institute of Information Technology Allahabad
Kenye, Lhilo — Indian Institute of Information Technology Allahabad
Kala, Rahul — Indian Institute of Information Technology Allahabad

Visual Simultaneous Localization and Mapping using budget-grade cameras only faces the challenges of continuous drifts that accumulate with time. While loop closure techniques mitigate the effects, they are applicable only when the robot completes a loop, which is a rarity in everyday navigation. The motion blur and smaller resolution of budget cameras further reduce the accuracy of SLAM. In this paper, we aim to solve the problem of active drift correction for a low-cost robot to solve autonomous navigation using the semantic map. Semantic maps have been used previously for re-localization but are useful only when the semantic maps themselves are highly

accurate which is not realizable for budget robots. The semantic maps also face problems of correspondence matching in areas rich with recurrent semantics. To alleviate the same effects, the robot performs SLAM using a hybrid graph optimization consisting of semantic points whose pose is obtained from the semantic map database, and the non-semantic point features. The semantic map corrects for the drift, while the non-semantic features apply local smoothing that helps in mitigating the errors of the semantic map. They also apply robustness against errors in correspondence matching. The semantic graph may itself have errors, which are hence learned with time as the robot navigates. The robot adds new semantic objects into the database if it observes them, while the robot also mends the position based on the new observations. The initial semantic map is made using images captured by a camera on a few known poses, based on which it adds the observed semantics.

17:10-17:30 ThC4.3

Motion Planning for Mobile Robots Using the Collidable Velocity Obstacles Method, pp. 737-742

Gyenes, Zoltan Balint — Budapest University of Technology and Economics
Gincsaine Szadeczky-Kardoss, Emese — Budapest University of Technology and Economics

The collision-free motion planning for mobile robots is a challenging task in dynamic environment. There are situations when the robot has no chance to select a velocity vector that would cause no collision in the next steps of the motion. Most of the motion planning algorithms for mobile robots cannot generate an appropriate solution for that problem. At the autonomous systems, the only acceptable solution in this situation is emergency braking which could cause huge damage between the robot and the obstacle. The main focus of this paper is to introduce a novel motion planning method for mobile robots that could generate a velocity vector for the robot that would cause the least damage between the robot and the environment. It can be assumed that the obstacles in the environment are passive, and low damage collisions would be attempted only when avoidance is not possible at the sampling time. If the robot has an opportunity to select a velocity vector from the Reachable Avoidance Velocities set, then a cost-function-based algorithm can be used considering different aspects.

17:30-17:50 ThC4.4

Disturbance Rejection for Legged Robots through a Hybrid Observer, pp. 743-748

Morlando, Viviana — Università Degli Studi di Napoli Federico II
Ruggiero, Fabio — Università Degli Studi di Napoli Federico II

A legged robot needs to move in unstructured environments continuously subject to disturbances. Existing disturbance observers are not enough when significant forces act on both the centre of mass and the robot's legs, and they usually employ indirect measures of the floating base's velocity. This paper presents a solution combining a momentum-based observer for the angular term and an acceleration-based observer for the translational one, employing directly measurable values from the sensors. Due to this combination, we define this observer as "hybrid," and it can detect disturbances acting on both the legged robot's centre of mass and its legs. The estimation is employed in a whole-body controller. The framework is tested in simulation on a quadruped robot subject to significant disturbances, and it is compared with existing observer-based techniques.

17:50-18:10 ThC4.5

Experimental Analysis of Slip Ratio Using the Wheel Walking Locomotion Mode in Reconfigurable Rovers, pp. 749-754

Dominguez-Durante, Salvador — University of Malaga
Perez-del-Pulgar, Carlos — University of Malaga
Paz-delgado, Gonzalo — University of Malaga
Azkarate, Martin — European Space Agency

Planetary exploration has been affected by the ability of rovers to avoid getting trapped on sandy terrains. Currently, the European Space Agency in collaboration with the Russian Federal Space Agency are preparing the ExoMars mission, with the objective of placing a rover on the Martian surface to seek for signs of life. This rover is capable of a novel locomotion mode, commonly called wheel walking. It consists of moving the wheel forward and backward in order to improve traction and escape from terrains with a high slip ratio. The main drawback of this locomotion mode is related to the efficiency in power consumption. Therefore, it should be used only in extreme conditions. The objective of this paper is twofold. First, the definition of an experimental setup, based on a rover prototype, an experimental flat terrain and a mechanism to induce a given slip to the rover. Second, the use of this experimental scenario to validate a method, previously proposed by authors, to estimate the rover slip during the wheel walking locomotion mode.

Technical Program for Friday July 1, 2022

FrA1 Platon Hall

Fault Diagnosis (Regular Session)

Chair: Monteriù, Andrea — Università Politecnica Delle Marche
Co-Chair: Somarakis, Christoforos — Palo Alto Research Center

10:30-10:50 FrA1.1

Specific Data Sampling and Filtering Helps to Detect and Isolate Periodic Disturbances, pp. 755-760

Ettler, Pavel — Compureg Plzeň S.r.o
Puchr, Ivan — Compureg Plzeň S.r.o

The Fast Fourier Transform is the unique tool enabling to engage the frequency domain analysis in detection and isolation of periodic disturbances in industrial processes containing rotating elements. Nevertheless, there exist specific problems where the time-domain examination of oscillations can provide equally or more accurate results with less effort. Specific data sampling, filtering and process modelling are introduced in the paper with the aim to classify sources of oscillations in the process of cold rolling. Although the FFT may

not be part of the method itself, its use allows to illustrate the presented research.

10:50-11:10 FrA1.2

Learning-Based Diagnostics for Fault Detection and Isolation in Linear Stochastic Systems, pp. 761-766

Noorani, Erfaun — University of Maryland College Park
Somarakis, Christoforos — Palo Alto Research Center
Goyal, Raman — Palo Alto Research Center
Feldman, Alexander — Palo Alto Research Center
Rane, Shantanu — Palo Alto Research Center

AI-enabled mechanisms are deployed to guard controlled systems against sensor anomalies. We explore a two-level architecture design in which a low-level feedback controller of a linear system uses measurements from one or more potentially unreliable sensors. These observations are prone to sensor noise but unknown additive faults. Our proposed, high-level, guard mechanism consists of a Reinforcement Learning (RL) agent that monitors available vitals of the system. In the event of a fault on the sensor components, the RL agent automatically detects, estimates the fault, localizes and takes action to cancel the fault. In addition, we develop design methodologies for efficient training of the RL agent that take advantage of system dynamics and sensor fusion schemes. We show that the associated training cost functions can be designed so that their optimal policy achieves efficient of arbitrary constant or piece-wise constant sensor faults. To illustrate our theoretical results, we consider a linearized version of a chemical process with multiple sensors, controlled by a Linear Quadratic Gaussian (LQG) Servo-Controller with Integral Action. Our simulations show that the RL-agent is successful in localizing the faulty sensors and mitigating the effects of faults in an online fashion.

11:10-11:30 FrA1.3

Actuator Fault Diagnosis of Nonlinear Systems Based on Unknown Input Root-Mean-Square Cubature Kalman Filter, pp. 767-772

Qian, Huaming — Harbin Engineering University
Yan, Shuya — Harbin Engineering University
Ding, Peng — Harbin Engineering University
Chu, Shuai — Harbin Engineering University

This paper proposes an unknown input root mean square cubature Kalman filter algorithm, which is applied to the fault diagnosis of nonlinear systems with unknown input. Firstly, a standard linear regression equation with unknown input is constructed, and orthogonal trigonometric decomposition is combined to solve the equation to improve the estimation accuracy of unknown input. In addition, to improve the numerical stability of algorithm, the root mean square algorithm is introduced into the error covariance matrix calculated from the unknown input estimation and state estimation results. Secondly, the root mean square value of the sliding window of residual obtained from the difference between the measured value and the estimated value is computed to judge whether the actuator has a fault. The generalized regression neural network is used for fault identification. Finally, a single link manipulator system is taken for simulation verification.

11:30-11:50 FrA1.4

Robust Fault Detection Based on Zonotopic Observers for Linear Parameter Varying Systems, pp. 773-778

Lamouchi, Rihab — National Engineering School of Gabes
Amairi, Messaoud — National Engineering School of Gabes
Raïssi, Tarek — Conservatoire National Des Arts Et Métiers
Aoun, Mohamed — National Engineering School of Gabes

In this paper, zonotopic fault detection methodology is proposed for a class of discrete-time Linear Parameter Varying (LPV) systems with sensor faults. The disturbances and measurement noise are assumed to be unknown but bounded by zonotope. First, a fault detection observer is designed based on L ∞ performance to attenuate the effects of the uncertainties and to improve the accuracy of the proposed residual framers. Then, the fault sensitivity is considered by measuring H − performance and zonotopic residual evaluation is presented. Finally, the effectiveness of the proposed method is demonstrated by a numerical example

11:50-12:10 FrA1.5

A Comparison of Feature Extraction Methods for Crack and Ice Monitoring in Wind Turbine Blades: System Identification and Matrix Decomposition, pp. 779-784

Calderano, Pedro — Pontifical Catholic University of Rio De Janeiro
Marins, Daniel — Pontifical Catholic University of Rio De Janeiro
Hultmann Ayala, Helon Vicente — Pontifical Catholic University of Rio De Janeiro

The global trend of increasing the relevance of renewable energy in the power grid is likely to remain in the following years. As wind power is a relevant renewable energy source, wind capacity generation has increased considerably. Consequently, the costs of maintenance of wind turbines increase as well. Therefore, the development of Structural Health Monitoring (SHM) systems is important since they can detect defects as early as possible, reduce the wind turbine's downtime, and maintain the efficiency of the generation sites, which reduces losses. In this work, we use a public wind turbine blades benchmarking dataset to build a model that predicts and classifies fault scenarios. The dataset presents cases considering various fault events under different climate conditions. First, it is analyzed which of the sensors best captures the dynamics difference when there is a fail presence on the wind turbine blade. Then, we extract features from the sensor signal through Principal Component Analysis (PCA) and system identification, an Auto-Regressive Moving-Average (ARMAX) model. After, the addition of a fault classification module that uses Machine Learning classification algorithms completes the development of the SHM systems.

FrA2 Athina A

Networked Systems (Regular Session)

Chair: Konstantopoulos, George — University of Patras

Co-Chair: Zorzi, Mattia — Universita Degli Studi di Padova

10:30-10:50 FrA2.1

Distributed Kalman Filtering with Event-Triggered Communication: A Robust Approach, pp. 785-790

Ghion, Davide — Serenissima Informatica Spa

Zorzi, Mattia — Università Degli Studi Di Padova

We consider the problem of distributed Kalman filtering for sensor networks in the case there is a limit in data transmission and there is model uncertainty. More precisely, we propose a distributed filtering strategy with event-triggered communication in which the state estimators are computed according to the least favourable model. The latter belongs to a ball (in Kullback-Leibler topology) about the nominal model. We also present a preliminary numerical example in order to test the performance of the proposed strategy.

10:50-11:10 FrA2.2

Centrality Measure Based on the Laplacian Matrix Spectral Radius Eigenvector Application to the Identification of a Leader, pp. 791-796

Bateman, Francois — Ecole De l'Air Et De L'Espace

Niel, Fabien — Centre De Recherche De l'Ecole De L'air

Centrality measures evaluate the importance of vertices in a graph. In a multi-agent framework i.e. robots swarm, computing these indicators may be useful in identifying a leader. As a first step, the paper deals with a centrality measure based on the analysis of the eigenvector associated with the largest eigenvalue of the Laplacian matrix. For the studied class of graphs, this centrality measure highlights the most connected vertex which is also associated with the largest binding energy. The results are established for complement of trees. For these highly connected graphs, the most popular centrality measures make hard to distinguish an important vertex. On the contrary, the proposed indicator distinctly highlights this vertex. As a second step, for a network of autonomous agents, the leader identification problem based on this centrality measure is solved in a decentralized way. All the agents cooperate to appoint their leader. The calculations are conducted in the frequency domain and are based on maximum-consensus functions

11:10-11:30 FrA2.3

Distributed Bounded Integral Control for Multimachine Power Systems, pp. 797-802

Perantonis, Ioannis — University of Patras

Alexakis, Zaint — University of Patras

Konstantopoulos, George — University of Patras

Alexandridis, Antonio — University of Patras

In this paper, the problem of frequency control in multimachine power networks is investigated in a distributed manner. Taking as an example a cyber-physical architecture of the IEEE 68 bus, 16 machine power system, a new distributed bounded integral control (DiBIC) scheme is proposed to achieve frequency restoration to the rated value and power sharing among the 16 generators with only neighbour-to-neighbour communication, while maintaining the mechanical torque of each generator within predefined limits. The boundedness of the mechanical torque inputs is analytically proven independently of the distributed control tasks and without the need for saturation mechanisms that might lead the power system to instability. To verify the proposed DiBIC performance, the IEEE 68 bus network is simulated under a change of the load demand and tested under both the proposed and the conventional distributed integral control with saturation.

11:30-11:50 FrA2.4

A Generalized Distributed Analysis and Control Synthesis Approach for Networked Systems with Arbitrary Interconnections, pp. 803-808

Welikala, Shirantha — University of Notre Dame

Lin, Hai — University of Notre Dame

Antsaklis, Panos J. — University of Notre Dame

We consider the problem of distributed analysis and control synthesis to verify and ensure properties like stability and dissipativity of a large-scale networked system comprised of linear subsystems interconnected in an arbitrary topology. We design systematic networked system analysis and control synthesis processes that can be executed in a distributed manner at the subsystem level with minimal information sharing among the subsystems. Compared to recent work in the literature, we consider a substantially more generalized problem setup and develop distributed processes to verify and ensure a broader range of properties. We show that optimizing subsystems' indexing scheme used in such distributed processes can substantially reduce the required information-sharing sessions between subsystems. We also show that sharing information among the neighbouring subsystems is sufficient for the proposed distributed processes in some network topologies. Moreover, the proposed distributed processes are compositional and thus allow them to handle situations where new subsystems are being added conveniently and efficiently to an existing network. We also provide significant insights into our approach so that it can be quickly adopted to verify and ensure properties beyond the stability and dissipativity of networked systems. Finally, we provide a numerical example to demonstrate the proposed distributed processes and highlight our contributions.

11:50-12:10 FrA2.5

Finite and Fixed Time Semistability and Consensus for Nonlinear Discrete-Time Network Systems, pp. 809-814

Lee, Junsoo — Georgia Institute of Technology

Haddad, Wassim M. — Georgia Institute of Technology

This paper focuses on finite time and fixed time consensus protocols for discrete-time networks. Specifically, we build on the theory of finite time semistability for discrete-time dynamical systems to develop Lyapunov theorems for fixed time semistability. These results are then used to develop a framework for designing finite and fixed time semistable consensus protocols for discrete dynamical networks that achieve multiagent coordination tasks in finite and fixed time.

FrA3	Athina B
Cyber-Physical Systems (Regular Session)	
Chair: Giuseppi, Alessandro	Sapienza Università Di Roma
Co-Chair: Oliva, Gabriele	Università Campus Bio-Medico Di Roma

10:30-10:50 FrA3.1

Distributed and Asynchronous Secure State Reconstruction for Cyber-Physical Systems, pp. 815-820

Fioravanti, Camilla — Università Campus Bio-Medico di Roma
Oliva, Gabriele — Università Campus Bio-Medico di Roma
Panzieri, Stefano — Università Degli Studi Roma Tre

The greater availability and accessibility of IoT sensors, data acquisition systems and computer networks, led to the development of distributed control strategies aimed at monitoring and securing of Cyber-Physical Systems (CPS). In this paper, we propose a distributed asynchronous algorithm for the Secure State Reconstruction (SSR) which relies on a gossip-based procedure to let a network of agents reach a shared estimate of the process state based on measurements taken by the different agents at different time instants. In particular, the procedure aims to reduce measurement noise and provide resilience in the event of cyber-attacks that modify the readings of agents or cause their disconnection, combined with the possibility of providing new virtual measurements in real-time. In addition, the gossip-based pair connection is randomly established and subsequently destroyed, making it difficult for an attacker to intercept the information exchange. In detail, we first analytically demonstrate the convergence and correctness of the proposed algorithm, and then we provide a simulation campaign to demonstrate its effectiveness.

10:50-11:10 FrA3.2

Optimal Energy Storage System Placement for Robust Stabilization of Power Systems against Dynamic Load Altering Attacks, pp. 821-828

Germanà, Roberto — Sapienza Università di Roma
Giuseppi, Alessandro — Sapienza Università di Roma
Pietrabissa, Antonio — Consortium for the Research in Automation and Telecommunication
Di Giorgio, Alessandro — Sapienza Università di Roma

This paper presents a study on the "Dynamic Load Altering Attacks" (D-LAAs), their effects on the dynamics of a transmission network, and provides a robust control protection scheme, based on polytopic uncertainties, invariance theory, Lyapunov arguments and graph theory. The proposed algorithm provides as a result an optimal Energy Storage Systems (ESSs) placement, that minimizes the number of ESSs placed in the network, together with the associated control law that can robustly stabilize against D-LAAs. The paper provides a contextualization of the problem and a power network subject to D-LAAs modelling approach suitable for the designed robust control protection scheme. The robust control protection scheme criteria is identified with the technological application. The paper proposes a reference scenario for the study of the dynamics of the control actions and their effects in different cases, and different numerical simulations for the validation of the approach on large networks.

11:10-11:30 FrA3.3

A Digital Twin Infrastructure for Designing an Underwater Survey with a Professional DPV, pp. 829-834

Bartolucci, Veronica — Università Politecnica Delle Marche
Ciuccoli, Nicolò — Università Politecnica Delle Marche
Prendi, Fatjon — Università Politecnica Delle Marche
Screpanti, Laura — Università Politecnica Delle Marche
Scaradozzi, David — Università Politecnica Delle Marche

This paper presents a digital twin infrastructure developed to study and test the buoyancy set-up of a diver propulsion vehicle (DPV) with and without payloads prior to the underwater survey. In order to obtain the final software simulator, MATLAB/Simulink (for physical and mathematical models) was connected with Unity (for robot and environment visualization and navigation). A user interface is also presented to simulate the model directly and guide the user in adding objects to the DPV and in running the code to recalculate the fundamental parameters of the model. This work originated from the DiveSafe European project (G.A. EASME/EMFF/2017/ 1.2.1.12/SI/02/ SI2.789635) and the need to study the proper buoyancy for the equipped systems involved. The system was verified and validated through case studies designed to test the behaviour of the virtual DPV.

11:30-11:50 FrA3.4

Control and Measurement of Nonlinear Dynamic Systems Over AWGN Channel with Application in Tele-Operation of Autonomous Vehicles, pp. 835-840

Dolatkhah Takloo, Somayeh — K. N. Toosi University of Technology
Farhadi, Alireza — Sharif University of Technology
Khaki Sedigh, Ali — K. N. Toosi University of Technology

This paper is concerned with state tracking as well as reference tracking of noisy nonlinear dynamic systems over Additive White

Gaussian Noise (AWGN) channel, which is sub- ject to transmission noise imperfection and transmission power constraint. To address these problems, in this paper we implement a suitable linearization method. Using this method, we linearize the nonlinear dynamic system around working points and for linearized systems, we present proper encoder and decoder for tracking the state trajectory of nonlinear dynamic systems at the end of communication link when sensor measurements are sent through the AWGN channel subject to imperfection and constraint. The satisfactory performance of the proposed state and reference tracking techniques are illustrated via computer simulations by applying these techniques on the unicycle model, which is an abstract representation for the nonlinear dynamics of autonomous vehicles.

11:50-12:10 FrA3.5

Automated Detection of Maize Leaf Diseases in Agricultural Cyber-Physical Systems, pp. 841-846

Verma, Anil — National Institute of Technology Karnataka
Bhowmik, Biswajit — National Institute of Technology Karnataka

Agricultural cyber-physical systems (ACPS) are an ever-increasing sector that affects the quality and quantity of agricultural products as the population increases rapidly. Maize, also known as 'corn,' is one of the world's old food crops, consumed every part of Bharat with 1.4 billion masses across the globe. But a disease, whether on seeds, leaves, or other parts of a crop plant, poses a significant risk to food security—for example, a Maize leaf experiences three diseases- blight, common rust, and gray leaf spot. Early detection and correct identification of these diseases can help restrict the spread of infection and ensure crop quality for long-term health. This paper proposes a deep convolutional neural network (DCNN) framework for Maize leaves named "MDCNN" that detects these diseases. The proposed MDCNN model undergoes training and is tuned to detect four prevalent classes of the conditions. The proposed model exercises a voluminous dataset of the diseases. Experimental results demonstrate that the proposed model achieves a training and test accuracy up to 95.51% and 99.54%, respectively. Furthermore, the precision, recall, and f1-score metrics achieved by the proposed approach are in the range of 89-100%, 87-100%, 92-100%, respectively. Thus, the MDCNN outperforms many existing methods and delivers a superior disease control solution for Maize leaf diseases.

FrA4 — Poseidon AB

Robotics IV (Regular Session)

Chair: Moustris, George — National Technical University of Athens
Co-Chair: Tarantos, Spyridon — Sapienza Università Di Roma

10:30-10:50 FrA4.1

Model-Based/Model Predictive Control Design for Free Floating Space Manipulator Systems, pp. 847-852

Psomiadis, Evangelos — National Technical University of Athens
Papadopoulos, Evangelos — National Technical University of Athens

The rapid increase in satellites and space debris mandates advanced capabilities for on-orbit operations. The hostile-to-human environment and the required high accuracy and robustness of on-orbit operations render Space Manipulator Systems (SMS) the appropriate choice. This work proposes an easily applicable, computationally inexpensive, nonlinear, and robust Cartesian control law for spatial Free- Floating SMS (FFSMS). The controller consists of two fundamental parts. The first is a Model-Based (MB) controller, which linearizes the system and guarantees prescribed performance. The second is a Model Predictive Controller (MPC), which integrates the model and provides optimal performance with parametric uncertainty, noise, and disturbances compensation. Input and output constraints are integrated into the latter to improve its performance. Numerical simulations for a planar model using Matlab/Simulink and MSC Adams highlight the MB/MPC's increased accuracy in comparison to a regular MB/PID controller, during a task that requires moving a captured object in the presence of parametric uncertainty, disturbances, and sensor noise. Monte-Carlo simulations substantiate the higher accuracy achieved by the MB/MPC.

10:50-11:10 FrA4.2

Real-Time Motion Generation for Mobile Manipulators Via NMPC with Balance Constraints, pp. 853-860

Tarantos, Spyridon — Sapienza Università di Roma
Oriolo, Giuseppe — Sapienza Università di Roma

We present a novel real-time motion generation approach for mobile manipulators which maintains balance even when the robot is called to execute aggressive motions. The proposed approach is based on Nonlinear Model Predictive Control (NMPC) and uses the robot full dynamics as prediction model. Robot balance is maintained by enforcing a constraint that restricts the feasible set of robot motions to those generating non-negative moments around the edges of the support polygon. This balance constraint, inherently nonlinear, is linearized using the NMPC solution of the previous iteration. In this way we facilitate the solution of the NMPC, and we achieve real-time performance without compromising robot safety. We validate our approach in scenarios of increasing difficulty and compare its performance with two other methods from the literature. The simulation results show that our method can generate motions that maintain balance in challenging situations where the other techniques fail.

11:10-11:30 FrA4.3

Modelling and Analysis of a Parallel Double Delta Mechanism for Robotic Surgery, pp. 861-866

Moustris, George — National Technical University of Athens
Tzafestas, Costas — National Technical University of Athens

In this paper we present the modelling and analysis of a novel parallel manipulator for research in laparoscopic robotic surgery. The robot's configuration is based on the parallel linking of two Delta robots. We analyse the point and velocity kinematics of the platform, and show that it can accommodate a dynamic remote centre of motion, tailored to the specific needs of each task. Finally, we analyse the platform's reachable and orientation workspaces and show that it meets the demands of various tasks in laparoscopic surgery.

11:30-11:50 FrA4.4

A Framework for Active Vision-Based Robot Planning Using Spiking Neural Networks, pp. 867-871

Oikonomou, Katerina Maria — Democritus University of Thrace
Kansizoglou, Ioannis — Democritus University of Thrace
Gasteratos, Antonios — Democritus University of Thrace

Robust and energy-efficient robot planning is of utmost importance for mobile robots since the dynamic changes of the environment entail robotic agents with high adaptation capacities, so as to excel in their tasks. In this work, we introduce a hybrid spiking and deep neural network architecture for actor-critic control of a 6-DOF robot arm. Our method firstly involves autonomous object detection via active vision exploration and thereafter, the entire hybrid architecture is described. In specific, the actor utilises an integrated-and-fire model for action generation, while the critic a deep neural one for action evaluation. Lastly, the benefits of this approach in terms of energy efficiency are extensively discussed.

11:50-12:10 FrA4.5

Towards Quasi-Static Kinematic Calibration of Serial Articulated Industrial Manipulators, pp. 872-877

Theissen, Nikolas Alexander — KTH Royal Institute of Technology
Monetti, Fabio Marco — KTH Royal Institute of Technology
Gonzalez, Monica Katherine — KTH Royal Institute of Technology
Maffei, Antonio — KTH Royal Institute of Technology

Research on kinematic calibration of industrial robots has focused on applying different measurement instruments into open- and closed-loop approaches and optimising calibration configurations through various cost functions. Such ways are either expensive or time-consuming. This work presents essential steps towards realising quasi-static kinematic calibration of industrial manipulators. This approach employs measurement data from a quasi-static measurement instead of a static one to identify the model parameters and has the potential of considerably reducing the measurement phase time during calibration. The focus lies on the technological challenges needed to achieve a successful quasi-static kinematic calibration, such as the trajectory generation, the measurement instrument and the controller data synchronisation. A case study assess the data obtained from a quasi-static kinematic measurement with a robot/tracker configuration of 100 mm/s and 100 Hz. The average positioning accuracy is similar for the static and the quasi-static measurement. The time for the quasi-static trajectory is reduced to almost one-third of the static trajectory time without considering the setup time.

FrB1 Platon Hall

Fault Tolerant Control (Regular Session)

Chair: Papadopoulos, Evangelos — National Technical University of Athens
Co-Chair: Monteriù, Andrea — Università Politecnica Delle Marche

14:00-14:20 FrB1.1

An Integrated Design of PI Interval Observer-Based FTC for LTI Systems, pp. 878-883

Nguyen, Duc To — University of Évry-Val d'Essonne - University of Paris-Saclay
Mammar, Said — University of Paris-Saclay
Ichalal, Dalil — University of Paris-Saclay
Smaili, Mohand — University of Paris-Saclay

This paper deals with an integrated design interval observer-based Fault Tolerant Control (FTC) for linear time invariant (LTI) system subject to the uncertain modeling, actuator fault and external disturbances. Under the assumption that uncertainties and disturbances are unknown but bounded with priori known bounds, a design method for obtaining Proportional Integral (PI) interval observer that provides guaranteed lower and upper bounds of the state as well as faults is considered. Based on the estimated information, FTC controller is designed to ensure robust stability of the closed-loop system. Sufficient stability conditions with H_∞ performance are expressed in terms of Linear Matrix Inequalities. An application to vehicle lateral dynamics is considered to show the effectiveness of the proposed algorithms.

14:20-14:40 FrB1.2

Economic Reliability-Aware MPC for Operational Management of Flow-Based Networks Using Bayesian Networks, pp. 884-889

Pedrosa, Javier — Universitat Politecnica De Catalunya
Puig, Vicenç — Universitat Politecnica De Catalunya
Nejjari, Fatiha — Universitat Politecnica De Catalunya

This paper presents an economic reliability-aware Model Predictive Control (MPC) approach for the Prognostics and Health Management (PHM) of generalized flow-based networks. The main enhancement with respect to some existing approaches relies on the integration of the network reliability model obtained from a Bayesian Network. The goal is that the controller can optimally manage the supply taking into consideration the distribution of the control effort, in order to extend the life of the actuators by delaying as much as possible the network reliability decay. But, it also considers an optimal inventory replenishment policy based on a desired risk acceptability level, leading to the availability of safety stocks for unexpected excess demand in networks. The proposed implementation is illustrated with a real case study corresponding to an aggregate model of the Drinking Water transport Network (DWN) of Barcelona.

14:40-15:00 FrB1.3

Simulation-Based Debugging of Formal Environment Models, pp. 890-895

Meywerk, Tim — University of Bremen

Niedzwiecki, Arthur — University of Bremen
Herdt, Vladimir — University of Bremen, DFKI GmbH
Drechsler, Rolf — University of Bremen, DFKI GmbH

Logic-based formal models of robot environments are often used to aid the generation and verification of robotic plans. They are however often simplified and rather abstract compared to the real world that the robot acts in. This can lead to considerable discrepancies between the behavior of the formal model and that of physics-based simulation engines. These discrepancies are not always apparent to the designer. In this paper we propose a new methodology to make these discrepancies explicit by combining formal verification and simulation. Our approach can find relevant discrepancies, while only requiring a small number of simulations.

15:00-15:20 FrB1.4

Optimization-Based Attack against Control Systems with CUSUM-Based Anomaly Detection, pp. 896-901

Gualandi, Gabriele — Mälardalens University
Maggio, Martina — Lund University
Papadopoulos, Alessandro Vittorio — Mälardalens University

Security attacks on sensor data can deceive a control system and force the physical plant to reach an unwanted and potentially dangerous state. Therefore, attack detection mechanisms are employed in cyber-physical control systems to detect ongoing attacks, the most prominent one being a threshold-based anomaly detection method called CUSUM. Literature defines the maximum impact of stealth attacks as the maximum deviation in the plant's state that an undetectable attack can introduce and formulates it as an optimization problem. This paper proposes an optimization-based attack with different saturation models, and it investigates how the attack duration significantly affects the impact of the attack on the state of the plant. We show that more dangerous attacks can be discovered when allowing saturation of the control system actuators. The proposed approach is compared with the geometric attack, showing how longer attack durations can lead to a greater impact of the attack while keeping the attack stealthy.

FrB2 — Athina A

Distributed Systems (Regular Session)

Chair: Gasparri, Andrea — Università Degli Studi Roma Tre
Co-Chair: Eser, Steffen — RWTH Aachen University

14:00-14:20 FrB2.1

Distributed Model Predictive Control of a Nonlinear Building Energy System Using Consensus ADMM, pp. 902-907

Eser, Steffen — RWTH Aachen University
Stoffel, Phillip — RWTH Aachen University
Kümpel, Alexander — RWTH Aachen University
Müller, Dirk — RWTH Aachen University

Model predictive control (MPC) is a promising approach to reduce energy usage in buildings and provide grid flexibility. However, MPC in buildings requires a high modeling effort and struggles with reliability and scalability. Distributed control architectures can help to alleviate these problems. Existing work for distributed building MPC mainly focuses on the consumer side, neglecting the producer dynamics. In this work, we investigate a distributed MPC scheme based on the alternating direction method of multipliers (ADMM), considering the dynamics of producers and consumers simultaneously. The control agents employ nonlinear plant models and are directly coupled through their states. Consequently, a distributed, non-convex optimization problem needs to be solved. We test the distributed control algorithm on an energy system consisting of two thermal zones, a stratified hot water tank, a boiler, and a CHP. In a simulation, we demonstrate that the closed-loop system can be stabilized using the distributed MPC scheme, given a sufficient number of iterations.

14:20-14:40 FrB2.2

Finite-Time Distributed Protocol for Tracking the Upper (Lower) Bound for a Set of Time-Varying Reference Signals, pp. 908-913

Lippi, Martina — Università Degli Studi Roma Tre
Furchi', Antonio — Università Degli Studi Roma Tre
Marino, Alessandro — Università Degli Studi di Cassino
Gasparri, Andrea — Università Degli Studi Roma Tre

In this paper we address the problem of distributively tracking the upper or lower bound of *n* time-varying signals in finite-time. In detail, each agent has access to a time-varying exogenous signal, which may encode the evolution of a physical phenomenon. All the agents are required to follow the upper or lower bound value among such output signals in a distributed fashion. We provide a protocol to solve the above problem in the case of networked agents and undirected communication, together with formal proof of convergence and estimation of an upper bound of the convergence time. We corroborate the protocol via numerical validations in a precision farming setting.

14:40-15:00 FrB2.3

Hierarchical Distributed Model Predictive Control Based on Dual Decomposition and Quadratic Approximation, pp. 914-919

Yfantis, Vassilios — Technische Universität Kaiserslautern
Gafur, Nigora — Technische Universität Kaiserslautern
Wagner, Achim — German Research Center for Artificial Intelligence

Ruskowski, Martin — Technische Universität Kaiserslautern

This paper presents a dual decomposition-based distributed optimization algorithm and applies it to distributed model predictive control (DMPC) problems. The considered DMPC problems are coupled through shared limited resources. Lagrangian duality can be used to decompose an MPC problem, so that each subsystem can compute its individual resource utilization, without sharing information, such as dynamics or constraints, with the other subsystems. The feasibility of the central problem is ensured by the coordination of the subproblems through dual variables which can be interpreted as prices on the shared limited resources. The proposed coordination algorithm makes efficient use of information collected from previous iterations by performing a quadratic approximation of the dual function of the central MPC problem. Aggressive update steps of the dual variables are prevented through a covariance-based step size constraint. The non-smoothness encountered in dual optimization problems is addressed by the construction of cutting planes, like bundle methods for non-smooth optimization. The cutting planes ensure that the updated dual variables do not lie outside the range of validity of the dual approximation. The proposed algorithm is evaluated on a two-tank system and compared to the standard sub-gradient method. The results show that the rate of convergence towards the centralized solution can be significantly improved while still preserving privacy between the subsystems through limited information exchange.

15:00-15:20 FrB2.4

Optimal Load Control and Scheduling through Distributed Mixed-Integer Linear Programming, pp. 920-926

Yfantis, Vassilios — Technische Universität Kaiserslautern
Motsch, William — Technologie-Initiative SmartFactory KL E.V
Bach, Nico — Technische Universität Kaiserslautern
Wagner, Achim — German Research Center for Artificial Intelligence
Ruskowski, Martin — Technische Universität Kaiserslautern

This paper presents a mixed-integer linear programming-based optimization model for simultaneous optimal load control and scheduling of distributed systems coupled through their energy consumptions. The subsystems are able to adjust their energy consumption during the execution of a task and aim at minimizing their completion time and energy cost. The overall problem is solved in a distributed fashion, where each subsystem optimizes its individual operation without sharing sensitive information. To this end, dual decomposition is employed and a new algorithm to update the dual variables is presented. It relies on a transformation of the gradient of the quadratically approximated dual function and the subsequent solution of a regression problem. The proposed algorithm makes efficient use of information collected in previous iterations. The solution obtained from the distributed optimization of the subsystems is compared to both a decentral and a system-wide solution, showing that the distributed solution lies close to the global optimum of the process.

15:20-15:40 FrB2.5

Private Consensus Using Chaotic Oscillator-Based Encryption, pp. 927-932

Fioravanti, Camilla — Università Campus Bio-Medico di Roma
Oliva, Gabriele — Università Campus Bio-Medico di Roma
Panzieri, Stefano — Università Degli Studi Roma Tre
Hadjicostis, Christoforos — University of Cyprus

Distributed average consensus is a fundamental feature of multi-agents systems; yet, in several cases agents are reluctant to disclose their initial conditions, e.g., due to their sensitivity about private data. Consequently, ensuring the privacy of such information against honest but curious neighbours becomes a mandatory necessity. In this paper we propose to implement a privacy-preserving consensus strategy that exploits, for this purpose, unpredictable chaotic phenomena, such as the trend of variables in a Chua oscillator. The initial conditions are then split into two fragments, one of which always remains hidden in the node, while the other is exchanged after undergoing oscillator-dependent manipulation, adding an extra layer of security to what is exchanged over the network. In this way, the combination of the two fragments converges to the average of the true initial conditions of each node. The paper is complemented by a simulation campaign aimed at numerically demonstrating the effectiveness of the proposed approach.

FrB3 — Athina B

Automotive Control (Regular Session)

Chair: Sename, Olivier — Grenoble INP / GIPSA-Lab
Co-Chair: Basargan, Hakan — Budapest University of Technology and Economics

14:00-14:20 FrB3.1

Integrated Adaptive Velocity and Semi-Active Suspension Control for Different Road Profiles, pp. 933-938

Basargan, Hakan — Budapest University of Technology and Economics
Mihaly, Andras — SZTAKI - Institute for Computer Science and Control
Gaspar, Peter — SZTAKI - Institute for Computer Science and Control
Sename, Olivier — Grenoble INP / GIPSA-Lab

This study represents the integrated comfort-oriented velocity design, tracking control, and adaptive semi-active suspension control method. The velocity design approach is based on the ISO 2631-1 standard, while the proposed velocity tracking control method is based on the LPV control architecture. A road adaptive semi-active suspension control method, where a trade-off between vehicle stability and driving comfort is accomplishable to achieve desirable performance results at different road profiles and velocities. The trade-off is accomplishable due to flexibility and online reconfigurability of the LPV control method by online modification of scheduling variables. The design is based on the performance index, road profile, and the designed velocity of the velocity. The velocity designer, velocity tracking controller, and adaptive suspension controller have been integrated and simulated in the TruckSim environment to show the operation of the proposed method.

14:20-14:40 FrB3.2

MPC Control Strategy for Autonomous Vehicles Driving in Roundabouts, pp. 939-944

Farkas, Zsofia — Budapest University of Technology and Economics
Mihaly, Andras — SZTAKI - Institute for Computer Science and Control
Gaspar, Peter — SZTAKI - Institute for Computer Science and Control

The appearance of autonomous vehicles (AVs) in transportation has increased the attention of the scientific community to develop modern solutions for the control design of AVs in different traffic scenarios. In this paper a control method is proposed for the coordination of autonomous vehicles in roundabout scenarios. For collision avoidance and minimization of traveling time, a Model Predictive Control (MPC) with a centralized controller is introduced to calculate the traveling times of the vehicles. A presented algorithm determines velocity profiles for safety reasons and for the reduction of possible congestion. The operation of the proposed MPC method is tested and demonstrated in CarSim simulation environment.

14:40-15:00 FrB3.3

Integrated Control of Steering and Braking for Effective Collision Avoidance with Autonomous Emergency Braking in Automated Driving, pp. 945-950

Wang, Dekun — KTH Royal Institute of Technology
Nazem Tahmasebi, Kaveh — KTH Royal Institute of Technology
Chen, Dejiu — KTH Royal Institute of Technology

This paper presents a control approach allowing a tight integration of several driver assistance functions in automotive vehicles, including front steering, differential braking and autonomous emergency braking. The goal is to support a more effective collision avoidance with necessary emergency maneuvers during automated driving, while avoiding situations with a high risk of undesired vehicle instability due to separated steering and braking actions. The approach adopts a Model Predictive Control (MPC) based methodology using a set of performance indexes calculated according to the actual time to collision, braking and steering capabilities. The effectiveness of the proposed methodology is evaluated in a simulation on MATLAB/Simulink.

15:00-15:20 FrB3.4

MPC-Based Optimal Parameter Scheduling of LPV Controllers: Application to Lateral ADAS Control, pp. 951-956

Medero, Ariel — Grenoble INP / GIPSA-Lab
Menezes Morato, Marcelo — Universidade Federal De Santa Catarina
Sename, Olivier — Grenoble INP / GIPSA-Lab
Puig, Vicenç — CSIC-UPC

In this paper, we propose an optimal online tuning scheme for design-related scheduling parameters of adaptive Linear Parameter Varying (LPV) control systems. Specifically, the method is conceived within the Model Predictive Control (MPC) framework, which we demonstrate to ensure an input-to-state stable closed-loop and a recursively feasible optimisation program. The major advantage of the proposed solution is that it automatically determines the LPV scheduling parameters online, without the need to for the designer to develop any scheduling function (which is often a repetitive and obscure task). Moreover, it offers a direct and simple tuning procedure, able to directly incorporate multi-objective performance goals into a single quadratic cost. The proposed method is tested for an LPV Advanced Driver Assistance System, showing enhanced performances when compared to state-of-the-art methods based on nonlinear scheduling functions.

15:20-15:40 FrB3.5

Communication Topologies Evaluation for Vehicle Platoon Moving on Highway, pp. 957-962

Pauca, Ovidiu — Gheorghe Asachi Technical University of Iasi
Maxim, Anca — Gheorghe Asachi Technical University of Iasi
Caruntu, Constantin-Florin — Gheorghe Asachi Technical University of Iasi

Vehicle-to-vehicle communication represents the main capability of vehicles that stays at the base of cooperative control solutions. Vehicle groups, e.g., platoons, exchange information about velocities to improve the performances of the traffic (i.e., reducing fuel consumption/emissions, improving the quality of the travel). Due to the importance of communication in literature, manifold types of communication topologies were proposed for various scenarios. In this paper, a study of the performances of the communication topologies is performed, starting from a cooperative adaptive cruise control (CACC) algorithm used to control the vehicles from a platoon in a specific scenario, four communication topologies were tested, and numerical analysis was performed to point out the advantages of each topology.

FrB4 Poseidon AB

Robotics V (Regular Session)

Chair: Fabian, Martin — Chalmers University of Technology
Co-Chair: Artemiadis, Panagiotis — University of Delaware

14:00-14:20 FrB4.1

Precise Motion Control of Autonomous Robots, pp. 963-968

Novakovic, Branko — University of Zagreb
Majetic, Dubravko — University of Zagreb
Kasac, Josip — University of Zagreb

Brezak, Danko University of Zagreb

In the case of the control synthesis of the autonomous robot precise motions in production processes, or autonomous micro/nano robot motions in drug delivery, one have to use a related Hamiltonian. It is assumed that the autonomous robot (or micro/nano robot) motions are in a multipotential field. In order to simplify control process, the concept of the external linearization is used. In that case, the nonlinear control in the closed loop with the nonlinear canonical differential equations of the autonomous robot (or micro/nano robot) motion is resulting in the linear behavior of the whole system. Therefore, the linear control algorithms can be applied. This is the main contribution of the paper. The control process is calculated in the combination of the electromagnetic and gravitational fields. In that case, the autonomous robot (or micro/nano robot) moves towards a target with limited information about the environment. The main point of these algorithms is to minimize the use of the outer perimeter of an obstacle, which also minimizes total path length taken by the autonomous robot (or micro/nano robot).

14:20-14:40 FrB4.2

Robust Dynamic Walking for a 3D Dual-SLIP Model under One-Step Unilateral Stiffness Perturbations: Towards Bipedal Locomotion Over Compliant Terrain, pp. 969-975

Karakasis, Chrysostomos University of Delaware
Poulakakis, Ioannis University of Delaware
Artemiadis, Panagiotis University of Delaware

Bipedal walking is one of the most important hallmarks of human that robots have been trying to mimic for many decades. Although previous control methodologies have achieved robot walking on some terrains, there is a need for a framework allowing stable and robust locomotion over a wide range of compliant surfaces. This work proposes a novel biomechanics-inspired controller that adjusts the stiffness of the legs in support for robust and dynamic bipedal locomotion over compliant terrains. First, the 3D Dual-SLIP model is extended to support for the first-time locomotion over compliant surfaces with variable stiffness and damping parameters. Then, the proposed controller is compared to a Linear-Quadratic Regulator (LQR) controller, in terms of robustness on stepping on soft terrain. The LQR controller is shown to be robust only up to a moderate ground stiffness level of 200 kN/m, while it fails in lower stiffness levels. On the contrary, the proposed controller can produce stable gait in stiffness levels as low as 30 kN/m, which results in a vertical ground penetration of the leg that is deeper than 10% of its rest length. The proposed framework could advance the field of bipedal walking, by generating stable walking trajectories for a wide range of compliant terrains useful for the control of bipeds and humanoids, as well as by improving controllers for prosthetic devices with tunable stiffness.

14:40-15:00 FrB4.3

Analyzing Interoperability and Security Overhead of ROS2 DDS Middleware, pp. 976-981

Aartsen, Max The Hague University of Applied Sciences
Banga, Kanta The Hague University of Applied Sciences
Talko, Konrad The Hague University of Applied Sciences
Touw, Dustin The Hague University of Applied Sciences
Wisman, Bertus The Hague University of Applied Sciences
Meinsma, Daniel The Hague University of Applied Sciences
Björkqvist, Mathias DFINITY Foundation

Robot Operating System 2 (ROS2) is the latest release of a framework for enabling robot applications. Data Distribution Service (DDS) middleware is used for communication between nodes in a ROS2 cluster. The DDS middleware provides a distributed discovery system, message definitions and serialization, and security. In ROS2, the DDS middleware is accessed through an abstraction layer, making it easy to switch from one implementation to another. The existing middleware implementations differ in several ways, e.g., in how they are supported in ROS2, in their support for the security features, their ease of use, their performance, and their interoperability. In this work, the focus is on the ease of use, interoperability, and security features aspects of ROS2 DDS middleware. We compare the ease of installation and ease of use of three different DDS middleware and test the interoperability of different middleware combinations in simple deployment scenarios. We highlight the difference that enabling the security option makes to interoperability and conduct performance experiments that show the effect that turning on security has on the communication performance. Our results provide guidelines for choosing and deploying DDS middleware on a ROS2 cluster.

15:00-15:20 FrB4.4

Formal Verification of Deadlock Avoidance Rules for AGV Systems, pp. 982-987

Riazi, Sarmad AGVE AB
Falk, Jonathan Chalmers University of Technology
Greger, Alexander Chalmers University of Technology
Pettersson, Anton Chalmers University of Technology
Fabian, Martin Chalmers University of Technology

Automated Guided Vehicles (AGVs) are increasingly popular and bring many industrial benefits. However, when several AGVs autonomously execute their itineraries, it is possible for two or more AGVs to prevent each other from completing their tasks and cause a deadlock from where the system cannot progress. One way that companies try to avoid this is to, based on simulations, generate deadlock avoidance rules (DA-rules) that determine for different scenarios how the AGVs should behave. This paper presents an application of translating such DA-rules to extended finite-state automata and then to formally verify if the rules do avoid deadlocks. This is done by using information of an existing system setup where there are two major types of DA-rules. Both can be modelled as automata with guards and actions that prevent a transition from occurring if associated conditions are not fulfilled. These guards are generated automatically for all the DA-rules corresponding to the current itineraries. For a chosen itinerary a complete automaton is generated, as well as automata representing the DA-rules. It is shown that the existing DA-rules do not manage to remove all deadlocks in all cases. Even worse, it is shown that the DA-rules can lead to a fully blocking system, even though a deadlock-free solution does exist, as can be shown by computing a supervisor for the system without the DA-rules.

15:20-15:40 FrB4.5

Towards Dynamic Quadruped Locomotion: Development of a CPG-Driven Foot Trajectory Generator, pp. 988-993

Teixeira de Paula, Daniel — São Paulo State University
Godoy, Eduardo Paciencia — São Paulo State University
Becerra-Vargas, Mauricio — São Paulo State University

Legged locomotion has been a widespread daily activity of animals for millions of years, and many of its subtleties are founded on imposed conditions for survival. Agile movement in environments built for human locomotion could be achieved by extracting and implementing key aspects of legged locomotion in artificial creations. This work proposes a novel high-level control system module for dynamic quadruped robot locomotion, integrating the rhythmic developing capabilities of CPGs with foot trajectory generation based on Bezier curves. The proposed system utilizes CPG output signals as driving parameters for a foot trajectory generator based on Bezier curves} and is built using a Matlab/Simulink simulated environment, with tests being carried out to validate its quadruped locomotion aptitude with regards to limit-cycle convergence and establishment of synchronized and stable phase shifts corresponding to desired gaits. The results point toward a sound performance of the proposed strategies, showing great promise regarding its locomotion capabilities. Lastly, additions to enhance the system's effectiveness and enable its use in a complete locomotion control system are suggested to be further explored in future works.

FrC1 Platon Hall

Discrete-Event and Hybrid Systems (Regular Session)

Chair: Iacono, Francesca — Università Degli Studi Di Pavia
Co-Chair: Motta, Carlo — Università Degli Studi Di Napoli Federico II

16:30-16:50 FrC1.1

Assessment of Initial-State-Opacity in Live Bounded and Reversible Discrete Event Systems Via Integer Linear Programming, pp. 994-999

Basile, Francesco — Università Degli Studi di Salerno
De Tommasi, Gianmaria — Università Degli Studi di Napoli Federico II
Motta, Carlo — Università Degli Studi di Napoli Federico II
Santini, Stefania — Università Degli Studi di Napoli Federico II
Petrillo, Alberto — Università Degli Studi di Napoli Federico II

Opacity is a property of discrete event systems (DES) that is related to the possibility of hiding a secret from external observers (the intruders). When the secret is the initial state of the system, the related opacity problem is referred to as Initial State Opacity (ISO). A sufficient condition to check ISO by solving Integer Linear Programming problems is given in this paper. Such a condition exploits the algebraic representation of Petri nets and a structural one of its behaviour in terms of minimal support T-invariants. The effectiveness of the proposed approach is shown by means of examples.

16:50-17:10 FrC1.2

Disturbance Decoupling by Dynamic Output Feedback for Linear Impulsive Systems with Periodic Jumps, pp. 1000-1005

Zattoni, Elena — Alma Mater Studiorum Università Di Bologna
Otsuka, Naohisa — Tokyo Denki University
Perdon, Anna Maria — Accademia Marchigiana Di Scienze Lettere Ed Arti
Conte, Giuseppe — Università Politecnica Delle Marche

In this paper, we consider the problem of decoupling the output of a given system from a disturbance input by means of a dynamic output feedback for the class of linear impulsive systems with periodic jumps. By introducing a suitable notion of hybrid (C,A,B)-pair, the solvability of the problem is completely characterized by means of a structural condition. The additional requirement of stability, in a suitable sense, of the closed-loop system is also considered and a sufficient condition for the solution of the problem in this case is found. Viable algorithmic procedures for constructing solutions, if any exist, are also devised.

17:10-17:30 FrC1.3

Interval State Estimation of Switched Takagi-Sugeno Systems with Metzler-Lipschitz Features, pp. 1006-1011

Krokavec, Dusan — Technical University of Kosice
Filasova, Anna — Technical University of Kosice

The paper deals with the interval switching observers design for nonlinear switched positive systems. The systems are represented by the Takagi-Sugeno fuzzy switched models, with measurable premise variables. Proposed design conditions for the interval switching observer structure are formulated via linear matrix inequalities to ensure non-negative state estimation of the considered class of fuzzy switched systems. Under such conditions the proposed method allows to compute the lower and upper bounds of the system state assuming that Lipschitz function is positive, and the system disturbance is positive and bounded. The properties of the proposed approach are illustrated by a numerical example.

17:30-17:50 FrC1.4

Output Feedback Control of Nondeterministic Finite–State Systems with Reach–Avoid Specifications, pp. 1012-1017

Ajeleye, Daniel Ajedamola — Università Degli Studi Dell'Aquila
Tommaso, Masciulli — Università Degli Studi Dell'Aquila
Pola, Giordano — Università Degli Studi Dell'Aquila

In this paper we address control design of nondeterministic finite state systems with reach-avoid specifications. A general class of controllers is considered, which combines feedforward and output feedback schemes. Results proposed here extend those of [1] in two directions: first, here we consider reach avoid-specifications instead of simply reachability specifications; second, we propose algorithms exhibiting better time computational complexity than those given in [1].

17:50-18:10 FrC1.5

Power Management Strategies of Hybrid Storage System Suppling Electric Vehicle, pp. 1018-1023

Degas, Laid — Ecole Supérieure Des Techniques Aéronautiques Et De Construction

Jarraya, Imen — National Engineering School of Sfax

Rizoug Nassim, Pr.rizoug — Ecole Supérieure Des Techniques Aéronautiques Et De Construction

Daas, Sara — Badji Mokhtar University

Larouci, Cherif — Ecole Supérieure Des Techniques Aéronautiques Et De Construction

Telmoudi, Achraf Jabeur — University of Tunis

Battery electric vehicles (BEV) initially appeared as a promising solution against climatic disasters due to petroleum vehicles and the continuous growth in energy demand for road transport. However, their weak autonomy combined with too high a cost slowed down their development in the world market. However, a second transition to multi-source electric vehicles which consist of a set of Energy Storage Systems (ESSs), may be possible solutions to improve the vehicle's autonomy and the duration of battery life by significantly reducing polluting emissions to the environment. In fact, this paper presents a hybrid SSE which is mainly based on High energy lithium-ion (Li-ion) batteries and High-power batteries for powering an all-electric vehicle. This hybridization of a main High energy Li-ion battery source with the secondary High power batteries source adds greater HEV autonomy but it increases the complexity of the Energy Management System (EMS). In this work, the main objective is designed to simulate the strategies based on deterministic rules like the filtering method (MF) and the Limitation method (ML) for running electric vehicle with hybrid source in real time. Strategies ML and MF were chosen in the first place thanks to their simplicity in time integration real but unfortunately these techniques have no control over the behaviour of the High-power batteries during the rolling cycle. For this an improvement of these three strategies was introduced by integrating a technique of control of the state of charge "Control SOC" of this secondary source in order to follow the behaviour of the High-power batteries along the conduct of the driver in order to ensure loading the High power batteries at the end of each cycle.

FrC2 — Athina A

Power Systems and Smart Grid (Regular Session)

Chair: Braitor, Andrei-Constantin — The University of Sheffield

Co-Chair: Michos, Grigoris — The University of Sheffield

16:30-16:50 FrC2.1

Direct MPP Tracking of PV by Estimating the Virtual Optimal Resistance, pp. 1024-1029

Alexakis, Zaint — University of Patras

Alexandridis, Antonio — University of Patras

Konstantopoulos, George — University of Patras

The challenging issue of designing an enhanced, stable and robust method capable to track the maximum power point (MPP) of a PV is presented. In the present work, the notion of the virtual optimal resistance (VOR) is firstly introduced while a merit analysis of its importance on the current and voltage characteristic of a PV is indicated. Secondly, a neural network (NN) based implementation is proposed with its swift and robust response to effectively provide a novel and successful methodology of the MPP tracking. The advantage of the method is that it drives the PV power production to its MPP without creating further ripples or oscillations on the output signal. More specifically, we exploit the fact that the MPP is a unique point on the PV current-voltage (I-V) characteristic and that VOR results from the intersection of the I-V curve with the line connecting the origin with the MPP. Then, to utilize this new entity on determining the MPP, a reliable and fast, on-line estimation of the VOR is required. This task is realized by the proposed NN scheme. The NN structure and the training procedure are precisely explained in the paper, whereas the very good performance of the methodology is examined. Different simulation studies are conducted, and the results are compared with the most popular perturb and observe (P&O) technique to indicate the improvements achieved.

16:50-17:10 FrC2.2

On the Existence and Uniqueness of Equilibria in Meshed DC Microgrids with CPLs, pp. 1030-1035

Braitor, Andrei-Constantin — The University of Sheffield

Konstantopoulos, George — University of Patras

In this paper, we analyse the existence and uniqueness of equilibria of constant power loads (CPLs) in meshed DC microgrid architectures. Given the CPLs' nonlinear characteristic and negative impedance behaviour, they are commonly known to introduce a destabilising effect into the system, effect intuitively coined as negative impedance instability. In the present approach, we start by deriving the characteristic polynomial from the power balance equation aiming to observe the nature of the CPLs voltage solutions and assess their feasibility. Then, the algebraic expression is transformed into a problem of existence and uniqueness of a fixed point, and further tested by means of contraction mapping theory. A sufficient condition for the sources' voltage references is obtained to guarantee the existence and uniqueness of equilibria. This provides a useful guidance in selecting the voltage references in the control design process. A numerical investigation on a meshed DC microgrid is carried out to verify the acquired sufficient condition and its underlying developed theory.

17:10-17:30 FrC2.3

Robust Distributed Control for DC Microgrids with System Constraints, pp. 1036-1041

Michos, Grigoris — The University of Sheffield
Baldivieso Monasterios, Pablo — The University of Sheffield
Konstantopoulos, George — University of Patras

This work proposes a distributed robust control architecture for meshed DC Microgrid networks. Each interlinking converter is modelled as a network node and is connected in parallel to a constant power load representing the network's power consumption. Each node employs a local controller consisting of two parts; current regulation based on a modified version of the state-limiting PI and a distributed MPC driving the system to desired setpoints. We analytically prove each controller's robustness to model variations caused by changes in both the power demand and the transmitted information among the subsystems. The concept of positive invariance sets and the inherent robustness properties of the nominal MPC are used to prove recursive feasibility of the optimal control problem and guarantee constraint satisfaction at all times. The stability proof of the cascaded node dynamics is based upon the emerging properties of both the state limiting PI and the distributed MPC design. Demonstration of the results is given in a simulated scenario.

17:30-17:50 FrC2.4

Sensitivity Analysis of Impedance Measurement Algorithms Implemented in Intelligent Electronic Devices, pp. 1042-1046

Rohadi, Nanang — Universitas Padjadjaran
Zivanovic, Rastko — University of Applied Sciences Upper Austria

In this paper a global sensitivity analysis technique for testing impedance measurement algorithms is described. The technique is based on the Analysis of Variance (ANOVA) statistical method. Accuracy of impedance measurement algorithms, when influenced by uncertainties, can be systematically analysed. This technique divides variance of a measurement algorithm output into components related to uncertain parameters (factors) and interactions between factors. As an application example, we simulate transmission line faults with varying values of fault parameters (factors) according to the Sobol's quasi-random sampling. The algorithm for automating this task was developed via DIgSILENT Programming Language (DPL). The SIMLAB software is used for generating samples in a factor space according to the Sobol's quasi-Monte Carlo technique.

17:50-18:10 FrC2.5

Dominant Modes Estimation Using SCUSUM Method Along with SSI, pp. 1047-1052

Verma, Shashank Shekhar — Veermata Jijabai Technological Institute
Raphel, Mariya — Veermata Jijabai Technological Institute
Maran, Mamta — Veermata Jijabai Technological Institute

Low-frequency oscillations (LFOs) in the power system have emerged as a significant possible cause of abrupt wide-area blackouts in several parts of the world. As consumer demand grows, so does the insecurity of the operational stability points of power systems as a result of unforeseen events such as connection and disconnection of loads, generators, or inter-area power networks. Although the stochastic subspace identification performed well in identifying certain LFO modes, it gives inaccurate results due to incorrect model order estimates. Incorrect estimation of model order results in the inclusion of trivial modes to essential subspace modes of a power system. The Sequential Cumulative Sum (SCUSUM) approach of order estimation detects changes in the mean with respect to the eigenvalues. This paper proposes the use of the SCUSUM method instead of estimating using the singular value decomposition of the weighted projection matrix in Stochastic Subspace Identification.

FrC3 — Athina B

Control, Optimization, and Learning Methods for Emerging Mobility Systems in Smart Cities (Invited Session)

Chair: Malikopoulos, Andreas — University of Delaware
Co-Chair: Fényes, Dániel — SZTAKI - Institute for Computer Science and Control
Organizer: Malikopoulos, Andreas — University of Delaware
Organizer: Siri, Silvia — Università Degli Studi Di Genova

16:30-16:50 FrC3.1

Performance Analysis of Optimally Coordinated Connected and Automated Vehicles in a Mixed Traffic Environment (I), pp. 1053-1058

Valencia, Alejandra — University of Delaware
Mahbub, A.M. Ishtiaque — University of Delaware
Malikopoulos, Andreas — University of Delaware

Trajectory planning of connected and automated vehicles (CAVs) poses significant challenges in a mixed traffic environment due to the presence of human-driven vehicles (HDVs). In this paper, we apply a framework that allows coordination of CAVs and HDVs traveling through a traffic corridor consisting of an on-ramp merging, a speed reduction zone, and a roundabout. We study the impact of different penetration rates of CAVs and traffic volumes on the efficiency of the corridor. We provide extensive simulation results and report on the benefits in terms of total travel time and fuel economy.

16:50-17:10 FrC3.2

PWA-CTM: An Extended Cell-Transmission Model Based on Piecewise Affine Approximation of the Fundamental Diagram (I), pp. 1059-1065

Alimardani, Fatemeh — University of Maryland College Park

Baras, John S. University of Maryland College Park

Throughout the past decades, different versions of the widely used first-order Cell-Transmission Model (CTM) have been proposed for optimal traffic control. Highway traffic management techniques such as Ramp Metering (RM) are typically designed based on an optimization problem with nonlinear constraints originating in the flow-density relation of the Fundamental Diagram (FD). Most of the extended CTM models are based on the trapezoidal approximation of the flow-density relation of the Fundamental Diagram (FD) to simplify the optimization problem. However, this relation is naturally nonlinear, and crude approximations can greatly impact the efficiency of the optimization solution. Here, we propose a class of extended CTMs that are based on piecewise affine approximations of the flow-density relation such that (a) the integrated squared error with respect to the true relation is greatly reduced in comparison to the trapezoidal approximation, and (b) the optimization problem remains tractable for real-time application of ramp metering optimal controllers. A two-step identification method is used to approximate the FD with piecewise affine functions resulting in what we refer to as PWA-CTMs. These models are evaluated by the performance of the optimal ramp metering controllers, e.g., using the widely used PI-ALINEA approach, in complex highway traffic networks. Simulation results show that the optimization problems based on the PWA-CTMs require less computation time compared to other CTM extensions while achieving higher accuracy of the flow and density evolution. Hence, the proposed PWA-CTMs constitute one of the best approximation approaches for first-order traffic flow models that can be used in more general and challenging modeling and control applications.

17:10-17:30 FrC3.3

Overlapping Internal Boundary Control of Lane-Free Automated Vehicle Traffic with State and Input Inclusion (I), pp. 1066-1073

Malekzadeh, Milad Technical University of Crete
Papamichail, Ioannis Technical University of Crete
Papageorgiou, Markos Technical University of Crete

Lane-free vehicle driving has been recently proposed for connected automated vehicles. Lane-free traffic implies that incremental changes of the road width lead to corresponding incremental changes of the traffic flow capacity. Internal boundary control (IBC) was introduced to flexibly share the total road width and capacity among the two traffic directions of a highway in real-time, to maximize the crossroad infrastructure utilization. Centralized solutions, requiring information from the whole highway stretch under consideration, have already been proposed, which, however, may be problematic for long highways with respect to the required communications and physical system architecture in real-time operation. This paper introduces an overlapping decentralized control scheme for IBC of lane-free automated vehicle traffic, based on a contractible controller, which is designed in a decomposed way (per subsystem) for an extended system. Simulation investigations, involving a realistic highway stretch and demand scenario, demonstrate that the proposed decentralized regulator is similarly efficient as the centralized solutions

17:30-17:50 FrC3.4

Combined Observer Design for Road Vehicles Using LPV-Based and Learning-Based Methods, pp. 1074-1079

Fényes, Dániel SZTAKI - Institute for Computer Science and Control
Hegedus, Tamas Budapest University of Technology and Economics
Nemeth, Balazs SZTAKI - Institute for Computer Science and Control

In this paper a novel observer design method is proposed, which combines Linear Parameter-Varying-based (LPV) and machine-learning-based design tools. As a first step, a parameter optimization technique is developed to achieve a polytopic LPV formulation of the system model. This modeling technique also involves a machine-learning-based solution to determine scheduling parameters for the LPV system. In the second step, a LPV-based observer design based on the achieved system representation is proposed. Finally, the operation and the effectiveness of the proposed observer algorithm are demonstrated through a vehicle-oriented estimation problem, i.e., estimation of the lateral velocity. In the paper two simulations illustrate the accuracy and the advantageous impact of the observer on the control performances of the closed-loop system.

17:50-18:10 FrC3.5

Cooperative Multi-Lane Shock Wave Detection and Dissipation Via Local Communication (I), pp. 1080-1086

Suriyarachchi, Nilesh University of Maryland College Park
Mavridis, Christos University of Maryland College Park
Baras, John S. University of Maryland College Park

Traffic shock waves are well-known naturally occurring phenomena that lead to unnecessary congestion in highway networks. Introducing connected autonomous vehicles (CAVs) to highways of human-driven vehicles (HDVs) allows for the development of traffic control schemes that can mitigate the effects of the shock waves. In this work, we propose a shock wave detection algorithm based on communication between CAVs with local traffic information. The proposed methodology is suitable for multi-lane mixed traffic highways of arbitrary structure, i.e., it is not limited to closed-circuit ring roads. We show that the detection information can be used to design a class of proactive shock wave mitigating CAV controllers. The choice of the controller can depend on design parameters such as the aggressiveness of the driving behavior allowed. We also demonstrate the importance of the positioning of autonomous agents in multi-lane scenarios. The shock wave dissipation efficiency is evaluated on a three lane circular highway loop using realistic traffic simulation software and low CAV penetration levels.

FrC4 Poseidon AB

Applications (Regular Session)

Chair: Doitsidis, Lefteris Technical University of Crete
Co-Chair: Ivanjko, Edouard University of Zagreb

16:30-16:50 FrC4.1

Automated Generation of PLC Code for Implementing Mode-Based Control Algorithms in Buildings, pp. 1087-1092

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In practice, manual planning and implementation of control function logic in building automation and control systems (BACS) is a source of failure. Textual descriptions of control functions are often not standardized and inaccurate. Therefore, they may result in misunderstandings in the following implementation process. The increasing complexity of building energy systems makes the problem even worse. Regarding this problem, we have introduced the MODI method in previous work. The MODI method enables a systematic development of mode-based control algorithms and utilizes signal-interpreted Petri nets as a formalized description method to avoid ambiguity in the description of control algorithms. However, the implementation of the mode-based control algorithms in BACS remains unclear. Manual programming of the algorithms is in practice time-consuming and error prone. In this paper, we introduce a software-assisted framework to support the implementation of mode-based control algorithms in programmable logic controllers (PLCs) by generating PLC code automatically. In a case study, we apply the framework to implement a mode-based control strategy for an air handling unit and test the strategy in a simulation. In future work, a digital data source and exchange method across the planning and the construction processes of BACS will be considered as a data input of this framework to further facilitate the generation of PLC code.

16:50-17:10 FrC4.2

Reinforcement Learning Based Variable Speed Limit Control for Mixed Traffic Flows Using Speed Transition Matrices for State Estimation, pp. 1093-1098

Vrbanić, Filip — University of Zagreb
Tisljaric, Leo — University of Zagreb
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Ivanjko, Edouard — University of Zagreb

The ever-increasing growth of the car industry and the demand for personal vehicles have put current traffic management systems and infrastructure to strain. The enlarged number of vehicles in traffic flows often creates congestion due to the increased demand to use the existing road capacity. This is especially evident in urban areas that consist of urban roads and urban motorways. Increasing the capacity by building additional infrastructure is not always a feasible solution. Thus, approaches derived from Intelligent Transportation Systems are frequently used to increase the level of service, especially on urban motorways. The development of Connected and Autonomous Vehicles (CAVs) creates additional challenges and opportunities for the traffic management system to cope with. In this study, the Variable Speed Limit (VSL) based on Q-Learning (QL) with CAVs as actuators and mobile sensors combined with Speed Transition Matrices (STMs) for state estimation named STM-QL-VSL is developed and analysed. Varying traffic scenarios with different CAV penetration rates are analysed, including the comparison of motorway configuration with one and two applicable VSL zones. The developed STM-QL-VSL algorithm managed to learn the control policy for each tested scenario and improve measured macroscopic traffic parameters such as Total Time Spent and Mean Travel Time.

17:10-17:30 FrC4.3

HYDRA 2.0: Towards Developing a Holistic Tool for STEM Education, pp. 1099-1104

Kakaras, George — Technical University of Crete
Goumenakis, Epaminodas — Technical University of Crete
Glynos, Evangelos — Technical University of Crete
Spanoudakis, Polychronis — Technical University of Crete
Tsinarakis, George — Technical University of Crete
Tsourveloudis, Nikos — Technical University of Crete
Doitsidis, Lefteris — Technical University of Crete

In the current research a holistic tool towards STEM education is introduced. The proposed method is implemented using an enhanced version of a previously introduced educational framework [5], namely HYDRA 2.0. The proposed system offers a set of hardware and software tools which allow the creation of working artefacts. An application using augmented reality has been developed allowing the users to interact and obtain information about the different building blocks. To adopt the tools in a classroom environment, an educational procedure consisting of sequential tasks and actions has been introduced and modelled using Timed Petri nets, for representation, monitoring, what-if analysis and root cause analysis purposes. To highlight the applicability of the proposed approach a sample test case which results in a mobile robot with autonomous capabilities is presented and future extensions and conclusions are discussed.

17:30-17:50 FrC4.4

A Multipole Expansion Method for PDE Constrained Problems, pp. 1105-1110

Zivanovic, Rastko — University of Applied Sciences Upper Austria

It is crucial to choose the appropriate numerical method for treating partial differential equations in shape optimization and control problems. This paper introduces a meshless approach derived from the well-known charge simulation method. Instead of a large number of heuristically located monopoles (i.e. charges or sources), the proposed technique relies on more rigorously located poles with multiplicity. A well-conditioned method is devised by applying basis orthogonalization in this multipole expansion. The basis size is determined by a recursive process of orthogonalization in order to achieve the desired accuracy as shown in the numerical examples.

17:50-18:10 FrC4.5

EMG Onset and Offset Detection Via a Modified Threshold Crossings Algorithm, pp. 1111-1116

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In this study, we propose a novel family of onset and offset detection algorithms for electromyographic (EMG) signals, based on the Teager-Kaiser Energy Operator (TKEO). These algorithms are derived from an existing double-threshold statistical detector, which is modified to use Shifted Skew Log Laplace Distribution (SSLLD) probabilities and likelihoods to take advantage of the improved TKEO SNR ratio. The performance of the proposed algorithms is compared against existing approaches on synthetic EMG signals generated using a heteroscedastic autoregressive Gaussian model.

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